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# eachIntroducing and implementing an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up

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## Abstract

**Background:** Immunization is undeniable as a critical aspect of safe children from infections. To increase the coverage of immunization, valid and real-time data is needed. Accordingly, having a good report system is essential that rolled as defaulter tracking to prevent the children's immunization failure. DIY health office developed an individual electronic immunization registry and successfully implemented it for more than five years. It is the only individual-based record system in Indonesia that has survived for such a long time. To date, there is no systematic assessment of this system. Therefore, this research aimed to examine SIMUNDU's introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.

**Methods:** An explanatory sequential mixed-method design was used in this study by involving 142 and 9 participants quantitative and qualitative study - respectively. Entry data clerk in all level of health facility was systematically selected to participate in the survey. While in the key informant interview, the informant was selected based on the survey result. The descriptive and thematic approach was employed to analyze the quantitative and qualitative data. Integration between the two approaches was accomplished in the interpretation of the result by comparison and contrast.

**Results:** Three core themes emerged from our analysis that describes the SIMUNDU success journey as an electronic immunization registry: system strengths, potential threats and opportunities.

**Conclusions:** The individual electronic immunization registry has been implemented well, and it may contribute to increase immunization coverage in DIY. Stakeholders should consider the sustainability of this system by providing related resources and consider scale-up nationally by looking at this promising program.

**Keywords:** immunization, electronic immunization registry, immunization information system, interoperability, implementation research

## Background

Neonatal and childhood vaccination is an essential component of infectious disease prevention and an absolute human right (1),(2). Vaccination has been proven to reduce the burden of infectious disease globally (3). According to the WHO, in 2020 estimated 23 million children under one year of age did not receive their essential vaccinations. Of these, 60% live in just ten countries, one of which is Indonesia (4). Indonesia is the fourth most populous country globally. It is composed of thousands of islands organized into 34 provinces. Various geographical and cultural factors influence population inequalities to access to health services (5). In 2001, the Indonesian government's decentralization policy was enacted. This was an excellent strategy to foster development by engaging regional resources (6). However, this strategy was not without consequence. One major concern is the fragmentation of the Health Information System (HIS).

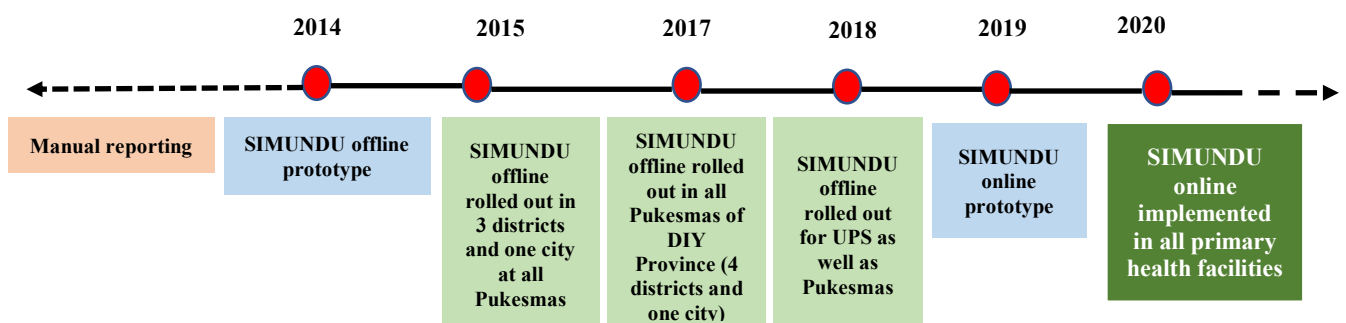
Indonesia's federal structure results in provinces and districts being relatively independent of the national Ministry of Health. This means that information systems at provincial and district levels are locally regulated (7). For instance, *Pemantauan Wilayah Setempat* (PWS) is a management tool used to monitor coverage of specific health services in an administrative boundary. It can be paper- or electronic-based, depending on the service and region. PWS-KIA is the monitoring system specific to maternal and child health (KIA), including immunization. Data recorded in the PWS-KIA are reported to the District or City Health Office, which reports to the Province Health Office, which transmits the data to the central level through simple emails if reporting is done in excel, or through various information systems including Komdat, SiTT, SIHA, PISPK, SIKDA Generik. In some provinces only, PWS-KIA data feeds into the DHIS2. Regional information systems have varying data quality, which reflects inequities in resources across regions. This adds to data integration challenges at the national level (7),(8) and affects strategic policymaking.

In the context of Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) Province has the authority to regulate and use its budget within its four districts (Sleman, Gunungkidul, Bantul, Kulonprogo) and Yogyakarta city. Regarding childhood vaccination, DIY is among the top ten performing provinces in the country, with 97.7 % complete basic immunization coverage in 2019 (9). Immunization services are provided by Primary Health Centres (*Puskesmas*), as well as private clinics, hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* (UPS)).

In 2014, the DIY Health Office introduced an electronic immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu*/ Integrated Immunization Information System). An electronic immunization registry is a tool for recording individual children's immunization histories. An electronic registry serves essential functions at all levels of the health system. The service delivery level can facilitate individual follow-up of vaccination status and enable health workers to identify children due for vaccination and those who missed their vaccinations (defaulters). At the district and higher levels, it allows for monitoring vaccination coverage by the vaccine, dose, cohort, and other variables – and can support microplanning and vaccine management.

SIMUNDU was designed to link with the PWS-KIA for immunization and interoperability with the DHIS2. While it predominantly contains individual-level immunization records, SIMUNDU also serves as a source for aggregation and can synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this reason, it can be considered an Immunization Information System (IIS). This means that data from City and District levels feed into Provincial and National levels (*Personal communication with DIY immunization program officer*).

The original prototype was designed by the information and technology (IT) department of DIY Health Office to be operated offline. In DIY, three out of the four districts and the city introduced the system in 2015. The final district introduced it in 2017. At this stage, the point of data entry was the Puskesmas only. By 2018, UPS facilities were also equipped with SIMUNDU and could enter data into the system. In 2019, the prototype was further developed to operate online. The online version was rolled out in 2020 (Figure 1). As of May 2021, 79.4% of all Puskesmas and UPS facilities were complying. This average rate masks, however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce its use in UPC facilities (Suyani 2020, oral communication, 2020 May 11)



**Figure 1.** SIMUNDU’s development and introduction

When a child receives a vaccination in a health facility, information on the child and the vaccination is entered in SIMUNDU as an individual child record. Each record includes an individual identifier, child’s socio-demographic characteristics (e.g., name, gender, date of birth, name of parents, address), the antigen administered, and the date and place of vaccination. SIMUNDU has been recently updated to allow recording of vaccinations administered in schools (e.g., Human papillomavirus (HPV), Difteri Toxoid (DT), Tetanus Difteri (TD), and Measles-Rubella (MR)) – at this stage, only in aggregate form. Furthermore, SIMUNDU is being developed to record COVID-19 vaccinations in health facilities and those carried out in masse.

Monitoring is conducted every month to assess data completeness across health facilities, while an evaluation is conducted every year. These exercises have allowed the identification of several challenges related to implementing the system (e.g., workload, staff turnover, and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic assessment of the system has been conducted to date.

SIMUNDU is the first immunization information system ever introduced in Indonesia. Other districts and provinces have shown interest in rolling it out, and the Ministry of Health has acknowledged the innovation. The objective of this work was to examine SIMUNDU’s introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.

## Methods

From May to October 2020, we examined the experience of introducing and implementing an immunization information system in the DIY province using a sequential mixed-method design, where each step informed the next (10). First, we conducted a desk review of all relevant documentation available in the DIY health office – e.g., staff notes, meeting notes and monitoring notes – documenting SIMUNDU development and management processes. We also examined online documents, including health profiles and regulations on health reporting systems in Indonesia. This served as the initial source of data and provided an overview of who was involved and their role in developing and implementing SIMUNDU. This informed the survey design that we conducted as a second step. The survey was conducted with staff responsible for entering data in SIMUNDU across Puskesmas and UPS facilities and staff responsible for managing the system at the district and city level. Sampling and recruitment strategies are outlined in Table 1.

**Table 1. Survey sampling**

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
<b>Puskesmas/Primary Health Centre (PHC)</b>	121	Immunization coordinator and data entry clerk	All facilities	Open invitation across all facilities	115
<b>Hospital (Central, General, Maternity and Pediatric)</b>	65	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
<b>Clinic</b>	73	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
<b>Midwives’ Practice</b>	271	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	110
<b>District/City Health Office</b>	5	Immunization coordinator	Total sampling	Open invitation	6*
<b>Total</b>					<b>146</b>

\*As the immunization coordinator had recently changed, the former was also invited.

All immunization coordinators and data entry clerks from all primary health facilities and the District/City Health Office were invited to participate in this survey. For UPS facilities, we randomly selected two clinics, two midwives' practices, and two hospitals per district and city and invited all of their staff involved in SIMUNDU data entry and management.

We developed and pre-tested an online survey in Bahasa Indonesia to inquire about SIMUNDU implementation, processes, and outcomes (*Sup.1*). All participants provided consent to participate in the survey. All participants were invited to the DIY health office to fill out the survey on their laptops. Having all participants in a room allowed researchers to monitor potential gaps in responses in real-time and follow-up with individual participants on-site to fill any gaps. Data were then exported into and analyzed in Microsoft Excel.

Next, we conducted key informant interviews to explore the challenges of implementing the system both from a practice and managerial standpoint. Each interview was conducted by three researchers with a different role: main interviewer, observer, and field note taker. SS, RR, TWS, SKW, and SAM were involved in the interviews. All of them were female with a public health background and worked as lecturers and researchers at university. An interview guide was developed by the research group and was consulted with the expert prior used for the interview. The interview takes approximately 30 minutes.

Informants were purposefully selected among survey participants to follow up on the range of perspectives that had emerged from the survey. As informed by the desk review, others were chosen for their management functions. The informant and interviewer did not know each other prior to the interview. Informants were invited to Province Health Office for interview purposes due to COVID-19 pandemic reasons. Before the interview, the informant was informed about the study and asked to sign the informed consent. All invited informants agreed to participate. A total of nine key informants were interviewed in Bahasa Indonesia language. The face-to-face interviews were recorded with consent from the informants. After the interview, the interviewer summarized our field notes to the informant for correction.

Thematic analysis was conducted using Quirkos qualitative tool following Braun and Clarke's approaches (11). Researchers familiarized themselves with the data, searching for initial codes and allowing themes to emerge. SS was the main coder during the analysis. Then the result of the coding reviewed together among the research group continued with defining and naming the core themes, analyzed the data for each of the core themes, triangulated information from the desk review, the survey, and the interviews. Themes were generated from the data during the analysis.

## Results

Findings from the study are presented across the three core themes that emerged from the analysis, notably system strengths, potential threats, and opportunities, drawing from the qualitative and quantitative data collected (Figure 2).

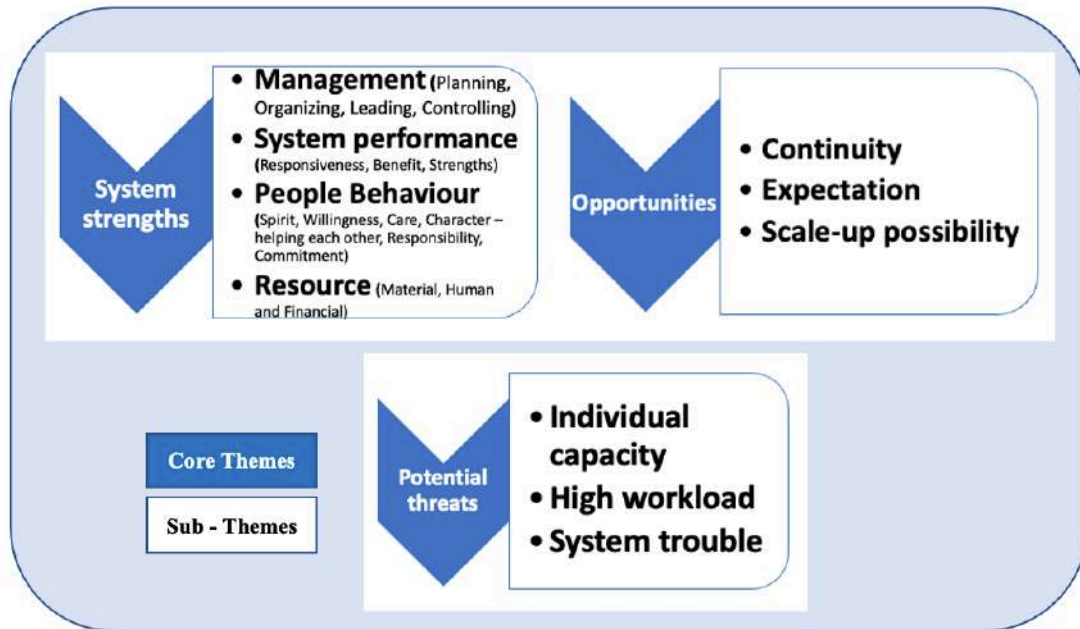


Figure 2. Strengths, potential threats, and opportunities for scale-up

### **System's Strengths**

Factors contributing to the success of SIMUNDU include management, system performance, people's behavior, and resources.

#### **Management**

Management factors relate to SIMUNDU development and all levels of the management chain (**planning, organizing, leading, and controlling**). SIMUNDU arose due to concerns from the DIY health office immunization section around data quality, including inaccurate data, duplicate or missing data and lack of timely data, and the need to support follow-up and appropriate planning. SIMUNDU was designed to address these challenges and needs.

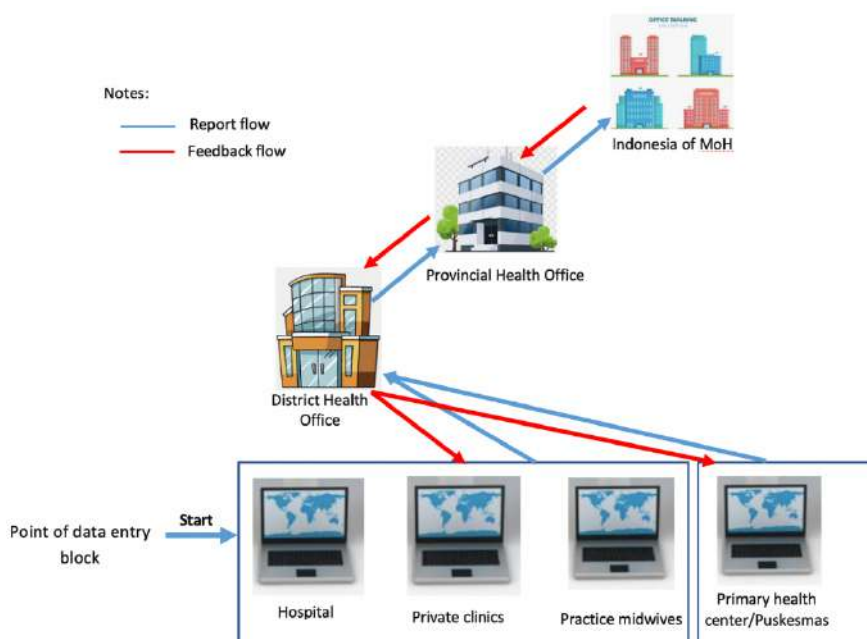
*To our knowledge, [SIMUNDU development] started with a problem: estimates of the target population varied depending on the data source.*

*Yes, I think [SIMUNDU management team] started to tire of managing a large volume of data with dubious validity. They need to know the situation in each district.*

Effective management of SIMUNDU from development to implementation has been highlighted as an essential determinant of its success. Here, we review its management across the critical functions of Planning, Organizing, Leading, and Controlling.

**Careful Planning** has been ensured at each stage of SIMUNDU development and implementation. These stages include an initial business plan, training on and socialization to SIMUNDU, and a staff replacement plan to respond to turnover or retirement of staff in charge of operating or entering data into SIMUNDU. The parties involved in planning included the head disease prevention and control department, IT personnel, and immunization program staff from the DIY health office.

**Organizing** - the organization of SIMUNDU is carried out at several levels. The top-level is at the level of the DIY health office, the second level is at the district/city health office, and the third level is the level of the health facilities (figure 2). A third party was also involved in developing the system interface.



**Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

At the beginning of SIMUNDU development, essential functions included database administrators, interface designers, and server administrators, and their interplay facilitated the smooth operation of the system. Training specific to SIMUNDU was integrated with other training, typically immunization-related training. This enabled to sharing of resources with other programs, thus ensuring viability. The training was delivered in the district/city health office: 70% of survey respondents indicated they had benefited. Training typically consisted of short training and included practice on the trainee's device and how to operate the system both in online and offline mode. Day-to-day operations were carried out autonomously by the staff, through adjusting their work



to protect time to enter the data. Some informants reported that staff members divided tasks effectively to ensure work was carried out effectively.

**Leading** - the success of SIMUNDU implementation is arguably related to strong leadership. Informants noted that managers played a key role in bridging the immunization program with the system design, closely monitoring the initial implementation process, and creating an enabling environment.

*I try to combine supporting and managing the people involved and monitoring them. Currently, I monitor whether [SIMUNDU] can run optimally as our users are health facilities. I also monitor program development and the system's output.*

*[SIMUNDU] was born from program managers, primary health centers, Districts, and DIY health offices wanting to build systems together. We – DIY health office - give them motivation in every meeting.*

*I see that [management] is very good at networking. Staff data entry in the field always said that these people are very kind.*

The role of IT in developing SIMUNDU was also reported to be significant. They helped develop the system and supported correct data entry by assisting data entry operators who experienced technical issues or helping resolve inconsistencies in the data records. Acknowledgment of staff efforts was also an important lever to maintain motivation and buy-in.

*In the early days of SIMUNDU's development, the system was challenging to operate, as it wasn't as stable as it is now. I praise the enthusiasm and dedication of the users).*

Managing **quality assurance** was critical to avoid data duplication or missing entries. This process was not regulated by specific Standard Operating Procedures but was addressed during training and monitored monthly. In addition, the DIY health office provided negative incentives to health facilities that were not providing complete records and provided regular feedback from monitoring and evaluation exercises.

We found that 90%, 76%, and 100% of survey respondents in PHC, UPS, and DHO, respectively, reported their work had been monitored regarding SIMUNDU. More than half of the respondents in Puskesmas and UPS facilities were observed at least once in 2019. At the PHC level, more than 50% reported that staff from the district/city level conducted the monitoring, and >40% reported that the DIY health office staff conducted monitoring. Furthermore, almost 40% of respondents from UPS facilities were monitored by Puskesmas. Nearly 100% of survey respondents stated they received feedback from the monitoring, mainly from the District/City and DIY health offices. Forty percent of respondents from UPS facilities reported receiving feedback from Puskesmas. Immunization coordinators from the District/City health offices reported that the DIY health office provided them with feedback.

*In a [evaluation] meeting, DIY health office or district health office showed the progress of our data entry – correct or not, proper or not*

Another resource that influences the successful implementation of SIMUNDU is the size of the DIY province. This province is quite a small geographic area. Because it consists of five districts and one city, this province is relatively easy to monitor across all phases, from planning through monitoring and evaluation.

### **System performance**

While SIMUNDU predominantly contains individual-level immunization records, it also serves as a source for aggregation and can synergize with other information systems. Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports as per Ministry of Health requirements. These reports are sent to the upper levels directly if SIMUNDU is operated online or submitted via email if SIMUNDU is operated offline. This functionality had an essential role in ensuring the acceptability and adoption of the system.

Informants noted how transitioning from paper-based tools to an electronic system made data entry easier and reduced errors. It also facilitated the implementation of protocols for data storage and security. It facilitated follow-up and defaulter tracking. Finally, integration with the DHIS2 meant reduced workload for the staff.

*We can do faster tracking of children who may have immunizations in different locations. For example, when the first dose of a vaccine is given in Bantul, then the second immunization in Yogyakarta can be connected and detected with the SIMUNDU system.*

*Using SIMUNDU makes it easier to detect what data and immunizations are missing since we enter data from the children's birth through the end of the immunization schedule. So, we will know where they missed any vaccine.*

*The benefit of using SIMUNDU is first: we know the situation of immunizations more accurately....so, we say that our predictions are real for planning for the future... So, our budget, staff, facilities can be more effective and efficient in providing services.*

*Colleagues from the mother and child health (KIA) program enter via the KIA "Sembada." So, this data will appear automatically in SIMUNDU because the two-system are connected.*

SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the responsible staff to maintain data entry irrespective of connectivity. More than 80% of survey respondents indicated they use the online version of SIMUNDU, and less than 20% of them operate the system offline.

## People behavior

The survey showed that staff commitment was critical for the successful implementation of SIMUNDU, as indicated by their willingness to work overtime and bring home the data to enter into the system.

*I take it [the data] home too, for example, after immunization sessions– in my clinic, immunization runs four times per month, every week. So, when the session is finished, we can take it home, [and] do the entry at home while relaxing*

Some determinants that facilitated the implementation of SIMUNDU were the societal culture of helping others and responsibility and commitment to the team. An enabling environment helped people view SIMUNDU as a shared responsibility and a collective endeavor. Informants also noted the high motivation of dedicated staff.

*That's all; we cannot judge by money [people kindness, culture, and behavior]; it's essential to explain how good people are in Yogyakarta. I was in another place before, and I could not find people's kindness like in Yogyakarta - different characters.*

*The second thing is that we need human resources who are concerned and love with data; otherwise, even though we have a good system, it will amount to nothing without good human resources. But when people are concerned about data, good implementation will come more easily.*

Other characteristics, such as the culture of helping others and responsibility and commitment to tasks, revealed from the interviews, were critical determinants in the successful implementation of SIMUNDU.

## Resource: human, financial, and material resources

Infrastructure and equipment emerged as critical factors to introducing and sustaining SIMUNDU implementation. Some desktops were specifically allocated to the immunization program, and some had to be shared with other programs' staff. Other data entry officers reported using laptops or personal smartphones. The survey found that in Puskesmas, almost 40% of data entry clerks used their private laptops to enter data into SIMUNDU. In UPS facilities, nearly 41% reported using office-supplied PCs, and in the DHO, more than half of the respondents stated they used an office-supplied laptop. The majority of respondents reported their current device was sufficient to perform their work on SIMUNDU. Regarding internet access, more than 60% of PHC and UPS staff reported using the office internet connection to enter data into SIMUNDU. However, 75% of DHO respondents reported no internet source found during SIMUNDU monitoring.

Management of financial resources was also crucial. Key informant interviews revealed no special allocation of funds to SIMUNDU in the initial stages. Resources were leveraged by sharing activities such as monitoring visits or transportation with other

programs, thus allowing cost efficiencies. Integration with other programs proved critical to ensuring sustainability.

*SIMUNDU's budget comes from the state budget called as Anggaran Pendapatan dan Belanja Negara (APBN). Every year the APBN allocates funding envelop for immunization to DIY and other provinces, where the budget is apportioned across the program [not explicitly written for SIMUNDU]*

Human resources are critical to the operation of SIMUNDU. According to respondents, SIMUNDU data entry clerks must have patience, work carefully and not rush, be interested in data, be responsible, and have basic computer skills such as Ms word and Ms excel. Our survey showed that most data entry clerks in PHC and UPS facilities had a diploma level of education (>80%), while at the managerial level (DHO), 75% of respondents had a bachelor's degree, suggesting that they have good computer literacy. Our survey shows that less than 20% and 9% of respondents in PHC and UPS, respectively, had low computer literacy.

Various data entry clerks looked for strategies to resolve their obstacles to entering data to SIMUNDU. Among them, they increased their computer skills by taking private computer courses. In addition, some of them learned from other colleagues at their offices. To deal with the accumulation of data needing to be entered in SIMUNDU, staff sometimes took data home for entry purposes because there is insufficient time during work hours since they have several other duties. If data entry clerks faced SIMUNDU trouble, informants said they asked for help from those who might have more information, for example, the district person in charge.

*If we found obstacles, we asked people in charge in PHC – asking for a solution or sharing by WhatsApp – or sometimes I asked the IT person in the DIY health office.*

### **Potential threats**

The potential constraints on implementing SIMUNDU are individual capacity, technical or IT issues, and high workload. To date, SIMUNDU can be said to have had successful implementation. But it does not mean there were no obstacles faced. However, the important thing is how these obstacles were dealt with.

Computer literacy of staff was identified as one of the main issues. Internet connectivity was another obstacle to implementation, as not a good network supported all health facilities equally. As shown by the survey, only about 60% of Puskesmas and UPS staff used office internet, while others had to rely on their home internet.

Another issue that emerged was related to incomplete and inconsistent records; for example, the child's date of birth or name spelling not matching across different entries, making it difficult to have a unique and consistent record for each child. During the development stage, the system interface had to be incrementally finetuned, and some system failures made it challenging to enter the data. Even though these were temporary

and were promptly resolved, these system failures were an issue for staff, who were already juggling a very tight schedule in the office, as they caused some delay. As shown by the survey, for more than 97% of respondents, entering data in SIMUNDU was not their only responsibility or function – they also had other tasks.

### **Opportunities**

Informants said that SIMUNDU is a good system for immunization data. SIMUNDU has become necessary for program managers and policymakers because it facilitates monitoring coverage and informing planning and programming. Currently, SIMUNDU is stable, thus is easier to manage than when it was in the development phase. This means that the system is not as reliant on the core workforce that has been heavily involved since inception and will possibly accommodate changes in the workforce. The hopes expressed by data entry clerks are that SIMUNDU would be easier to operate, and system errors did not occur. In addition, informants revealed the need for refresher SIMUNDU training so that their understanding of SIMUNDU would not be lost.

*In my opinion, SIMUNDU is the best program in DIY which is a collaboration between program managers and IT. It will continue to be implemented because it is a necessity.*

*It has been stably used for more than five years, meaning this is needed.*

*If I have the tool, in this case, SIMUNDU, when it is stable, whoever will hold it, I am sure that anyone can operate it. It means that it doesn't matter if we have people shifting (jobs).*

*In the future, if SIMUNDU is still used, other reports are not necessary. Now we have two different reports: SIMUNDU and stock card of vaccine – each stand-alone and need a separate report.*

Based on the informants' statements, SIMUNDU is likely to be developed on a broader scale. The DIY health office is open to any party learning and implementing SIMUNDU in their region. However, informants advised that SIMUNDU must have a strong commitment from the data entry staff and management sides. The leadership in DIY has shown willingness to assign staff to other provinces who have expressed interest in SIMUNDU for orientation to the system,

### **Discussion**

Robust health information systems (HIS) are essential components of strong health systems (12). Having a timely Immunization Information System (IIS) that collects individual information and vaccine recipient's history to improve immunization services is essential to personalize vaccination information, communicate targeted information as a decision support system, and record vaccination hesitancy (13). Here, we provide evidence of how an immunization information system has been implemented in practice.

Sistem Informasi Imunisasi Terpadu (SIMUNDU) or Integrated Immunization Information System in the DIY province enabled the creation of individual immunization records for children. SIMUNDU allows users and managers to collect, store and analyze data on utilization of immunization services, including following up individual children and creating cohort data. Currently, DIY is the only province in Indonesia – out thirty-four - that uses an IIS. This work has shed light on the strengths and underlying barriers of implementing an IIS in this context. The objective was to draw lessons that inform sustainable scale-up in other regions and possibly at the national level.

This study studied the potential factors that facilitate or pose a barrier to SIMUNDU implementation. We identified management, system performance, people's behavior, and resources as determinants for SIMUNDU's strength that influenced implementation outcomes: the acceptability, implementation cost, and adoption of this innovation (14). Individual capacity, system trouble, and high workload were barriers to implementation.

Despite several obstacles encountered during the implementation of SIMUNDU, we see that this innovation is well accepted by the stakeholders involved. The first stakeholder group is data entry clerks, who accept several aspects of SIMUNDU: data entry content, ease of input to the system (not complex), and comfort using SIMUNDU compared to the previous system. The second stakeholder group is managers; they accepted this system well and felt there was a benefit in this innovation, namely the output in cohort data to help them monitor and improve immunization coverages.

Having an excellent managerial process – meaning proper planning, monitoring, and evaluation - is one reason SIMUNDU has survived and been viable for the last 5 years. Managers use their power to encourage the beliefs and actions of other people (15). This requires a dedicated and robust process for the whole of the management process cycle. SIMUNDU was born from the need for credible data at the DIY health office to assist in carrying out its duties at the managerial and operator levels. At the managerial level, the disease prevention and control department and the IT department collaborated to create a system readily accepted by users. Immunization and IT programmers played a central role from the beginning of the design throughout the implementation process with appropriate coordination and communication. Their ability to do so was facilitated by the full support of their respective superiors.

SIMUNDU is cost-effective in several ways. During the introductory period of SIMUNDU implementation, immunization programmers, IT officers, and other staff assisted in disseminating SIMUNDU to all existing districts. This was done side by side with other programs, making it cost and time-efficient for managers and staff. As mentioned, organizing activities is certainly not easy, but it can be carried out well, even sustainably, by sharing resources. Additionally, SIMUNDU maintenance does not require high costs because the DIY Health Office developed and maintained the system. Thus, the IT department can develop improvement processes and tailor them to user needs

without additional cost. In addition, the location of affordable services (health facilities) is also part of cost-effectiveness.

A good program without good leadership could fail in its implementation, and even if it was initially successful, it might not be sustainable (16). In the context of SIMUNDU, support from leadership and the involvement of good people at managerial levels may have facilitated the program's adoption. The level of SIMUNDU uptake was good because all health facilities providing immunization services have successfully used this system, and it has been running well. The adoption of SIMUNDU was facilitated by the strong networks of the main person in charge of SIMUNDU. Communication, care, and attention to staff concerns positively affected staff performance. They feel well supported and are treated kindly – this means that they carry out their work joyfully. Several informants brought up this theme who stated that the person who played an essential role in SIMUNDU was the immunization program manager.

The monitoring and evaluation mechanisms of SIMUNDU were also important. Preferred monitoring and evaluation activities include monthly reports and direct discussion with staff during site monitoring visits. The immunization program manager suggested this approach to maintain data quality and system sustainability. These chosen mechanisms allow program managers to know the real conditions in the field and the obstacles faced to inform decisions about the follow-up actions that must be taken. This supports the ongoing development and learning of SIMUNDU as a tool for data collection, analysis, and visualization tool, provides benefits for managers to carry out monitoring and evaluation. The same point was stated by previous research in India about the innovation of health management information systems for primary health care agrees that this can provide essential benefits (17).

Human resources are determinants of the success of health information system implementation (18). The people's behavior affects how the system works, develops, and survives (19),(20). In the case of SIMUNDU, implementation was facilitated by the caring character, networks, and meticulous attitude towards data of both the program manager and IT team. From the staff's point of view, the local culture of helping each other and doing their job correctly and responsibly is translated into staff that carries out their duties with enthusiasm and high commitment. Although facilities, funding and volume of human resources are limited, the people involved are highly motivated and supportive. Socio-cultural values, attitudes and beliefs held by staff have contributed to the successful implementation of SIMUNDU.

Despite the clear strengths of SIMUNDU, there are potential obstacles to its sustainability in the future. These obstacles can be divided into human variables and technical variables. From the human variables side, unequal individual capacities at the operator level can cause obstructions during data entry in the field. Another potential future obstacle is the staff's high workload because generally, they have to do other tasks besides SIMUNDU data entry. From the interview results, the data entry clerks have tried finding strategies

to overcome this additional workload burden, such as doing data entry at home and overtime at the office. But from the health system perspective, if this is not anticipated and a strategy to address it is implemented, it may become unsustainable to expect staff to continue to do overtime. This will potentially interfere with the data's quality and overall harm SIMUNDU sustainability.

From this study, we know that SIMUNDU is a promising immunization reporting system. Although obstacles exist, the benefits and strengths outweigh them. In-depth interviews revealed the potential for scale-up of this program to other areas. Our findings show that to maintain the continuity of SIMUNDU, some actions should be taken, such as providing regular training to the data entry clerks, as the system is constantly being updated. In addition, there is a need to layering the management structure to anticipate staff rotation or retiring. Lastly, appropriate motivation, incentive, and support for data entry clerks need to be ensured.

## **Conclusions**

SIMUNDU was developed in 2014 by the DIY health office. It was introduced in 2015 across the province and has been successfully implemented. However, there was no systematic evaluation of the data collected to date's accuracy, completeness, and timeliness. The benefit of SIMUNDU can be seen from the outputs generated, such as the cohort data that allows the immunization staff to track and observe each child's immunization progress, which may contribute to the increase in immunization coverage in this region.

Despite resource constraints, it was still possible to run SIMUNDU. Initially, there was no special allocation funding for SIMUNDU, so the program ran side-by-side with other health programs in the DIY health office. This mechanism allowed cost-efficiency. There were three prominent persons in charge of developing SIMUNDU: 1) IT person responsible for system creation and maintenance, 2) the immunization program manager responsible for the strategic development of SIMUNDU, and 3) data entry clerks who are accountable for careful data entry into SIMUNDU. When seen from a facility perspective, SIMUNDU does not require expensive equipment – all that is needed is a computer or phone and internet access. The fair managerial process influenced the success of SIMUNDU to date from the DIY province. This required appropriate planning, organizing, leading, and controlling.

Three recommendations stemmed from this study, addressed to the DIY health office, the national government, and researchers. First, to guarantee continuity and sustainability and reduce the system's dependency on the particular person or party, SIMUNDU management and maintenance should be related to others with the competency and interest in a good reporting system. Furthermore, existing human resources should be strengthened in preparation for scaling up SIMUNDU in other regions or at a national level; this is necessary to avoid vacant positions when DIY province staff are seconded



to requests for mentoring from other areas. Second, the bottom-up approach to developing and implementing SIMUNDU has shown that the system is feasible and viable. The approach to scaling up SIMUNDU should be stepwise, considering each region's specific characteristics and problems. Therefore, it is vital to develop a readiness map and a timeline for the roll-out of SIMUNDU in a particular region. Third, further research is needed on the impact of SIMUNDU on immunization coverage, for instance, through a before and after comparative study with a 2–3-year time window in a low-performing region.

## **Declarations**

### Ethics approval and consent to participate

This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan, Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began, consent to participate was obtained from research subjects (both survey and key informant interviews).

### Adherence to national and international regulations

Not applicable

### Consent for publication

Before data collection begins, an approval that data is taken for publication purposes is obtained from research subjects (both surveys and key informant interviews).

### Availability of data and materials

The datasets generated and/or analyzed for this study can be requested to the corresponding author.

### Competing interests

The authors declare that they have no competing interests

### Funding

This study was supported by the Alliance for Health Policy and Systems Research (Alliance). The Alliance is able to conduct its work thanks to the commitment and support from a variety of funders. These include Gavi, the Vaccine Alliance contributing designated funding and support for this project, along with the Alliance's long-term core contributors from national governments and international institutions. For the full list of Alliance donors, please visit: <https://ahpsr.who.int/about-us/funders>.

### Authors' contributions

SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the data. SS and RR conducted data analysis. SS developed the paper with inputs and comments from MF on each draft. All authors agree with the manuscript's results and conclusions.

### Acknowledgments

We are grateful to Mr. Suyani Hartono and Mrs. Ani Roswiani for assisting with the data collection. We also thank all immunization coordinators, managers, and data entry staff who participated in the survey and interviews. Finally, we thank Geetanjali Lamba for the editorial support.

### Authors' information:

The authors alone are responsible for the views expressed in this article. They do not necessarily represent the views, decisions, or policies of the institutions affiliated with them.

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# Revisi 1

**Date:** 15 Feb 2022  
**To:** "Sulistyawati Sulistyawati" sulistyawati.suyanto@ikm.uad.ac.id  
**From:** "BMC Health Services Research Editorial Office" Eloisa.HadeNolasco@springernature.com  
**Subject:** Your submission to BMC Health Services Research - BHSR-D-21-00992R1

BHSR-D-21-00992R1

Introducing and implementing an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up  
Sulistyawati Sulistyawati; Trisno Agung Wibowo; Rokhmayanti Rokhmayanti; Andri Setyo Dwi Nugroho; Tri Wahyuni Sukes; Siti Kurnia Widi Hastuti; Surahma Asti Mulasari; Marta Feletto  
BMC Health Services Research

Dear Dr Sulistyawati,

Your manuscript 'Introducing and implementing an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up' (BHSR-D-21-00992R1) has been assessed by our reviewers. They have raised a number of points which we believe would improve the manuscript and may allow a revised version to be published in BMC Health Services Research.

Their reports, together with any other comments, are below. Please also take a moment to check our website at <https://www.editorialmanager.com/bhsr/> for any additional comments that were saved as attachments. If you are able to fully address these points, we would encourage you to submit a revised manuscript to BMC Health Services Research.

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Please also ensure that your revised manuscript conforms to the journal style, which can be found at the Submission Guidelines on the journal homepage.

A decision will be made once we have received your revised manuscript, which we expect by 17 Mar 2022.

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Technical Comments:

Editor Comments:

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reviewers are not named (unless they opt in to include their name).

#### Reviewer reports:

##### Reviewer 1: Overall Comments:

This article makes an important contribution by highlighting the transition and use of digital data systems in tracking childhood immunization in Indonesia. The authors provided a strong description of the system's rollout, enabling factors, challenges, and opportunities. The article could be strengthened by providing additional information from the survey to support the quotes presented. Also, the article would benefit from having short (1 paragraph) limitations and recommendations sections. (The last paragraph of the conclusion is well done and could be expanded for a recommendation section)

##### Abstract:

Line 31 "To increase the coverage of immunization, valid and real-time data is needed.

Accordingly, having a good report system is essential that rolled as defaulter tracking to prevent the children's immunization failure" Please reword this sentence, as it is difficult to understand the meaning of the word "rolled".

Line 40: Reword to : An explanatory sequential mixed-method design was used in this study which collected quantitative data from 142 participants and quantitative data from 9 participants.

##### Background:

Pg 2 Line 22: Add "the" before provincial

Pg 2 Line 44: Changes to "with 97.7% of children completing basic immunization coverage in 2019"

##### Methods:

Overall: Note the procedures that were used for transcription and translation of qualitative data (if not conducted in and analyzed in the same language). For quantitative data collection, was the survey

\* Pg 5 Line 12: The text states "All participants were invited to the DIY health office to fill out the survey on their laptops. Having all participants in a room allowed researchers to monitor potential gaps in responses in real-time and follow-up with individual participants on-site to fill any gaps." It is important to note the potential for bias that this method introduces into the data collection - monitoring the answering of questions and asking participants to fill in gaps left. This can be noted in the discussion section or in limitations.

\* Pg 5 line 25: Was the interview guide semi-structured? Did the researchers ask probing questions (not on the interview guide) depending on the answers?

\* Add a few sentences/paragraph on limitations of the study

##### Results:

Overall: The data and information presented appears to rely heavily on the 9 qualitative interviews. The section refers very little to the answers from the survey. If possible, add more of the survey data into the results section, and attribute the information to the survey. Additionally, ensure that data is presented fully instead of rounding off the point estimates and writing "more than or less than 50%. Instead, state the true % - example 52.3%.

Change the highlights/red text so it is consistent for each sub section of the results.

\* Pg 9 line 52 (and elsewhere where survey data is presented)" Present the quantitative results fully - instead of saying "More than 80% of survey respondents", give the actual statistic (for example 81.2%).

\* Pg 11 line 42-44: reword: A number of obstacles were encountered and addressed during implementation.

\* Pg 11 line 53: replace ";" with "." After the first sentence. Then change sentence two to read: "An example of this inconsistency of child's date of birth or name spelling among different entries, making it difficult to consistently record immunization information.

##### Discussion:

Overall, gives a good overview of the results and opportunities, however, it can be difficult to follow at points.

\* Pg 15 line 45: Reword: "The fair managerial process influenced the success of SIMUNDU to date from the DIY province." What does "the fair managerial process mean? Please reword or explain this better

\* Pg 16 line 1-2: "Second, the bottom-up approach to developing and implementing SIMUNDU has shown that the system is feasible and viable." Can this be reworded? It is difficult to understand as written.

\* Pg 16 line 8-9: How would the information from a study like this be useful? Please state it in the paper. Third, further research is needed on the impact of SIMUNDU on immunization coverage, for instance, through a before and after comparative study with a 2-3-year time window in a low-performing region.

##### Reviewer 2: General Comments:

Immunization information systems are an important infrastructure. Authors describe the implementation and evaluation of a system in Indonesia for children. However, methods are very unclear. Perhaps the manuscript could be restructured to describe the implementation first, because it is very unclear if the information was obtained from the methods or not? Seems some of the implementation data was obtained from documents review. Then use the survey and key informant information as an evaluation of the system?

Title: Recommend changing to "Implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up

##### Abstract:

Background - change safe to save

Authors use abbreviations in the abstract that should be defined such as DIY, SIMUNDU

##### Background:

Page 2, paragraph 2. Please provide a definition of the DHIS2 since it is used later

Page 2, paragraph 3. Authors describe primary health centres as puskesmas or PHC in other areas of the manuscript. Please be consistent in terminology and if going to use PHC please define it here.

Page 3, paragraph 2. This paragraph uses both puskesmas and PHCs

Page 3, paragraph 3. Please use English diphtheria

Page 3, paragraph 3, - please explain how the school information is being loaded into SIMUNDU in aggregate Methods:

Page 4, paragraph 2. Last sentence. Please explain the difference between staff responsible and immunization coordinator are they the same. The table uses immunization coordinator. Also here use puskesmas versus PHC. Are you also using private clinics and hospitals as in the table.

Table 1. Seems a small sample for the clinic and hospital versus PHC and UPS - is there a reason?

Page 5, paragraph 1. Again are the immunization coordinators the staff responsible and would all facilities have an immunization coordinator.

Page 5, paragraph 1, last sentence. Authors state all staff involved with data entry and management. Authors need to be more clear who completed surveys - seems the samples are not consistent across all practices does that mean that private clinics for example had much fewer staff involved with SIMUNDU than UPS for example?

Page 5, paragraph 2. Please describe the survey in more depth - how was it developed, how many questions, what types of questions? Any demographic data of the respondents? Usually, a key informant interview would be done first to then inform the survey. So methods are slightly different approach. How was the survey data used to drive the key informant interviews.

Results:

Authors do not present any of the survey data from 146 respondents? Only key themes and not sure where the key themes are from - the survey or the key informant interviews. Were the themes already developed when the survey was developed?

Author reporting of the results seem to mix the introduction and the use of SIMUNDU. Perhaps authors could describe the implementation as part of the background and introduction and then use the survey data and key informants as the results of the system. But it is not clear because authors do not provide enough information to evaluate the survey and the key informant interviews.

Page 6, paragraph 2. This provides a lot of information about why the system was implemented. Did this come from the survey or the desk review?

Throughout the authors mentioned the survey showed? But how? What were the questions how many respondents, etc.

Page 9, paragraph 3. The authors provide some survey data - this is helpful. Need to see this in all sections to really understand.

Page 11. Also has some survey data presented by the authors but it is difficult to interpret with not all sections containing survey data.

Discussion

Page 13, paragraph 1. Authors provide a nice summary here, but are these questions that were included in the survey.

Conclusion

Authors should include recommendations and be identified as lessons for scale-up in the discussion instead of conclusion. Conclusion contains background information, that should be deleted. The conclusion should offer a succinct concl

If you have been asked to edit the English language of the main text to improve readability and clarity, and would like the assistance of paid editing services to do this, we can recommend our affiliates, Nature Research Editing Service:

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Declarations

- Ethics approval and consent to participate
- Consent to publish

- Availability of data and materials
- Competing interests
- Funding
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## Reviewer 1

Dear Reviewer 1, thank you very much for your advance comments and inputs to this manuscript; we appreciate it. Our response to all your comments and input is presented in the table below.

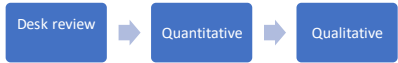
<p>Reviewer 1: Overall Comments: This article makes an important contribution by highlighting the transition and use of digital data systems in tracking childhood immunization in Indonesia. The authors provided a strong description of the system's rollout, enabling factors, challenges, and opportunities.</p> <p>The article could be strengthened by providing additional information from the survey to support the quotes presented. Also, the article would benefit from having short (1 paragraph) limitations and recommendations sections. (The last paragraph of the conclusion is well done and could be expanded for a recommendation section)</p>	<p>Study limitation has been added on Page 16. The recommendation has been completed together with the conclusion.</p>
<p>Abstract: Line 31 "To increase the coverage of immunization, valid and real-time data is needed. Accordingly, having a good report system is essential that rolled as defaulter tracking to prevent the children's immunization failure"</p> <p>Please reword this sentence, as it is difficult to understand the meaning of the word "rolled".</p>	<p>We change rolled to function. The change can be found in Abstract – Page 1</p> <p><i>"To increase the coverage of immunization, valid and real-time data is needed. Accordingly, having a good report system is essential that functions as defaulter tracking to prevent the children's immunization failure"</i></p>
<p>Line 40: Reword to: An explanatory sequential mixed-method design was used in this study which collected quantitative data from 142 participants and quantitative data from 9 participants.</p>	<p>Thank you for your input; the correction can be found in the methods section – Page 1</p>
<p>Background: Pg 2 Line 22: Add "the" before provincial</p>	<p>Thank you for your correction. The change can be found on page 2</p>
<p>Pg 2 Line 44: Changes to "with 97.7% of children completing basic immunization coverage in 2019"</p>	<p>Thank you for your correction. The change can be found on page 2</p>
<p>Methods: Overall: Note the procedures that were used for transcription and translation of qualitative data (if not conducted in and analyzed in the same language). For quantitative data collection, was the survey</p>	<p>The information about the translation process has been added in the method section – Page 5.</p>
<p>* Pg 5 Line 12: The text states "All participants were invited to the DIY health office * to fill out the survey on their laptops. Having all participants in a room allowed * researchers to monitor potential gaps in responses in real-time and follow-up with *individual participants on-site to fill any gaps."</p>	<p>Study limitation has been added on Page 16</p>

<p>It is important to note the potential for bias that this method introduces into the data collection - monitoring the answering of questions and asking participants to fill in gaps left.</p> <p>This can be noted in the discussion section or in limitations.</p>	
<p>* Pg 5 line 25: Was the interview guide semi-structured? Did the researchers ask probing questions (not on the interview guide) depending on the answers?</p>	<p>Yes, we used a semi-structured interview that allowed the interviewer to probe questions. This information has been added to Page 5.</p>
<p>* Add a few sentences/paragraphs on limitations of the study</p>	<p>Study limitation has been added on Page 16</p>
<p>Results: Overall: The data and information presented appears to rely heavily on the 9 qualitative interviews. The section refers very little the answers from the survey.</p>	<p>We are presenting the Quantitative result in the Table that we put on the Supplementary file due to the length of pages. Then Qualitative study presents in Figure 2.</p> <p>In the narrative, we put together the result among the two studies with a sequence</p> <ul style="list-style-type: none"> <li>- theme from qualitative</li> <li>- put quotations</li> <li>- survey result (percentage)</li> </ul>
<p>If possible, add more of the survey data into the results section, and attribute the information to the survey.</p>	<p>Information about respondent and informant have been added on Page 6-7. For the survey result, we put it in the supplement. While the narration of the percentage presented together in each theme emerged</p>
<p>Additionally, ensure that data is presented fully instead of rounding off the point estimates and writing "more than or less than 50%. Instead, state the true % - example 52.3%.</p>	<p>All percentages have been changed to the true %</p>
<p>Change the highlights/red text so it is consistent for each sub section of the results.</p>	<p>All read highlight has been changed to make it consistent all sections</p>
<p>* Pg 9 line 52 (and elsewhere where survey data is presented)" Present the quantitative results fully - instead of saying "More than 80% of survey respondents", give the actual statistic (for example 81.2%).</p>	<p>All percentages have been changed to the true %</p>
<p>* Pg 11 line 42-44: reword: A number of obstacles were encountered and addressed during implementation.</p>	<p>The suggestion has been made on page 11</p>
<p>* Pg 11 line 53: replace ";" with "." After the first sentence. Then change sentence two to read: "An example of this inconsistency of child's date of birth or name spelling among different entries, making it difficult to consistently record immunization information.</p>	<p>The second sentence has been changed according to the reviewer's suggestion (Page 11)</p>
<p>Discussion: Overall, gives a good overview of the results and opportunities, however, it can be difficult to follow at points. * Pg 15 lin 45: Reword: "The fair managerial process influenced the success of SIMUNDU to date from the DIY province." What does "the</p>	<p>The fair managerial process means that the manager of SIMUNDU implements planning, monitoring and evaluation, and feedback correctly. Reword has been made on Page 17.</p>

fair managerial process mean? Please reword or explain this better	
* Pg 16 line 1-2: "Second, the bottom-up approach to developing and implementing SIMUNDU has shown that the system is feasible and viable." Can this be reworded?  It is difficult to understand as written.	This sentence is reworded to "Second, the bottom-up approach during SIMUNDU development and implementation positively impacts this system and makes it is feasible and viable to use"  Page 17
* Pg 16 line 8-9: How would the information from a study like this be useful? Please state it the paper. Third, further research is needed on the impact of SIMUNDU on immunization coverage, for instance, through a before and after comparative study with a 2-3-year time window in a low-performing region.	<b>Dear Marta, I don't get this point. Please help!</b>

## Reviewer 2

Dear Reviewer 2, thank you very much for your advance comments and inputs to this manuscript; we appreciate it. Our response to all your comments and input is presented in the table below.

<p>General Comments:</p> <p>Immunization information systems are an important infrastructure. Authors describe the implementation and evaluation of a system in Indonesia for children. However, methods are very unclear. Perhaps the manuscript could be restructured to describe the implementation first, because it is very unclear if the information was obtained from the methods or not?</p> <p>Seems some of the implementation data was obtained from documents review. Then use the survey and key informant information as an evaluation of the system?</p>	 <p>Desk review aimed at growing evidence of the history of SIMUNDU development from the beginning until recent implementation based on the available document. This desk review was conducted in collaboration with the DIY Health Office as the document provider. In general, we presented the result of the desk review in Figure 1, which is the history of SIMUNDU development and introduction. While quantitative was used to capture the implementation process, it was digging information gathered from the quantitative study in the qualitative.</p>
Title: Recommend changing to "Implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up	The title has been modified on page 1
Abstract: Background - change safe to save	Safe already changed to save – Page 1
Authors use abbreviations in the abstract that should be defined such as DIY, SIMUNDU	DIY dan SIMUNDU have been spelling out
Background: Page 2, paragraph 2. Please provide a definition of the DHIS2 since it is used later	DHIS2 has been spelled out on Page 2 DHIS2 means The District Health Information System 2
Page 2, paragraph 3. Authors describe primary health centers as puskesmas or PHC in other areas of the manuscript.	Puskesmas has been changed to PHC across the pages
Please be consistent in terminology and if going to use PHC please define it here.	Puskesmas has been changed to PHC across the pages
Page 3, paragraph 2. This paragraph uses both puskesmas and PHCs	Puskesmas has been changed to PHC across the pages
Page 3, paragraph 3. Please use English diphtheria	Difteri has been changed to Diphtheria

<p>Page 3, paragraph 3, - please explain how the school information is being loaded into SIMUNDU in aggregate</p>	<p>The information has been added on page 3. The aggregate is related to the number of students in a particular school.</p>
<p>Methods: Page 4, paragraph 2. Last sentence. Please explain the difference between staff responsible and immunization coordinator are they the same.</p> <p>The table uses immunization coordinator. Also here use puskesmas versus PHC. Are you also using private clinics and hospitals as in the table.</p>	<p>Let me explain as follow: Staff responsible for interfering with the data in PHC and UPS means staff who face the raw data that has to be input to SIMUNDU. While staff in district/city is a manager in that area who supervises the staff in PHC and UPS.</p> <p>The sentences have already been modified to make them clearer.</p> <p>Yes, UPS consists of some health facilities such as private clinics and hospitals.</p>
<p>Table 1. Seems a small sample for the clinic and hospital versus PHC and UPS - is there a reason?</p>	<p>Based on the information that has been collected before we executed the survey and considering that the characteristics of each group are almost the same, together with the provincial health office, we agreed to take 2 units per district randomly.</p>
<p>Page 5, paragraph 1. Again are the immunization coordinators the staff responsible and would all facilities have an immunization coordinator.</p>	<p>The modification has been made on Page 4. Immunization coordinator only in district/city, while data entry clerk in all health facility invited</p>
<p>Page 5, paragraph 1, last sentence. Authors state all staff involved with data entry and management. Authors need to be clearer who completed surveys - seems the samples are not consistent across all practices does that mean that private clinics for example had much fewer staff involved with SIMUNDU than UPS for example?</p>	<p>Immunization coordinator only in district/city, while data entry clerk in all health facility invited.</p> <p>Private clinics are part of UPS. So overall, we divided the sample into 3 groups: PHC, UPS (hospital, clinic, midwives practice)</p>
<p>Page 5, paragraph 2. Please describe the survey in more depth - how was it developed, how many questions, what types of questions? Any demographic data of the respondents?</p> <p>Usually, a key informant's interview would be done first to then inform the survey. So, methods are slightly different approach. How was the survey data used to drive the key informant interviews.</p>	<p>Detailed information about the survey has been added on Page 5, paragraph 1. Then how was information from the quantitative study used in qualitative study was completed on Page 5, Paragraph 2.</p> <p>Since we used to explain why a particular case like this or like that, we should know first the existing situation in the field, it is why in this research we used explanatory sequential mixed-method design, where quantitative data were completed first then the finding was used to inform the qualitative phase – referred to <i>Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs - Principles and practices. Health Serv Res. 2013;48(6 PART2):2134–56.</i></p> <p>I have added more information about the approach in the methods section, Page 4, paragraph 1.</p>
<p>Results: Authors do not present any of the survey data from 146 respondents? Only key themes and not sure where the key themes are from - the</p>	<p>Dear reviewer, We have added table 2 and table 3 for the informant's characteristics on Page 6-7.</p>

<p>survey or the key informant interviews. Were the themes already developed when the survey was developed?</p>	<p>Regarding the survey result, we will add it as a supplementary file because it has many pages. This supplementary will replace the questionnaire that we attached before.</p> <p>The theme had developed during the qualitative study analysis that we apply deductive analysis related to the managerial process (input – process and output)</p>
<p>Author reporting of the results seem to mix the introduction and the use of SIMUNDU.</p> <p>Perhaps authors could describe the implementation as part of the background and introduction and then use the survey data and key informants as the results of the system. But it is not clear because authors do not provide enough information to evaluate the survey and the key informant interviews.</p>	<p>Dear reviewer, Our research aim was to draw lessons learned about SIMUNDU to a scale-up possibility since it is the first system developed in Indonesia. We thought that we should explain the system from development, introduction, implementation and how it was monitored.</p>
<p>Page 6, paragraph 2. This provides a lot of information about why the system was implemented. Did this come from the survey or the desk review?</p>	<p>We present surveys and key informant interviews (KII). In the result section, we put together information from KII and survey to compare what we found in the 2 approaches.</p>
<p>Throughout the authors mentioned the survey showed? But how? What were the questions, how many respondents, etc.</p>	<p>Thank you for your question. The information about respondent and informant characteristics has been added on Page 6-7. The survey result will add as supplementary due to the page length.</p>
<p>Page 9, paragraph 3. The authors provide some survey data - this is helpful. Need to see this in all sections to understand.</p>	<p>Yes, we add the survey result as Sup. 1</p>
<p>Page 11. Also has some survey data presented by the authors but it is difficult to interpret with not all sections containing survey data.</p>	<p>We add the survey result as Sup. 1</p>
<p>Discussion Page 13, paragraph 1. Authors provide a nice summary here, but are these questions that were included in the survey.</p>	<p>Page 13, Par. 1: Sistem Informasi Imunisasi Terpadu (SIMUNDU) or Integrated Immunization Information System in the DIY province enabled the creation of individual immunization records for children. SIMUNDU allows users and managers to collect, store and analyze data on utilization of immunization services, including following up individual children and creating cohort data. Currently, DIY is the only province in Indonesia – out thirty-four - that uses an IIS. This work has shed light on the strengths and underlying barriers of implementing an IIS in this context. The objective was to draw lessons that inform sustainable scale-up in other regions and possibly at the national level.</p> <p>In this part, we declared our background and again stated our research aim to remind the reader.</p>
<p>Conclusion Authors should include recommendations and be identified as lessons for scale-up in the discussion instead of conclusion.</p> <p>Conclusion contains background information, that should be deleted. The conclusion should offer a succinct concl</p>	<p>Dear reviewer, The first paragraph containing the background has been deleted.</p> <p>We have put 3 recommendations in the second paragraph of the conclusion.</p>

# Implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up

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## Abstract

**Background:** Immunization is undeniable as a critical aspect of saving children from infections. To increase the coverage of immunization, valid and real-time data is needed. Accordingly, having a good report system is essential that functions as defaulter tracking to prevent the children's immunization failure. Daerah Istimewa Yogyakarta (DIY) health office developed an individual electronic immunization registry and successfully implemented it for more than five years. It is the only individual-based record system in Indonesia that has survived for such a long time. To date, there is no systematic assessment of this system. Therefore, this research aimed to examine Sistem Informasi Imunisasi Terpadu (SIMUNDU) introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.

**Methods:** This study used an explanatory sequential mixed-method design, which collected quantitative data from 142 participants and qualitative data from 9 participants. Entry data clerk in all level of health facility was systematically selected to participate in the survey. While in the key informant interview, the informant was selected based on the survey result. The descriptive and thematic approach was employed to analyze the quantitative and qualitative data. Integration between the two approaches was accomplished in the interpretation of the result by comparison and contrast.

**Results:** Three core themes emerged from our analysis that describes the SIMUNDU success journey as an electronic immunization registry: system strengths, potential threats, and opportunities.

**Conclusions:** The individual electronic immunization registry has been implemented well, and it may contribute to increasing immunization coverage in DIY. Stakeholders should consider the sustainability of this system by providing related resources and consider scale-up nationally by looking at this promising program.

**Keywords:** immunization, electronic immunization registry, immunization information system, interoperability, implementation research

## Background

Neonatal and childhood vaccination is an essential component of infectious disease prevention and an absolute human right (1),(2). Vaccination has been proven to reduce the burden of infectious disease globally (3). According to the WHO, in 2020 estimated 23 million children under one year of age did not receive their essential vaccinations. Of these, 60% live in just ten countries, one of which is Indonesia (4). Indonesia is the fourth most populous country globally. It is composed of thousands of islands organized into 34 provinces. Various geographical and cultural factors influence population inequalities to access to health services (5). In 2001, the Indonesian government's decentralization policy was enacted. This was an excellent strategy to foster development by engaging regional resources (6). However, this strategy was not without consequence. One primary concern is the fragmentation of the Health Information System (HIS).

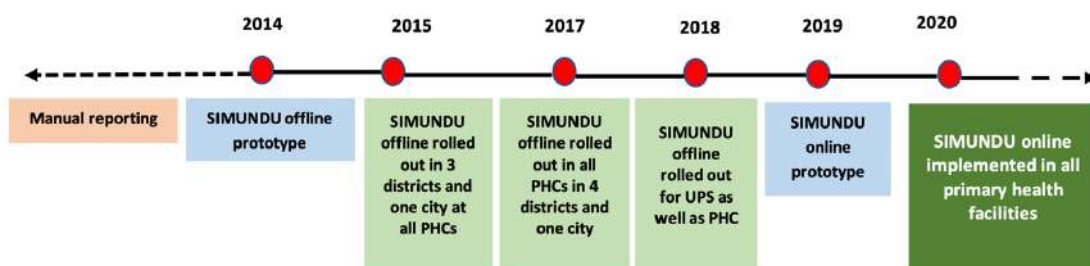
Indonesia's federal structure results in provinces and districts being relatively independent of the national Ministry of Health. This means that information systems at the provincial and district levels are locally regulated (7). For instance, *Pemantauan Wilayah Setempat* (PWS) is a management tool used to monitor coverage of specific health services in an administrative boundary. Depending on the service and region, it can be paper- or electronic-based. PWS-KIA is the monitoring system specific to maternal and child health (KIA), including immunization. PWS-KIA data are reported to the District or City Health Office, go to Province Health Office, and finally report to the main level. Generally, the data is in excel; it will report via emails or various information systems, including Komdat, SiTT, SIHA, PISPK, SIKDA Generik. PWS-KIA data feeds into the District Health Information System 2 (DHIS2) in some provinces. Regional information systems have varying data quality, reflecting inequities in regions' resources. This adds to data integration challenges at the national level (7),(8) and affects strategic policymaking.

In the context of Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) Province has the authority to regulate and use its budget within its four districts (Sleman, Gunungkidul, Bantul, Kulonprogo) and Yogyakarta city. Regarding childhood vaccination, DIY is among the top ten performing provinces in the country, with 97.7 % of children completing basic immunization coverage in 2019 (9). Immunization services are provided by Primary Health Centres (PHC), as well as private clinics, hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* (UPS)).

An electronic immunization registry is a tool for recording individual children's immunization histories. In 2014, the DIY Health Office introduced an electronic immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu/Integrated Immunization Information System*). An electronic registry serves essential functions at all levels of the health system. At the district and higher levels, it allows for monitoring vaccination coverage by the vaccine, dose, cohort, and other variables – and can support microplanning and vaccine management. The service delivery level can facilitate individual follow-up of vaccination status and enable health workers to identify children due for vaccination and those who missed their vaccinations (defaulters).

SIMUNDU was designed to link with the PWS-KIA for immunization and interoperability with the DHIS2. While it predominantly contains individual-level immunization records, SIMUNDU also serves as a source for aggregation and can synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this reason, it can be considered an Immunization Information System (IIS). This means that data from City and District levels feed into Provincial and National levels (*Personal communication with DIY immunization program officer*).

The original prototype was designed by the information and technology (IT) department of DIY Health Office to be operated offline. In DIY, three out of the four districts and the city introduced the system in 2015. The final district introduced it in 2017. At this stage, the point of data entry was the PHC only. By 2018, UPS facilities were also equipped with SIMUNDU and could enter data into the system. In 2019, the prototype was further developed to operate online. The online version was rolled out in 2020 (Figure 1). As of May 2021, 79.4% of all PHC and UPS facilities complied. However, this average rate masks that while all PHCs adopt SIMUNDU, it is more challenging to enforce its use in UPC facilities (Suyani 2020, oral communication, 2020 May 11).



**Figure 1.** SIMUNDU’s development and introduction

When a child receives a vaccination in a health facility, information on the child and the vaccination is entered in SIMUNDU as an individual child record. Each record includes a personal identifier, the child’s socio-demographic characteristics (e.g., name, gender, date of birth, name of parents, address), the antigen administered, and the date and place of vaccination. SIMUNDU has been recently updated to allow recording of vaccinations administered in schools (e.g., Human papillomavirus (HPV), Diphtheria Toxoid (DT), Tetanus-Diphtheria (TD), and Measles-Rubella (MR)). Furthermore, SIMUNDU is being developed to record COVID-19 vaccinations in health facilities and those carried out in masse. At this stage, SIMUNDU only facilitates the reporting in aggregate based on the number of students in the school.

Monitoring is conducted every month to assess data completeness across health facilities, while an evaluation is conducted every year. These exercises have allowed the identification of several challenges related to implementing the system (e.g., workload, staff turnover, and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic assessment of the system has been conducted to date.

SIMUNDU is the first immunization information system ever introduced in Indonesia. Other districts and provinces have shown interest in rolling it out, and the Ministry of Health has acknowledged the innovation. The objective of this work was to examine SIMUNDU’s introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.



## Methods

From May to October 2020, we examined the experience of introducing and implementing an immunization information system in the DIY province using an explanatory sequential mixed-method design, where quantitative data were completed first then the finding was used to inform the qualitative phase (10). Before the survey started, we conducted a desk review of all relevant documentation available in the DIY health office – e.g., staff notes, meeting notes and monitoring notes – documenting SIMUNDU development and management processes. We also examined online documents, including health profiles and regulations on health reporting systems in Indonesia. This served as the initial data source and provided an overview of who was involved and their role in developing and implementing SIMUNDU. This informed the survey design that we conducted as a second step. The survey was conducted with staff responsible for entering data in SIMUNDU across PHC and UPS facilities and immunization coordinator at the district and city level. Sampling and recruitment strategies are outlined in Table 1.

**Table 1. Survey sampling**

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
Puskesmas/Primary Health Centre (PHC)	121	Immunization coordinator and data entry clerk	All facilities	Open invitation across all facilities	113
UPS - Hospital (Central, General, Maternity and Pediatric)	65	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
UPS - Clinic	73	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
UPS - Midwives' Practice	271	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinator	Total sampling	Open invitation	4*
<b>Total</b>					<b>142</b>

\*When the immunization coordinator had recently changed, the former was also invited.

All immunization coordinators in each district/city and data entry clerks from all primary health facilities (PHC) participated in this survey. We randomly selected two clinics, two midwives' practices, and two hospitals per district/city for UPS facilities.

We developed and pre-tested an online survey in Bahasa Indonesia to inquire about SIMUNDU implementation, processes, and **outcomes in each different level (PHC, UPS and DHO/CHO)**. The total question for PHC and UPS were 48 and 46 – respectively, that

divided into 2 significant parts: 1) respondent identity and 2) SIMUNDU reporting and managerial. Questions are presented in “Yes, No” or “scale” questions. In some questions, respondent allows putting their reason for choosing a particular answer.

All participants provided consent to participate in the survey. All participants were invited to the DIY health office to fill out the survey on their laptops. Having all participants in a room allowed researchers to monitor potential gaps in responses in real-time and follow-up with individual participants on-site to fill any gaps. Data were then exported and analyzed in Microsoft Excel descriptively. A significant percentage for each question was noticed for informing the qualitative phase.

Next, we conducted key informant interviews to explore the challenges of implementing the system from practice and managerial standpoint. The interview takes approximately 30 minutes that runs in Bahasa Indonesia. Each interview was conducted by three researchers with a different role: main interviewer, observer, and field note taker. SS, RR, TWS, SKW, and SAM were involved in the interviews. All of them were female with a public health background worked as lecturers and researchers at university. The research group developed a semi-structured interview guide and consulted with the expert prior to the interview.

Informants were purposefully selected among survey participants to follow up on the range of perspectives that had emerged from the survey. As informed by the desk review, others were chosen for their management functions. The informant and interviewer did not know each other prior to the interview. Informants were invited to Province Health Office for interview purposes due to COVID-19 pandemic reasons. Before the interview, the informant was informed about the study and asked to sign the informed consent. All invited informants agreed to participate. A total of nine key informants were interviewed in Bahasa Indonesia language. The face-to-face interviews were recorded with consent from the informants. After the interview, the interviewer summarized our field notes to the informant for correction. Transcription was done in Indonesian by our research assistant.

Thematic analysis was conducted using Quirkos qualitative tool following Braun and Clarke’s approaches (11). Researchers familiarized themselves with the data, searching for initial codes and allowing themes to emerge. SS was the main coder during the analysis. Then the result of the coding reviewed together among the research group continued with defining and naming the core themes, analyzed the data for each of the core themes, triangulated information from the desk review, the survey, and the interviews. Themes were generated from the data during the analysis. The entire coding was performed in Indonesian, and from the subcategory level, the data were translated to English.

## **Results**

### **Characteristic participant**

a. Quantitative study

In total, 142 respondents participated in this study spread across five districts or cities in the DIY province. Most respondents came from Gunungkidul District, PHC, UPS, and DHO, 24.8%, 24%, and 25%, respectively. For all research units, the majority are women. At the UPS and DHO/CHO levels, most respondents aged 41-45 years, i.e., 28.3% and 75%, respectively, while at the PHC level, the majority aged 25-30 years (56.0%). For education level, PHC and UPS are dominated by Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, it is predominantly undergraduate graduates (75%) (Table 2)

**Table 2.** Characteristic respondent in three groups of respondents

Characteristic	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3 (2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25-30	3 (2.7)	14 (56.0)	0 (0.0)
31-35	30 (26.5)	3 (12.0)	0 (0.0)
36-40	19 (16.8)	1 (4.0)	0 (0.0)
41-45	32 (28.3)	0 (0.0)	3 (75.0)
46-50	18 (15.9)	0 (0.0)	1 (25.0)
>50	11 (9.7)	2 (8.0)	0 (0.0)
Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

b. Qualitative study

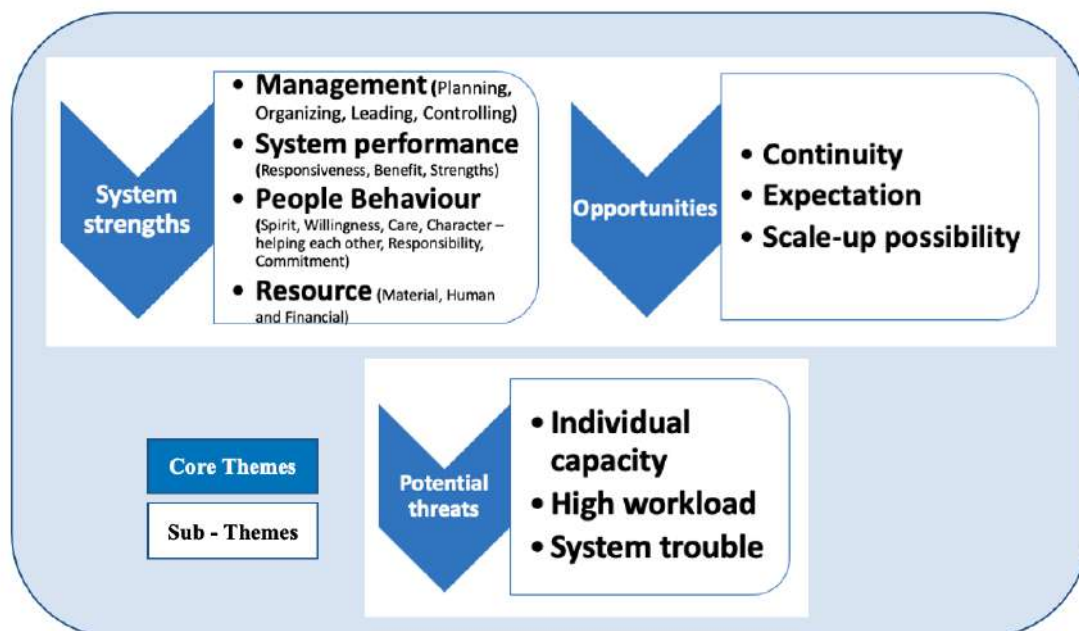
Nine informants were recruited to provide the required information to explore deeper into the quantitative study results. They hold roles as managers and staff at DHO/CHO, PHC, and UPS. Among the nine informants, 2 were men, and 7 were women. Three informants graduated from masters, one bachelor's, and five diploma graduates (Table 3).

**Table 3.** Informants' characteristics for the qualitative study

Sex	Age (years)	Education	Position	Subject group	Informant's code
Female	56	Magister	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Magister	The former of disease prevention and control section at PHO level	Managerial	M 02
Male	54	Bachelor	Immunization programmer at PHO level	Managerial	M 03
Female	47	Magister	IT Person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at UPS level	Staff	S 02
Female	31	Diploma	Data entry at UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

### c. Finding

Findings from the study are presented across the three core themes that emerged from the qualitative analysis, notably system strengths, potential threats, and opportunities shown in Figure 2. We present the qualitative and quantitative results together to increase the reliability and validity of the finding. **The detailed quantitative study is presented in Table Supplement 1.**



**Figure 2.** Strengths, potential threats, and opportunities for scale-up

## System's Strengths

Factors contributing to the success of SIMUNDU include management, system performance, people's behavior, and resources.

### Management

SIMUNDU arose due to concerns from the DIY health office immunization section around data quality, including inaccurate data, duplicate or missing data and lack of timely data, and the need to support follow-up and appropriate planning. SIMUNDU was designed to address these challenges and needs. Management factors relate to SIMUNDU development and all levels of the management chain (planning, organizing, leading, and controlling).

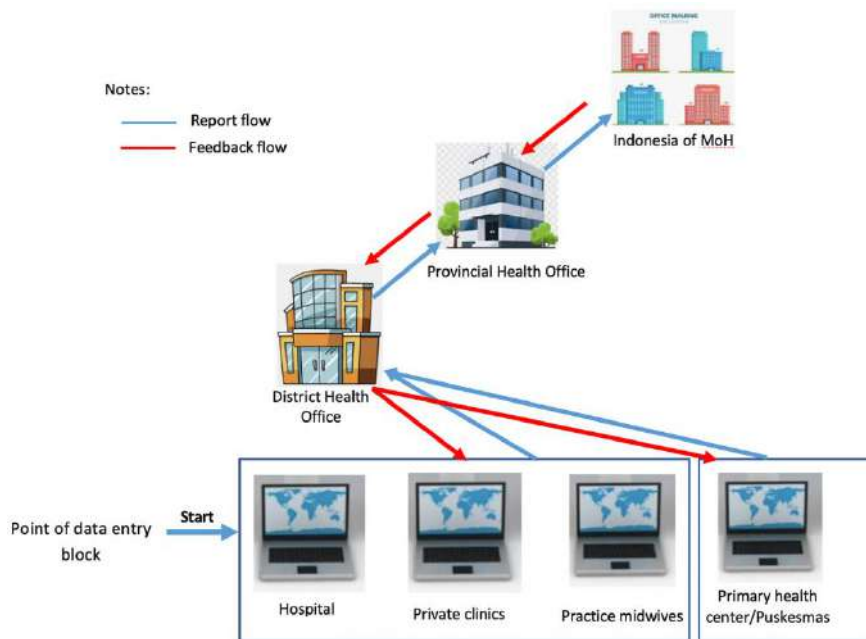
*To our knowledge, [SIMUNDU development] started with a problem: estimates of the target population varied depending on the data source.*

*Yes, I think [SIMUNDU management team] started to tire of managing a large volume of data with dubious validity. They need to know the situation in each district.*

Effective management of SIMUNDU from development to implementation has been highlighted as an essential determinant of its success. Here, we review its management across the critical functions of Planning, Organizing, Leading, and Controlling.

**Careful Planning** has been ensured at each stage of SIMUNDU development and implementation. These stages include an initial business plan, training on and socialization to SIMUNDU, and a staff replacement plan to respond to turnover or retirement of staff in charge of operating or entering data into SIMUNDU. The parties involved in planning included the head disease prevention and control department, IT personnel, and immunization program staff from the DIY health office.

**Organizing** - the organization of SIMUNDU is carried out at several levels. The top level is at the level of the DIY health office, the second level is at the district/city health office, and the third level is the level of the health facilities (Figure 2). A third party was also involved in developing the system interface.



**Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

At the beginning of SIMUNDU development, essential functions included database administrators, interface designers, and server administrators, and their interplay facilitated the smooth operation of the system. Training specific to SIMUNDU was integrated with other training, typically immunization-related training. This enabled to sharing of resources with other programs, thus ensuring viability. The training was delivered in the district/city health office: most of our respondents in PHC, UPS dan DHO/CHO stated they participated in this inhouse training with 87.6%, 72% and 75% - respectively. Training typically consisted of short training and included practice on the trainee's device and how to operate the system both in online and offline mode. Day-to-day operations were carried out autonomously by the staff, through adjusting their work to protect time to enter the data. Some informants reported that staff members divided tasks effectively to ensure work was carried out effectively.

**Leading** - the success of SIMUNDU implementation is arguably related to strong leadership. Informants noted that managers played a crucial role in bridging the immunization program with the system design, closely monitoring the initial implementation process, and creating an enabling environment.

*I try to combine supporting and managing the people involved and monitoring them. Currently, I monitor whether [SIMUNDU] can run optimally as our users are health facilities. I also monitor program development and the system's output.*

*[SIMUNDU] was born from program managers, primary health centers, Districts, and DIY health offices wanting to build systems together. We – DIY health office - give them motivation in every meeting.*

*I see that [management] is very good at networking. Staff data entry in the field always said that these people are very kind.*

The role of IT in developing SIMUNDU was also reported to be significant. They helped develop the system and supported correct data entry by assisting data entry operators who experienced technical issues or helping resolve inconsistencies in the data records. Acknowledgment of staff efforts was also an important lever to maintain motivation and buy-in.

*In the early days of SIMUNDU's development, the system was challenging to operate, as it wasn't as stable as it is now. I praise the enthusiasm and dedication of the users).*

Managing **quality assurance** was critical to avoid data duplication or missing entries. This process was not regulated by specific Standard Operating Procedures but was addressed during training and monitored monthly. In addition, the DIY health office provided negative incentives to health facilities that were not providing complete records and provided regular feedback from monitoring and evaluation exercises.

We found that 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO, respectively, reported their work had been monitored regarding SIMUNDU. **More than half of the respondents in PHC and UPS facilities were observed at least once in 2019-2020.** At the PHC level, more than 48.3% reported that staff from the district/city level conducted the monitoring, and 45.7% said that the DIY health office staff conducted monitoring. Furthermore, 40% of respondents from UPS facilities were monitored by PHC. Almost all survey respondents reported receiving feedback from the monitoring, mainly from the District/City and DIY health offices. Forty percent of respondents from UPS facilities reported receiving feedback from PHC. Immunization coordinators from the District/City health offices said that the DIY health office provided them with feedback.

*In a [evaluation] meeting, DIY health office or district health office showed the progress of our data entry – correct or not, proper or not*

Another resource that influences the successful implementation of SIMUNDU is the size of the DIY province. This province is quite a small geographic area. Because it consists of five districts and one city, this province is relatively easy to monitor across all phases, from planning through monitoring and evaluation.

### **System performance**

While SIMUNDU predominantly contains individual-level immunization records, it also serves as a source for aggregation and can synergize with other information systems. Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports per Ministry of Health requirements. These reports are sent to the upper levels directly if SIMUNDU is operated online or submitted via email if SIMUNDU is operated offline.

This functionality had an essential role in ensuring the acceptability and adoption of the system.

Informants noted how transitioning from paper-based tools to an electronic system made data entry easier and reduced errors. It also facilitated the implementation of protocols for data storage and security. It enabled follow-up and defaulter tracking. Finally, integration with the DHIS2 meant reduced workload for the staff.

*We can do faster tracking of children who may have immunizations in different locations. For example, when the first dose of a vaccine is given in Bantul, the second immunization in Yogyakarta can be connected and detected with the SIMUNDU system.*

*Using SIMUNDU makes it easier to detect what data and immunizations are missing since we enter data from the children's birth through the end of the immunization schedule. So, we will know where they missed any vaccine.*

*The benefit of using SIMUNDU is first: we know the situation of immunizations more accurately....so we say that our predictions are real for planning for the future... So, our budget, staff, facilities can be more effective and efficient in providing services.*

*Colleagues from the mother and child health (KIA) program enter via the KIA "Sembada." So, this data will appear automatically in SIMUNDU because the two-system are connected.*

SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the responsible staff to maintain data entry irrespective of connectivity. The percentage of using SIMUNDU online in PHC, UPS and DHO was 82.3%, 96% and 100%, respectively.

### **People behavior**

The survey showed that staff commitment was critical for the successful implementation of SIMUNDU, as indicated by their willingness to work overtime and bring home the data to enter into the system.

*I take it [the data] home too, for example, after immunization sessions– in my clinic, immunization runs four times per month, every week. So, when the session is finished, we can take it home, [and] do the entry at home while relaxing*

Some determinants that facilitated the implementation of SIMUNDU were the societal culture of helping others and responsibility and commitment to the team. An enabling environment allowed people to view SIMUNDU as a shared responsibility and a collective endeavor. Informants also noted the high motivation of dedicated staff.

*That's all; we cannot judge by money [people kindness, culture, and behavior]; it's essential to explain how good people are in Yogyakarta. I was in another place before, and I could not find people's kindness like in Yogyakarta - different characters.*



*The second thing is that we need human resources concerned and love with data; otherwise, even though we have a good system, it will amount to nothing without good human resources. But when people are concerned about data, good implementation will come more easily.*

Other characteristics, such as the culture of helping others and responsibility and commitment to tasks, revealed from the interviews, were critical determinants in the successful implementation of SIMUNDU.

### **Resource: material, human and financial**

Infrastructure and equipment emerged as critical factors to introducing and sustaining SIMUNDU implementation. Some desktops were specifically allocated to the immunization program, and some had to be shared with other programs' staff. Other data entry officers reported using laptops or personal smartphones. The survey found that in PHC, as much as 36.3% of data entry clerks used their laptops to enter data into SIMUNDU. In UPS facilities, nearly 40.7% reported using office PCs, and in the DHO, more than half of the respondents stated they used an office-supplied laptop. The majority of respondents said their current device was sufficient to perform their work on SIMUNDU. Regarding internet access, 64.6% of PHC staff and 67.7% of UPS staff reported using the office internet connection to enter data into SIMUNDU. However, 75% of DHO respondents reported no internet source.

Management of financial resources was also crucial. Key informant interviews revealed no special allocation of funds to SIMUNDU in the initial stages. Resources were leveraged by sharing activities such as monitoring visits or transportation with other programs, thus allowing cost efficiencies. Integration with other programs proved critical to ensuring sustainability.

*SIMUNDU's budget comes from the state budget called as Anggaran Pendapatan dan Belanja Negara (APBN). Every year the APBN allocates funding envelop for immunization to DIY and other provinces, where the budget is apportioned across the program [not explicitly written for SIMUNDU]*

Human resources are critical to the operation of SIMUNDU. According to respondents, SIMUNDU data entry clerks must have patience, work carefully and not rush, be interested in data, be responsible, and have basic computer skills such as Ms word and Ms excel. Our survey showed that most data entry clerks in PHC and UPS facilities had a diploma level of education (>80%), while at the managerial level (DHO), 75% of respondents had a bachelor's degree (Table 2). Our survey shows that 19.4% and 9.1% of respondents in PHC and UPS, respectively, had low computer literacy.

Various data entry clerks looked for strategies to resolve their obstacles to entering data to SIMUNDU. Among them, they increased their computer skills by taking private computer courses. In addition, some of them learned from other colleagues at their

offices. To deal with the accumulation of data needing to be entered in SIMUNDU, staff sometimes took data home for entry purposes because there is insufficient time during work hours since they have several other duties. If data entry clerks faced SIMUNDU trouble, informants said they asked for help from those who might have more information, for example, the district person in charge.

*If we found obstacles, we asked people in charge in PHC – asking for a solution or sharing by WhatsApp – or sometimes I asked the IT person in the DIY health office.*

### **Potential threats**

To date, SIMUNDU can be said to have had successful implementation. Several obstacles were encountered and addressed during implementation. The potential constraints on implementing SIMUNDU are individual capacity, technical or IT issues, and high workload.

Computer literacy of staff was identified as one of the main issues. Internet connectivity was another obstacle to implementation, as not a good network supported all health facilities equally. The survey shows that 64.6% and 67.7% of PHC and UPS staff used office internet, while others had to rely on their home internet.

Another issue that emerged was related to incomplete and inconsistent records; for example, the child's date of birth or name spelling not matching across different entries, making it difficult to have a unique and consistent record for each child. An example of this inconsistency of the child's date of birth or name spelling among different entries makes it challenging to record immunization information consistently. Even though these were temporary and were promptly resolved, these system failures were an issue for staff, who were already juggling a very tight schedule in the office, as they caused some delay. As shown by the survey, almost all respondents in PHC, UPS dan DHO stated that they have other responsibilities besides operating SIMUNDU; the percentages were 97.3%, 88% and 100% - respectively.

### **Opportunities**

Informants said that SIMUNDU is a good system for immunization data. SIMUNDU has become necessary for program managers and policymakers because it facilitates monitoring coverage and informing planning and programming. Currently, SIMUNDU is stable, thus is easier to manage than when it was in the development phase. This means that the system is not as reliant on the core workforce that has been heavily involved since inception and will possibly accommodate changes in the workforce. The hopes expressed by data entry clerks are that SIMUNDU would be easier to operate, and system errors did not occur. In addition, informants revealed the need for refresher SIMUNDU training so that their understanding of SIMUNDU would not be lost.

*In my opinion, SIMUNDU is the best program in DIY which is a collaboration between program managers and IT. It will continue to be implemented because it is a necessity.*

*It has been stably used for more than five years, meaning this is needed.*

*If I have the tool, in this case, SIMUNDU, when it is stable, whoever will hold it, I am sure that anyone can operate it. It means that it doesn't matter if we have people shifting (jobs).*

*In the future, if SIMUNDU is still used, other reports are not necessary. Now we have two different reports: SIMUNDU and stock card of vaccine – each stand-alone and need a separate report.*

Based on the informants' statements, SIMUNDU is likely to be developed broader. The DIY health office is open to any party learning and implementing SIMUNDU in their region. However, informants advised that SIMUNDU must have a strong commitment from the data entry staff and management sides. The leadership in DIY has shown willingness to assign staff to other provinces who have expressed interest in SIMUNDU for orientation to the system,

## **Discussion**

Robust health information systems (HIS) are essential components of robust health systems (12). Having a timely Immunization Information System (IIS) that collects individual information and vaccine recipient's history to improve immunization services is essential to personalize vaccination information, communicate targeted information as a decision support system, and record vaccination hesitancy (13). Here, we provide evidence of how an immunization information system has been implemented in practice.

Sistem Informasi Imunisasi Terpadu (SIMUNDU) or Integrated Immunization Information System in the DIY province enabled the creation of individual immunization records for children. SIMUNDU allows users and managers to collect, store and analyze data on utilization of immunization services, including following up individual children and creating cohort data. Currently, DIY is the only province in Indonesia – out thirty-four - that uses an IIS. This work has shed light on the strengths and underlying barriers of implementing an IIS in this context. The objective of this study was to draw lessons that inform sustainable scale-up in other regions and possibly at the national level.

This study studied the potential factors that facilitate or pose a barrier to SIMUNDU implementation. Individual capacity, system trouble, and high workload were barriers to implementation. We identified management, system performance, people's behavior, and resources as determinants for SIMUNDU's strength that influenced implementation outcomes: the acceptability, implementation cost, and adoption of this innovation (14).

Despite several obstacles encountered during the implementation of SIMUNDU, we see that this innovation is well accepted by the stakeholders involved. The first stakeholder group is data entry clerks, who accept several aspects of SIMUNDU: data entry content,

ease of input to the system (not complex), and comfort using SIMUNDU compared to the previous system. The second stakeholder group is managers; they accepted this system well and felt there was a benefit in this innovation, namely the output in cohort data to help them monitor and improve immunization coverages.

Having an excellent managerial process – meaning proper planning, monitoring, and evaluation - is one reason SIMUNDU has survived and been viable for the last 5 years. Managers use their power to encourage the beliefs and actions of other people (15). This requires a dedicated and robust process for the whole of the management process cycle. SIMUNDU was born from the need for credible data at the DIY health office to assist in carrying out its duties at the managerial and operator levels. At the managerial level, the disease prevention and control department and the IT department collaborated to create a system readily accepted by users. Immunization and IT programmers played a central role from the beginning of the design throughout the implementation process with appropriate coordination and communication. Their ability to do so was facilitated by the full support of their respective superiors.

SIMUNDU is cost-effective in several ways. During the introductory period of SIMUNDU implementation, immunization programmers, IT officers, and other staff assisted in disseminating SIMUNDU to all existing districts. This was done side by side with other programs, making it cost and time-efficient for managers and staff. As mentioned, organizing activities is certainly not easy, but it can be carried out well, even sustainably, by sharing resources. Additionally, SIMUNDU maintenance does not require high costs because the DIY Health Office developed and maintained the system. Thus, the IT department can develop improvement processes and tailor them to user needs without additional cost. In addition, the location of affordable services (health facilities) is also part of cost-effectiveness.

A good program without good leadership could fail in its implementation, and even if it was initially successful, it might not be sustainable (16). In the context of SIMUNDU, support from leadership and the involvement of good people at managerial levels may have facilitated the program's adoption. The level of SIMUNDU uptake was good because all health facilities providing immunization services have successfully used this system, and it has been running well. The adoption of SIMUNDU was facilitated by the strong networks of the main person in charge of SIMUNDU. Communication, care, and attention to staff concerns positively affected staff performance. They feel well supported and are treated kindly – this means that they carry out their work joyfully. Several informants brought up this theme who stated that the person who played an essential role in SIMUNDU was the immunization program manager.

The monitoring and evaluation mechanisms of SIMUNDU were also important. Preferred monitoring and evaluation activities include monthly reports and direct discussion with staff during site monitoring visits. The immunization program manager suggested this approach to maintain data quality and system sustainability. These chosen

mechanisms allow program managers to know the actual conditions in the field and the obstacles faced to inform decisions about the follow-up actions that must be taken. This supports the ongoing development and learning of SIMUNDU as a tool for data collection, analysis, and visualization tool, provides benefits for managers to carry out monitoring and evaluation. The same point was stated by previous research in India about the innovation of health management information systems for primary health care agrees that this can provide essential benefits (17).

Human resources are determinants of health information system implementation (18). The people's behavior affects how the system works, develops, and survives (19),(20). In the case of SIMUNDU, implementation was facilitated by the caring character, networks, and meticulous attitude towards data of both the program manager and IT team. From the staff's point of view, the local culture of helping each other and doing their job correctly and responsibly is translated into staff that carries out their duties with enthusiasm and high commitment. Although facilities, funding and volume of human resources are limited, the people involved are highly motivated and supportive. Socio-cultural values, attitudes and beliefs held by staff have contributed to the successful implementation of SIMUNDU.

Despite the clear strengths of SIMUNDU, there are potential obstacles to its sustainability in the future. These obstacles can be divided into human variables and technical variables. From the human variables side, unequal individual capacities at the operator level can cause obstructions during data entry in the field. Another potential future obstacle is the staff's high workload because generally, they have to do other tasks besides SIMUNDU data entry. From the interview results, the data entry clerks have tried finding strategies to overcome this additional workload burden, such as doing data entry at home and overtime at the office. But from the health system perspective, if this is not anticipated and a strategy to address it is implemented, it may become unsustainable to expect staff to continue to do overtime. This will potentially interfere with the data's quality and overall harm SIMUNDU sustainability.

This study may have a limitation related to the survey data collection procedure, whereas we monitored the respondent response and asked them to fill the gap left. However, this step is taken to anticipate respondents dropping out due to incomplete answers due to someone's carelessness, which can impact the inaccuracy of the data we collect.

### **Conclusion and recommendation**

From this study, we know that SIMUNDU is a promising immunization reporting system. In-depth interviews revealed the potential for scale-up of this program to other areas. Although obstacles exist, the benefits and strengths outweigh them. Our findings show that to maintain the continuity of SIMUNDU, some actions should be taken, such as providing regular training to the data entry clerks, as the system is constantly being updated. In addition, there is a need to layering the management structure to anticipate

staff rotation or retiring. Lastly, appropriate motivation, incentives, and support for data entry clerks must be ensured.

Despite resource constraints, it was still possible to run SIMUNDU. Initially, there was no special allocation funding for SIMUNDU, so the program ran side-by-side with other health programs in the DIY health office. This mechanism allowed cost-efficiency. There were three prominent persons in charge of developing SIMUNDU: 1) IT person responsible for system creation and maintenance, 2) the immunization program manager responsible for the strategic development of SIMUNDU, and 3) data entry clerks who are accountable for careful data entry into SIMUNDU. When seen from a facility perspective, SIMUNDU does not require expensive equipment – all that is needed is a computer or phone and internet access. An excellent managerial process that consists of planning, monitoring and evaluation and feedback influences the success of SIMUNDU to date from the DIY province. This required appropriate planning, organizing, leading, and controlling.

Three recommendations stemmed from this study, addressed to the DIY health office, the national government, and researchers. First, to guarantee continuity and sustainability and reduce the system's dependency on the particular person or party, SIMUNDU management and maintenance should be related to others with the competency and interest in a good reporting system. Furthermore, existing human resources should be strengthened in preparation for scaling up SIMUNDU in other regions or at a national level; this is necessary to avoid vacant positions when DIY province staff are seconded to requests for mentoring from other areas. Second, the bottom-up approach during SIMUNDU development and implementation positively impacts this system and makes it is feasible and viable to use. The approach to scaling up SIMUNDU should be stepwise, considering each region's specific characteristics and problems. Therefore, it is vital to develop a readiness map and a timeline for the roll-out of SIMUNDU in a particular region. Third, further research is needed on the impact of SIMUNDU on immunization coverage, for instance, through a before and after comparative study with a 2–3-year time window in a low-performing region.

## **Declarations**

### Ethics approval and consent to participate

This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan, Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began, consent to participate was obtained from research subjects (both survey and key informant interviews).

### Adherence to national and international regulations

Not applicable

### Consent for publication

Before data collection begins, approval that data is taken for publication purposes is obtained from research subjects (both surveys and key informant interviews).

#### Availability of data and materials

The datasets generated and or analyzed for this study can be requested to the corresponding author.

#### Competing interests

The authors declare that they have no competing interests

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#### Authors' contributions

SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the data. SS and RR conducted data analysis. SS developed the paper with inputs and comments from MF on each draft. All authors agree with the manuscript's results and conclusions.

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#### Authors' information:

The authors alone are responsible for the views expressed in this article. They do not necessarily represent the views, decisions, or policies of the institutions affiliated with them.

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## I. DESK EVALUATION CHECKLIST

**AIM:** To review what is available to tackled objectives 1 to 3, and identify issues to be explored further through the survey or more in-depth through the interviews

<b>History of SIMUNDU development</b>		<b>Source</b>
1	SIMUNDU goals	Report
2	Simundu initiation and the story	
3	People or stakeholder involved in the beginning	
4	The budget needed from the beginning until recently. How much, which slot was allocated	Report and documentation
5	The justification that SIMUNDU developed using internal funding	Report
<b>SIMUNDU resources requirement</b>		
1	The guideline that exists for SIMUNDU operation at any level <ul style="list-style-type: none"> <li>- Point of data entry</li> <li>- District health office</li> <li>- Provincial health office</li> </ul>	Report
2	The computer or IT and power/ electricity requirement to operate SIMUNDU at any level	
3	The skill needed for staff that operates SIMUNDU at any level	
4	Rooms/building requirements for SIMUNDU at any level?	
<b>SIMUNDU implementation</b>		
1	SIMUNDU training held from the beginning until current implementation since there was changing of the system at least 3 times: <ol style="list-style-type: none"> <li>1) Puskesmas as point data entry</li> <li>2) Offline system all point data entry</li> <li>3) Online system all point data entry</li> </ol>	Report
2	The person in charge conducts SIMUNDU training	Report, documentation
3	Guideline for SIMUNDU training	
<b>Data quality aspect</b>		
<b>Timelines</b>		
1	The agreement of reports via SIMUNDU be reported to upper level every month, for every level	Report
2	Number and % of districts that submitted on time. Follow cohort time since implementation <b>OR</b> Number of point data entry delayed the report	Report and routine evaluation document
3	Which point of data entry has poor and good timelines?	
<b>Accuracy</b>		
1	Is there any case of inaccurate data found during the implementation?	Report and routine evaluation document
2	Is there any irrelevant data between the report and the real data?	

3	The percentage (ratio) of data errors	
<b>Completeness</b>		
1	Number of variables should be entered in each level	Report and routine evaluation document
2	The number of missing or zero value	
3	Number and % of point of data entry < 90% <b>non-missing values</b>	
4	Number and % of point of data entry < 75% <b>non-missing values</b>	
5	In which variables usually missing occurred?	
6	Which point data entry major or frequent have missing values?	
<b>Data duplication</b>		
1	The number of duplication report occurred	Report and routine evaluation document
2	The number (percentage) of point data entry who did duplication data report and which point data entry	
3	The number of under report occurred.	
	The number (percentage) of point data entry who did under data report and which point data entry	
<b>Accessibility</b>		
1	SIMUNDU data availability, easily, quickly, retrievable	Observe SIMUNDU
2	Can users easily obtain and analyze the data?	
<b>Managerial Process</b>		
<b>Planning</b>		
1	Who is involved in the planning of SIMUNDU? What role?	Report and routine evaluation document
2	Assessment of the readiness for implementation? How, who? What aspect been assessed?	
3	Performance assessment among health facilities?	
<b>Implementing</b>		
1	Dissemination about SIMUNDU. When was it introduced? By whom? When? Where? How often	Report and routine evaluation document
2	The training when SIMUNDU was introduced. By whom? When? Where? How often	
<b>Monitoring and Evaluation</b>		
1	Who is responsible for monitoring and evaluation?	Report and routine evaluation document
2	How often?	
3	What aspect been monitored? For what purpose?	
4	Did the barrier found during implementation?	Routine evaluation document
5	System development and maintenance. Who, how?	Report and routine evaluation document


## II. SURVEY INSTRUMENT for RESPONDENT IN POINT OF DATA ENTRY

**AIM:** To gather more knowledge on the factors affecting data quality (obj.1), but also to illustrate how SIMUNDU was introduced and sustained (obj. 2 and 3).

**Respondent:** immunization coordinator and data entry staff in Puskesmas (PHC), clinic, hospital and midwives' practice.

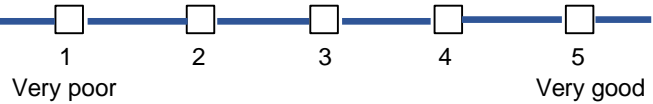
### A. Respondent identity

1	Name	
2	Sex	<input type="checkbox"/> Male <input type="checkbox"/> Female
3	Date of birth (Date/Month/Year)	
4	Age (years old)	
5	Role/ position (mention!)	
6	Education. Write your last degree!	
7	Name of health facility	
8	Address	
9	How many health facilities under the supervising of your office?	
10	Your phone number	
11	How far your office from your domicile?	_____ km _____ hour of travel
12	Who entered the immunization data into SIMUNDU	1. Myself 2. Others: Who? _____
13	How long have you been in the immunization program?	
14	Do you have other responsibilities/task beside in the immunization	<input type="checkbox"/> Yes <input type="checkbox"/> No If you <input checked="" type="checkbox"/> YES: How many _____ (write number) mention all the task is _____ _____

15	Do you ever participate in the SIMUNDU training/ BIMTEK?	<input type="checkbox"/> Yes <input type="checkbox"/> No If you <input checked="" type="checkbox"/> YES, state:  When _____  Where _____  By whom _____  Did any guideline used on that training? _____
16	In your opinion, how is your computer skill	 In case you <input checked="" type="checkbox"/> "very poor or poor," please answer this below questions:  Have you ever communicate about your problem <input type="checkbox"/> Yes <input type="checkbox"/> No  If you answer YES, explain with WHOM you communicate _____  What is the follow up to your complaint? _____  If your answer NO, explain why you do not communicate it _____
<b>B. SIMUNDU timeliness</b>		
1	When SIMUNDU reports should be submitted to your upper-level unit? (Date per Month)	
2	Have you been reporting SIMUNDU on time?	1. Yes 2. No  Explain WHY to your answer?
3	Usually, when you input toddler's immunization data to SIMUNDU?	1. Every day 2. Every week 3. Every month

		4. Other (explain)
4	Do you find a barrier to providing the SIMUNDU report on time? Explain	
<b>C. SIMUNDU accuracy</b>		
1	Have you ever experienced that the data you reported did not match the actual data in the field?	<input type="checkbox"/> Yes <input type="checkbox"/> No Write your explanation to your answer!
2	Have you ever verified the data that you enter to SIMUNDU with your immunization register?	<input type="checkbox"/> Yes <input type="checkbox"/> No Write your explanation to your answer!
3	What do you do when facing that case?	
<b>D. SIMUNDU completeness</b>		
1	In your opinion, does the input variable to SIMUNDU is a lot?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain your answer
2	Which part of the SIMUNDU variable that usually you the error/missed to input? (Explain it and why it happens)	
3	In your opinion, does data completeness on SIMUNDU is essential.	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain your answer
<b>E. SIMUNDU accessibility</b>		
Give your response to the statement below		

1	The SIMUNDU is easy to use	
2	Do you use SIMUNDU data for a specific purpose?	<input type="checkbox"/> Yes <input type="checkbox"/> No, If you <input checked="" type="checkbox"/> YES, what purpose is:
<b>F. Data duplication</b>		
1	Do you have experience with <b>under</b> -reporting on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
2	Do you have experience in <b>over</b> -reporting on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
3	Do you think under/over-reporting implies SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
<b>G. SIMUNDU resources</b>		
1	What type of computer that you used to SIMUNDU entry?	<input type="checkbox"/> PC <input type="checkbox"/> Laptop
2	Is it an office facility or your own?	<input type="checkbox"/> Office facility <input type="checkbox"/> Your own <input type="checkbox"/> Other, explain _____
3	The specification of your PC or laptop? <i>Your answer in G1</i>	Need to be completed with minimum requirements according to IT's information and a desk review. We will add later.
4	Do you feel your current device supports your work on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!

5	What is an internet source for SIMUNDU used?	<input type="checkbox"/> Office facility <input type="checkbox"/> Mobile phone data package <input type="checkbox"/> Other, explain _____  Do you think it supports your work on SIMUNDU?  <input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
6	What is the power source in your office?	<input type="checkbox"/> PLN (State company) <input type="checkbox"/> Genset <input type="checkbox"/> Other, explain _____  Do you have a problem related to the power source? <input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
7	Do you have a room/table to do your job/task/responsibilities in your office?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Other explain _____
8	In your opinion, on five scales. At what level of your report on time?	
9	What is your barrier to performing SIMUNDU reporting seen from the facility aspect?	
10	What is your barrier to performing SIMUNDU reporting seen from yourself?	<p><b>Choose an option that relevant to you! You allow choosing more than one.</b></p> <input type="checkbox"/> It is difficult to enter the data to SIMUNDU. <input type="checkbox"/> I don't have time to enter the data to SIMUNDU. <input type="checkbox"/> I have other tasks to do <input type="checkbox"/> I do not have computer skill s.



		<input type="checkbox"/> I was never getting training on operating SIMUNDU. <input type="checkbox"/> It is not essential to do <input type="checkbox"/> Other, explain_____
<b>H. Managerial process</b>		
1	What is the goal of SIMUNDU implementation?	
2	Do you think, are you have sufficient skill to use SIMUNDU?	
3	Have you participated in the SIMUNDU dissemination?	<input type="checkbox"/> Yes <input type="checkbox"/> No If you <input checked="" type="checkbox"/> YES, answer the question below: Who did the dissemination_____ When it was held_____ Where it was held_____
4	Who is monitor your work on SIMUNDU?	
5	How often, SIMUNDU been evaluated?	<hr/> Who did the evaluation_____
6	Did you receive the feedback related to the result of the evaluation of immunization data that you enter on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No If you <input checked="" type="checkbox"/> YES, answer next question: By whom_____
7	When you experience trouble with SIMUNDU, what do you do? Who are you contacting?	I did_____ I contacted_____

**III. SURVEY INSTRUMENT for RESPONDENT at DHO/CHO and PHO**

**AIM:** To gather more knowledge on the factors affecting data quality (obj.1), but also to illustrate how SIMUNDU was introduced and sustained (obj. 2 and 3).

**Respondent:** DHO/CHO, PHO

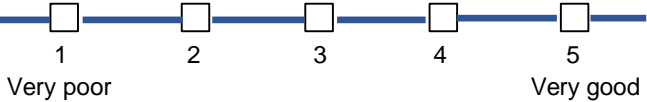
**I. Respondent identity**

1	Name	
2	Sex	<input type="checkbox"/> Male <input type="checkbox"/> Female
3	Date of birth (Date/Month/Year)	
4	Age (years old)	
5	Role/ position (mention!)	
6	Education. Write your last degree!	
7	Name of health facility	
8	Address	
9	How many health facilities under the supervising of your office?	
10	Your phone number	
11	How far your office from your domicile?	_____ km _____ hour of travel
12	What is your task related SIMUNDU?	
13	How long have you been in the immunization program?	
14	Do you have other responsibilities/task beside in the immunization	<input type="checkbox"/> Yes <input type="checkbox"/> No If you <input checked="" type="checkbox"/> YES: How many _____ (write number) mention all the task is _____ _____
15	Do you ever participate in the SIMUNDU training/ BIMTEK?	<input type="checkbox"/> Yes <input type="checkbox"/> No If you <input checked="" type="checkbox"/> YES, state: When _____ Where _____

		<p>By whom _____</p> <p>Did any guideline used on that training? _____</p>
16	In your opinion, how is your computer skill	<p style="text-align: center;"> <input type="checkbox"/> ————— <input type="checkbox"/> ————— <input type="checkbox"/> ————— <input type="checkbox"/> ————— <input type="checkbox"/> </p> <p style="text-align: center;">Very poor      Poor      OK      Good      Very good</p> <p>In case you <input checked="" type="checkbox"/> "very poor or poor," please answer this below questions:</p> <p>Have you ever communicate about your problem  <input type="checkbox"/> Yes      <input type="checkbox"/> No</p> <p>If you answer YES, explain with WHOM you communicate _____</p> <p>What is the follow up to your complaint? _____</p> <p>If your answer NO, explain why you do not communicate it _____</p>
<b>A. SIMUNDU timeliness</b>		
1	When SIMUNDU reports should be submitted to your upper-level unit? (Date per Month)	
2	Have you been reporting SIMUNDU on time?	<input type="checkbox"/> Yes <input type="checkbox"/> No Explain WHY to your answer?
3	Do you find a barrier to providing the SIMUNDU report on time? Explain	
<b>B. SIMUNDU accuracy</b>		
1	Have you ever experienced that the data you reported	<input type="checkbox"/> Yes <input type="checkbox"/> No Write your explanation to your answer!

	did not match the actual data in the field?	
2	What do you do when facing that case?	
<b>C. SIMUNDU completeness</b>		
1	Which part of the SIMUNDU variable that usually you the error/misled to input? (Explain it and why it happens)	
2	In your opinion, does data completeness on SIMUNDU is essential.	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain your answer
<b>D. SIMUNDU accessibility</b>		
Give your response to the statement below		
1	The SIMUNDU is easy to use	
2	Do you use SIMUNDU data for a specific purpose?	<input type="checkbox"/> Yes <input type="checkbox"/> No, If you <input checked="" type="checkbox"/> YES, what purpose is:
<b>E. Data duplication</b>		
1	Do you have experience with <b>under</b> -reporting on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
2	Do you have experience in <b>over</b> -reporting on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
3	Do you think under/over-reporting implies SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!

<b>F. SIMUNDU resources</b>		
1	What type of computer that you used to SIMUNDU entry?	<input type="checkbox"/> PC <input type="checkbox"/> Laptop
2	Is it an office facility or your own?	<input type="checkbox"/> Office facility <input type="checkbox"/> Your own <input type="checkbox"/> Other, explain_____
3	The specification of your PC or laptop? <i>Your answer in G1</i>	Need to be completed with minimum requirements according to IT's information and a desk review. We will add later.
4	Do you feel your current device supports your work on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
5	What is an internet source for SIMUNDU used?	<input type="checkbox"/> Office facility <input type="checkbox"/> Mobile phone data package <input type="checkbox"/> Other, explain_____
		Do you think it supports your work on SIMUNDU?  <input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
6	What is the power source in your office?	<input type="checkbox"/> PLN (State company) <input type="checkbox"/> Genset <input type="checkbox"/> Other, explain_____
		Do you have a problem related to the power source? <input type="checkbox"/> Yes <input type="checkbox"/> No, Explain WHY to your answer!
7	Do you have a room/table to do your job/task/responsibilities in your office?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Other explain_____

8	In your opinion, on five scales. At what level of your report on time?	
9	What is your barrier to performing SIMUNDU reporting seen from the facility aspect?	
10	What is your barrier to performing SIMUNDU reporting seen from yourself?	<p><b>Choose an option that relevant to you! You allow choosing more than one.</b></p> <p><input type="checkbox"/> It is difficult to enter the data to SIMUNDU.</p> <p><input type="checkbox"/> I don't have time to enter the data to SIMUNDU.</p> <p><input type="checkbox"/> I have other tasks to do</p> <p><input type="checkbox"/> I do not have computer skills</p> <p><input type="checkbox"/> I was never getting training on operating SIMUNDU.</p> <p><input type="checkbox"/> It is not essential to do</p> <p><input type="checkbox"/> Other, explain _____</p>
<b>G. Managerial process</b>		
1	What is the goal of SIMUNDU implementation?	
2	Do you think, are you have sufficient skill to use SIMUNDU?	
3	Have you participated in the SIMUNDU dissemination?	<p><input type="checkbox"/> Yes      <input type="checkbox"/> No</p> <p>If you <input checked="" type="checkbox"/> YES, answer the question below:</p> <p>Who did the dissemination _____</p> <p>When it was held _____</p> <p>Where it was held _____</p>
4	Who is monitor your work on SIMUNDU?	
5	Do you analyze data from SIMUNDU?	<p><input type="checkbox"/> Yes      <input type="checkbox"/> No</p> <p>If you <input checked="" type="checkbox"/> YES, answer the question below:</p>

		For what purpose? _____
6	How often, SIMUNDU been evaluated?	_____ Who did the evaluation _____
7	Did you receive the feedback related to the result of the evaluation of immunization data that you enter on SIMUNDU?	<input type="checkbox"/> Yes <input type="checkbox"/> No If you <input checked="" type="checkbox"/> YES, answer next question: By whom _____
8	When you experience trouble with SIMUNDU, what do you do? Who are you contacting?	I did _____ I contacted _____

#### IV. KEY INFORMANT INTERVIEW GUIDELINE

**AIM:** To elucidate the factors identified in the previous steps and also tell the successful story of SIMUNDU implementation from its introduction and throughout the 5 years of implementation.

**Proposed Key Informant:**

Note: *The key informants will be identified after the quantitative phase ben analyzed  
The interview will be stopped when saturation has been reached.*

The head of the provincial health office	<ol style="list-style-type: none"> <li>1) What is the goal of SIMUNDU development?</li> <li>2) From which slot the funding is taken?</li> <li>3) How has the government seen the sustainability of SIMUNDU? How to reach sustainability?</li> <li>4) How useful is SIMUNDU?</li> <li>5) What is the barrier during the SIMUNDU implementation?</li> </ol>
The head of district/city health office	<ol style="list-style-type: none"> <li>1) What is your opinion about SIMUNDU?</li> <li>2) Is it useful for you and your district? For what purpose?</li> <li>3) How you use this system?</li> <li>4) Do you think SIMUNDU is essential to keep? Why?</li> </ol>
Immunization coordinator in provincial, district/city HO	<ol style="list-style-type: none"> <li>1) What is your opinion about SIMUNDU?</li> <li>2) Is it useful for you and your district? For what purpose? Explain</li> </ol>

	<p>3) How you use this system? Explain.</p> <p>4) Do you think SIMUNDU is essential to keep? Why? Explain</p>
IT department in PHO	<p>1) Tell me about the history of SIMUNDU?</p> <p>2) Do you think that this system already stable?</p> <p>3) What aspect should be improved?</p> <p>4) What aspect is lacking?</p> <p>5) What is your suggestion to maintain SIMUNDU sustainability?</p>
Hospital	<p>1) Do you think you have sufficient capacity to use SIMUNDU?</p> <p>2) What barrier that you found on using SIMUNDU?</p> <p>3) How you solved this</p> <p>4) What aspect should be improved?</p> <p>5) What aspect is lacking?</p>
Private clinic	
Midwives practice	
Posyandu	
PHC in rural and urban	



**Table 1.** Respondent response during the survey

Questions	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
Among the two systems – Offline and Online – which one do you prefer? ONLINE OFFLINE	93 (82.3) 20 (17,7)	24 (96.0) 1 (4.0)	4 (100) 0 (0.0)
Do you carry out any other work/duties besides SIMUNDU? No Yes	3 (2,7) 110 (97,3)	3 (12.0) 22 (88.0)	0 (0.0) 4 (100)
Who is the main person in charge of doing data entry to SIMUNDU in your office? Myself Other	96 (85.0) 17 (15.0)	18 (72.0) 7 (28.0)	3 (75.0) 1 (25.0)
How long have you been in charge of entering immunization data using SIMUNDU? <1 year 1-2 year 2-3 year 3-4 year >4 year	8 (7.1) 7 (6.2) 16 (14.2) 17 (15.0) 65 (57.5)	5 (20.0) 15 (60.0) 1 (4.0) 1 (4.0) 3 (12.0)	*
How long have you been in charge of managing SIMUNDU? <1 year 1-2 year 2-3 year 3-4 year >4 year	*	*	1 (25.0) 0 (0.0) 0 (0.0) 0 (0.0) 3 (75.0)
23. Of the several items below, which ones you can operate to support work at SIMUNDU? Excel spreadsheet Extract file Export-import file Email/browsing Other <i>Respondent allows selecting more than one response.</i>	61 (23.6) 42 (16.3) 58 (22.5) 92 (35.7) 5 (1.9)	14 (32.6) 4 (9.3) 6 (14.0) 18 (41.9) 1 (2.3)	1 (20.0) 1 (20.0) 1 (20.0) 2 (40.0) 0 (0.0)
<b>Barrier perception</b>			
Have you ever had difficulty operating SIMUNDU? Yes No	93 (82.3) 20 (17.7)	16 (64.0) 9 (36.0)	2 (50.0) 2 (50.0)
When experienced with difficulties in operating SIMUNDU, with whom you discuss to ask solutions? Puskesmas / PHC District health office DIY health office Other (staff in other health facilities) <i>Respondent allows selecting more than one response.</i>	17 (9.6) 73 (41.0) 66 (37.1) 22 (12.4)	13 (56.6) 6 (26.1) 2 (8.7) 2 (8.7)	0 (0.0) 0 (0.0) 2 (100) 0 (0.0)

Are you satisfied with the follow-up taken from the results of the consultation?			
No	1 (1.1)	0 (0.0)	0 (0.0)
Yes	92 (98.9)	16 (100)	4 (100)
<b>Report Timeliness</b>			
In SIMUNDU OFFLINE that has been running so far, have you sent the report according to the specified date?			
No	17 (15.0)	4 (16.0)	1 (25.0)
Yes	87 (77.0)	21 (84.0)	3 (75.0)
I'm operating SIMUNDU online.	9 (8.0)	0	0 (0.0)
On the SIMUNDU OFFLINE. Did you experience any obstacles in the SIMUNDU data entry on time?			*
No	67 (59.3)	16 (64.0)	
Yes	46 (40.7)	9 (36.0)	
On the SIMUNDU OFFLINE. Did you have any obstacles in reporting SIMUNDU data on time?			*
Difficulties on the export file	10 (17.2)	4 (36.4)	
Difficulties on email or sending files	13 (22.4)	0	
Difficulties in the extracted file	9 (15.5)	2 (18.2)	
Other	26 (44.8)	5 (45.5)	
Pada SIMUNDU ONLINE, when do you input your baby/toddler data into SIMUNDU			*
The same day after the service is finished	37 (25.7)	4 (16.0)	
<1 week after service	50 (34.7)	10 (40.0)	
One week - 1 month after service	48 (33.3)	10 (40.0)	
> 1 month after service	9 (6.3)	1 (4.0)	
In the ONLINE system, do you have any obstacles in entering data in SIMUNDU timely?			*
No	52 (46.0)	14 (56.0)	
Yes	61 (54.0)	11 (44.0)	
In OFFLINE systems – in 5 scales. How many do you assess the timeliness of the reports you have provided so far?			
1	0 (0.0)	1 (4.0)	0
2	3 (2.7)	1 (4.0)	0
3	36 (31.9)	9 (36.0)	0
4	60 (53.1)	12 (48.0)	3 (75.0)
5	14 (12.4)	1 (8.0)	1 (25.0)
<b>Data Accuracy</b>			
Have you ever found the data entered at SIMUNDU to be different from the data in the immunization service register?			*
No	29 (25.7)	14 (56.0)	
Yes	84 (74.3)	11 (44.0)	
<b>Data verification</b>			
Have you ever verified the data between the data in SIMUNDU and the data in the immunization service register?			*
No	5 (4.4)	8 (32.0)	

Yes	108 (95.6)	17 (68.0)	
When is data verification done?			*
Monthly	42 (38.9)	10 (58.8)	
Bimonthly	4 (3.7)	2 (11.8)	
Three months	23 (21.3)	1 (5.9)	
Semester	17 (15.7)	1 (5.9)	
Other	22 (20.4)	3 (17.6)	
<b>Data completeness</b>			
According to you, are there a lot of menus/items to input into SIMUNDU?			*
No	51 (45.1)	18 (72.0)	
Yes	62 (54.9)	7 (28.0)	
In your opinion, is the completeness of the menu/item entries in SIMUNDU important?			*
No	1 (0.9)	2 (8.0)	
Yes	112 (99.1)	23 (92.0)	
<b>SIMUNDU accessibility</b>			
Do you agree with the statement that "SIMUNDU is easy to operate?"			
Agree	108 (95.6)	23 (92.0)	4 (100)
Disagree	5 (4.4)	2 (8.0)	0 (0.0)
Did you analyse the SIMUNDU data?		*	
No	26 (23.0)		0 (0.0)
Yes	88 (77.0)		(4 )100)
<b>Over/Under reporting</b>			
Do you have any experience finding data on children/babies in the Immunization Service Register that are not reported to SIMUNDU?			
No	36 (31.9)	13 (52.0)	0 (0.0)
Yes	77 (68.1)	12 (48.0)	4 (100)
Do you have the experience of finding children data in the Immunization Service Register that entry with more than one?			
No	38 (33.6)	15 (60.0)	1 (25.0)
Yes	75 (66.4)	10 (40.0)	3 (75.0)
According to you, does under or over-reporting have an impact on the achievements of the immunization program?			
No	5 (4.4)	1 (4.0)	1 (25.0)
Yes	108 (95.6)	24 (96.0)	3 (75.0)
<b>Facility and infrastructure</b>			
What type of computer do you most use to enter data in SIMUNDU?			
Private laptop	41 (36.3)	4 (14.8)	1 (25.0)
Laptop – office facility	38 (33.6)	4 (14.8)	2 (50.0)
PC – office facility	32 (28.3)	11 (40.7)	1 (25.0)
PC - private	0	0 (0.0)	0 (0.0)
Handphone	0	7 (25.9)	0 (0.0)
Other	2 (1.8)	1 (3.7)	0 (0.0)
Does your current computer/handphone/laptop support your work on operating SIMUNDU?			
No	11 (9.7)	0 (0.0)	1 (25.0)
Yes	102 (90.3)	25 (100)	3 (75.0)

Where are your internet sources from?			
None	0 (0.0)	0 (0.0)	3 (75.0)
Office facility (Wifi)	102 (64.6)	21 (67.7)	1 (25.0)
Data packages pay with their own money	48 (30.4)	9 (29.0)	0
Data packages paid by the office	1 (0.6)	0	0
Other	7 (4.4)	1 (3.2)	0
<i>Respondent allows selecting more than one response</i>			
Is the internet facility that you use, suit your needs for data entry SIMUNDU?			
No	18 (15.9)	2 (8.0)	1 (25.0)
Yes	95 (84.1)	23 (92.0)	3 (75.0)
Where is the source of your electricity?			
PLN	114 (80.9)	25 (80.6)	4 (100)
Genset	27 (19.1)	6 (19.4)	0
None	0	0	0
Other	0	0	0
<i>Respondent allows selecting more than one response.</i>			
Do you have any problems with electricity during SIMUNDU entry?			
No	78 (69.0)	24 (96.0)	4 (100)
Yes	35 (31.0)	1 (4.0)	0
From your side, what are the obstacles in SIMUNDU reporting?			
It is difficult for data entry at SIMUNDU	7 (3.7)	2 (6.1)	0
Do not have time	18 (9.4)	7 (21.2)	1 (20.0)
Have another assignment	95 (49.7)	16 (48.5)	2 (40.0)
My computer skill is poor	37 (19.4)	3 (9.1)	0
Never received SIMUNDU training	11 (5.8)	2 (6.1)	1 (20.0)
Other	23 (12.0)	3 (9.1)	1 (20.0)
<i>Respondent allows selecting more than one response</i>			
<b>Managerial Process</b>			
Do you know the purpose of SIMUNDU development in DIY?			
No	18 (15.9)	6 (24.0)	0
Yes	95 (84.1)	19 (76.0)	4 (100)
Have you ever participated in SIMUNDU in house training?			
No	14 (12.4)	7 (28.0)	1 (25.0)
Yes	99 (87.6)	18 (72.0)	3 (75.0)
When did you last take part in the SIMUNDU in house training?			
< 1 year ago	42 (42.4)	11 (61.1)	0
> 1 year ago	57 (57.6)	7 (38.9)	2 (100)
Which institution conducts SIMUNDU in house training, that you ever attended?			
Puskesmas (PHC)	0 (0.0)	2 (8.0)	0
District/City health office	56 (38.9)	15 (60.0)	0
DIY health office	88 (61.1)	7 (28.0)	0
Other	0 (0.0)	1 (4.0)	2 (100)
<i>Respondent allows selecting more than one response</i>			
What training guides are used during training?			
PPT	80 (49.1)	12 (56.1)	2 (50.0)

Word – hard copy	32 (19.6)	2 (9.5)	1 (25.0)
Word - soft file	36 (22.1)	2 (9.5)	1 (25.0)
Other	15 (9.2)	5 (23.8)	0
Have you ever been monitored and evaluated regarding SIMUNDU?			
No	10 (8.8)	6 (24.0)	0
Yes	103 (91.2)	19 (76.0)	4 (100)
In the last year (July 2019-July 2020), how many times monitoring and evaluation been conducted?			
>2 times	17 (16.5)	2 (10.5)	2 (50.0)
One time	57 (55.3)	11 (57.9)	1 (25.0)
1-2 times	29 (28.2)	6 (31.6)	1 (25.0)
Who did monitor and evaluation SIMUNDU on your place?			
Puskesmas (PHC)	11 (7.0)	11 (39.3)	0
District/City health office	81 (51.3)	8 (28.6)	0
DIY health office	65 (41.1)	8 (28.6)	4 (100)
Other	1 (0.6)	2 (3.6)	0
<i>Respondent allows selecting more than one response</i>			
Did you receive any feedback on the results of the SIMUNDU monitoring and evaluation?			
No	6 (5.8)	0 (0.0)	0
Yes	97 (94.2)	19 (100)	4 (100)
Who gave feedback on the M&E results?			
Puskesmas (PHC)	7 (4.6)	10 (40.0)	0
District/City health office	73 (48.3)	8 (32.0)	0
DIY health office	69 (45.7)	6 (24.0)	4 (100)
Other	2 (1.3)	1 (4.0)	0
<i>Respondent allows selecting more than one response</i>			
In the last year ((July 2019 - July 2020), have you ever monitored the health facility under your supervision?	*	*	
Yes			4 (100)
No			0
Have you ever participated in the dissemination of M&E results as well as updating knowledge?			
No	28 (24.8)	16 (64.0)	0
Yes	85 (75.2)	9 (36.0)	4 (100)
Who is organizing the dissemination of M&E results as well as updating the knowledge?			
Puskesmas (PHC)	3 (2.5)	0 (0.0)	0
District/City health office	53 (44.2)	6 (60.0)	1 (25.0)
DIY health office	63 (52.5)	4 (40.0)	3 (75.0)
Other	1 (0.8)	0 (0.0)	0
<i>Respondent allows selecting more than one response</i>			

\*data not applicable

# BMC Health Services Research

## Introducing and implementing an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up --Manuscript Draft--

<b>Manuscript Number:</b>	BHSR-D-21-00992R1	
<b>Full Title:</b>	Introducing and implementing an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up	
<b>Article Type:</b>	Research article	
<b>Section/Category:</b>	Health systems and services in low and middle income settings	
<b>Funding Information:</b>	Alliance for Health Policy and Systems Research (2020/1011143-0)	Dr Sulistyawati Sulistyawati
<b>Abstract:</b>	<p>Background : Immunization is undeniable as a critical aspect to safe children from any infections. To increase the coverage of immunization, valid and real-time data is needed. Accordingly, having a good report system is essential that rolled as defaulter tracking to prevent the children's immunization failure. DIY health office develops an individual electronic immunization registry and succeeds implemented it for more than five years. It is the only individual-based record system in Indonesia that has survived for such a long time. To date, there is no systematic assessment of this system. Therefore, this research aimed to examine SIMUNDU's introduction and implementation process to draw lessons that could inform scalability and sustainability across the country. Methods : An explanatory sequential mixed-method design was used in this study by involving 142 and 9 participants quantitative and qualitative study - respectively. Entry data clerk in all level of health facility was systematically selected to participate in the survey. While in the key informant interview, the informant was selected based on the survey result. The descriptive and thematic approach was employed to analyze the quantitative and qualitative data – respectively. Integration between the two approaches was accomplished in the interpretation of the result by comparison and contrast. Results : Three core themes emerged from our analysis that describes the SIMUNDU success journey as an electronic immunization registry: system strengths, potential threats and opportunities. Conclusions : The individual electronic immunization registry has been implemented well and it may contribute to increasing immunization coverage in DIY. Stakeholders should consider the sustainability of this system by providing related resources and consider scale-up nationally by looking at this promising program.</p>	
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# Introducing and implementing an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up

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## Abstract

**Background:** Immunization is undeniable as a critical aspect of safe children from infections. To increase the coverage of immunization, valid and real-time data is needed. Accordingly, having a good report system is essential that rolled as defaulter tracking to prevent the children's immunization failure. DIY health office developed an individual electronic immunization registry and successfully implemented it for more than five years. It is the only individual-based record system in Indonesia that has survived for such a long time. To date, there is no systematic assessment of this system. Therefore, this research aimed to examine SIMUNDU's introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.

**Methods:** An explanatory sequential mixed-method design was used in this study by involving 142 and 9 participants quantitative and qualitative study - respectively. Entry data clerk in all level of health facility was systematically selected to participate in the survey. While in the key informant interview, the informant was selected based on the survey result. The descriptive and thematic approach was employed to analyze the quantitative and qualitative data. Integration between the two approaches was accomplished in the interpretation of the result by comparison and contrast.

**Results:** Three core themes emerged from our analysis that describes the SIMUNDU success journey as an electronic immunization registry: system strengths, potential threats and opportunities.

**Conclusions:** The individual electronic immunization registry has been implemented well, and it may contribute to increase immunization coverage in DIY. Stakeholders should consider the sustainability of this system by providing related resources and consider scale-up nationally by looking at this promising program.



1 **Keywords:** immunization, electronic immunization registry, immunization information  
2 system, interoperability, implementation research  
3

## 4 **Background**

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6  
7 Neonatal and childhood vaccination is an essential component of infectious disease  
8 prevention and an absolute human right (1),(2). Vaccination has been proven to reduce  
9 the burden of infectious disease globally (3). According to the WHO, in 2020 estimated  
10 23 million children under one year of age did not receive their essential vaccinations. Of  
11 these, 60% live in just ten countries, one of which is Indonesia (4). Indonesia is the fourth  
12 most populous country globally. It is composed of thousands of islands organized into 34  
13 provinces. Various geographical and cultural factors influence population inequalities to  
14 access to health services (5). In 2001, the Indonesian government's decentralization policy  
15 was enacted. This was an excellent strategy to foster development by engaging regional  
16 resources (6). However, this strategy was not without consequence. One major concern  
17 is the fragmentation of the Health Information System (HIS).  
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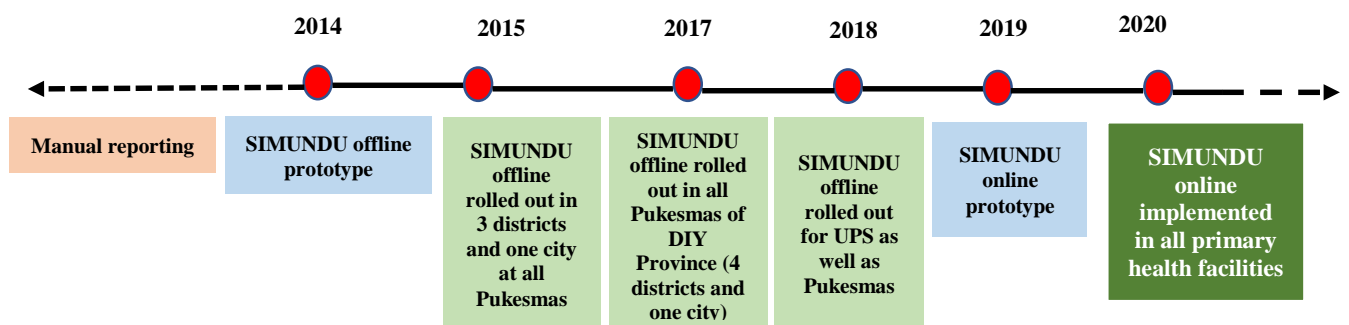
21 Indonesia's federal structure results in provinces and districts being relatively independent  
22 of the national Ministry of Health. This means that information systems at provincial and  
23 district levels are locally regulated (7). For instance, *Pemantauan Wilayah Setempat*  
24 (PWS) is a management tool used to monitor coverage of specific health services in an  
25 administrative boundary. It can be paper- or electronic-based, depending on the service  
26 and region. PWS-KIA is the monitoring system specific to maternal and child health  
27 (KIA), including immunization. Data recorded in the PWS-KIA are reported to the  
28 District or City Health Office, which reports to the Province Health Office, which  
29 transmits the data to the central level through simple emails if reporting is done in excel,  
30 or through various information systems including Komdat, SiTT, SIHA, PISPK, SIKDA  
31 Generik. In some provinces only, PWS-KIA data feeds into the DHIS2. Regional  
32 information systems have varying data quality, which reflects inequities in resources  
33 across regions. This adds to data integration challenges at the national level (7),(8) and  
34 affects strategic policymaking.  
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39 In the context of Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY)  
40 Province has the authority to regulate and use its budget within its four districts (Sleman,  
41 Gunungkidul, Bantul, Kulonprogo) and Yogyakarta city. Regarding childhood  
42 vaccination, DIY is among the top ten performing provinces in the country, with 97.7 %  
43 complete basic immunization coverage in 2019 (9). Immunization services are provided  
44 by Primary Health Centres (*Puskesmas*), as well as private clinics, hospitals, and  
45 midwives' practices (typically referred to as *Unit Pelayanan Swasta* (UPS)).  
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48 In 2014, the DIY Health Office introduced an electronic immunization registry named  
49 SIMUNDU (*Sistem Informasi Imunisasi Terpadu*/ Integrated Immunization Information  
50 System). An electronic immunization registry is a tool for recording individual children's  
51 immunization histories. An electronic registry serves essential functions at all levels of  
52 the health system. The service delivery level can facilitate individual follow-up of  
53 vaccination status and enable health workers to identify children due for vaccination and  
54 those who missed their vaccinations (defaulters). At the district and higher levels, it  
55 allows for monitoring vaccination coverage by the vaccine, dose, cohort, and other  
56 variables – and can support microplanning and vaccine management.  
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SIMUNDU was designed to link with the PWS-KIA for immunization and interoperability with the DHIS2. While it predominantly contains individual-level immunization records, SIMUNDU also serves as a source for aggregation and can synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this reason, it can be considered an Immunization Information System (IIS). This means that data from City and District levels feed into Provincial and National levels (*Personal communication with DIY immunization program officer*).

The original prototype was designed by the information and technology (IT) department of DIY Health Office to be operated offline. In DIY, three out of the four districts and the city introduced the system in 2015. The final district introduced it in 2017. At this stage, the point of data entry was the Puskesmas only. By 2018, UPS facilities were also equipped with SIMUNDU and could enter data into the system. In 2019, the prototype was further developed to operate online. The online version was rolled out in 2020 (Figure 1). As of May 2021, 79.4% of all Puskesmas and UPS facilities were complying. This average rate masks, however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce its use in UPC facilities (Suyani 2020, oral communication, 2020 May 11)



**Figure 1.** SIMUNDU’s development and introduction

When a child receives a vaccination in a health facility, information on the child and the vaccination is entered in SIMUNDU as an individual child record. Each record includes an individual identifier, child’s socio-demographic characteristics (e.g., name, gender, date of birth, name of parents, address), the antigen administered, and the date and place of vaccination. SIMUNDU has been recently updated to allow recording of vaccinations administered in schools (e.g., Human papillomavirus (HPV), Difteri Toxoid (DT), Tetanus Difteri (TD), and Measles-Rubella (MR)) – at this stage, only in aggregate form. Furthermore, SIMUNDU is being developed to record COVID-19 vaccinations in health facilities and those carried out in masse.

Monitoring is conducted every month to assess data completeness across health facilities, while an evaluation is conducted every year. These exercises have allowed the identification of several challenges related to implementing the system (e.g., workload, staff turnover, and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic assessment of the system has been conducted to date.

SIMUNDU is the first immunization information system ever introduced in Indonesia. Other districts and provinces have shown interest in rolling it out, and the Ministry of Health has acknowledged the innovation. The objective of this work was to examine SIMUNDU's introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.

## Methods

From May to October 2020, we examined the experience of introducing and implementing an immunization information system in the DIY province using a sequential mixed-method design, where each step informed the next (10). First, we conducted a desk review of all relevant documentation available in the DIY health office – e.g., staff notes, meeting notes and monitoring notes – documenting SIMUNDU development and management processes. We also examined online documents, including health profiles and regulations on health reporting systems in Indonesia. This served as the initial source of data and provided an overview of who was involved and their role in developing and implementing SIMUNDU. This informed the survey design that we conducted as a second step. The survey was conducted with staff responsible for entering data in SIMUNDU across Puskesmas and UPS facilities and staff responsible for managing the system at the district and city level. Sampling and recruitment strategies are outlined in Table 1.

**Table 1. Survey sampling**

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
<b>Puskesmas/Primary Health Centre (PHC)</b>	121	Immunization coordinator and data entry clerk	All facilities	Open invitation across all facilities	115
<b>Hospital (Central, General, Maternity and Pediatric)</b>	65	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
<b>Clinic</b>	73	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
<b>Midwives' Practice</b>	271	Immunization coordinator and data entry clerk	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	110
<b>District/City Health Office</b>	5	Immunization coordinator	Total sampling	Open invitation	6*
<b>Total</b>					<b>146</b>

\*As the immunization coordinator had recently changed, the former was also invited.

1 All immunization coordinators and data entry clerks from all primary health facilities and  
2 the District/City Health Office were invited to participate in this survey. For UPS  
3 facilities, we randomly selected two clinics, two midwives' practices, and two hospitals  
4 per district and city and invited all of their staff involved in SIMUNDU data entry and  
5 management.  
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9 We developed and pre-tested an online survey in Bahasa Indonesia to inquire about  
10 SIMUNDU implementation, processes, and outcomes (*Sup.1*). All participants provided  
11 consent to participate in the survey. All participants were invited to the DIY health office  
12 to fill out the survey on their laptops. Having all participants in a room allowed  
13 researchers to monitor potential gaps in responses in real-time and follow-up with  
14 individual participants on-site to fill any gaps. Data were then exported into and analyzed  
15 in Microsoft Excel.  
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19 Next, we conducted key informant interviews to explore the challenges of implementing  
20 the system both from a practice and managerial standpoint. Each interview was conducted  
21 by three researchers with a different role: main interviewer, observer, and field note taker.  
22 SS, RR, TWS, SKW, and SAM were involved in the interviews. All of them were female  
23 with a public health background and worked as lecturers and researchers at university.  
24 An interview guide was developed by the research group and was consulted with the  
25 expert prior used for the interview. The interview takes approximately 30 minutes.  
26  
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29 Informants were purposefully selected among survey participants to follow up on the  
30 range of perspectives that had emerged from the survey. As informed by the desk review,  
31 others were chosen for their management functions. The informant and interviewer did  
32 not know each other prior to the interview. Informants were invited to Province Health  
33 Office for interview purposes due to COVID-19 pandemic reasons. Before the interview,  
34 the informant was informed about the study and asked to sign the informed consent. All  
35 invited informants agreed to participate. A total of nine key informants were interviewed  
36 in Bahasa Indonesia language. The face-to-face interviews were recorded with consent  
37 from the informants. After the interview, the interviewer summarized our field notes to  
38 the informant for correction.  
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42 Thematic analysis was conducted using Quirkos qualitative tool following Braun and  
43 Clarke's approaches (11). Researchers familiarized themselves with the data, searching  
44 for initial codes and allowing themes to emerge. SS was the main coder during the  
45 analysis. Then the result of the coding reviewed together among the research group  
46 continued with defining and naming the core themes, analyzed the data for each of the  
47 core themes, triangulated information from the desk review, the survey, and the  
48 interviews. Themes were generated from the data during the analysis.  
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## Results

Findings from the study are presented across the three core themes that emerged from the analysis, notably system strengths, potential threats, and opportunities, drawing from the qualitative and quantitative data collected (Figure 2).

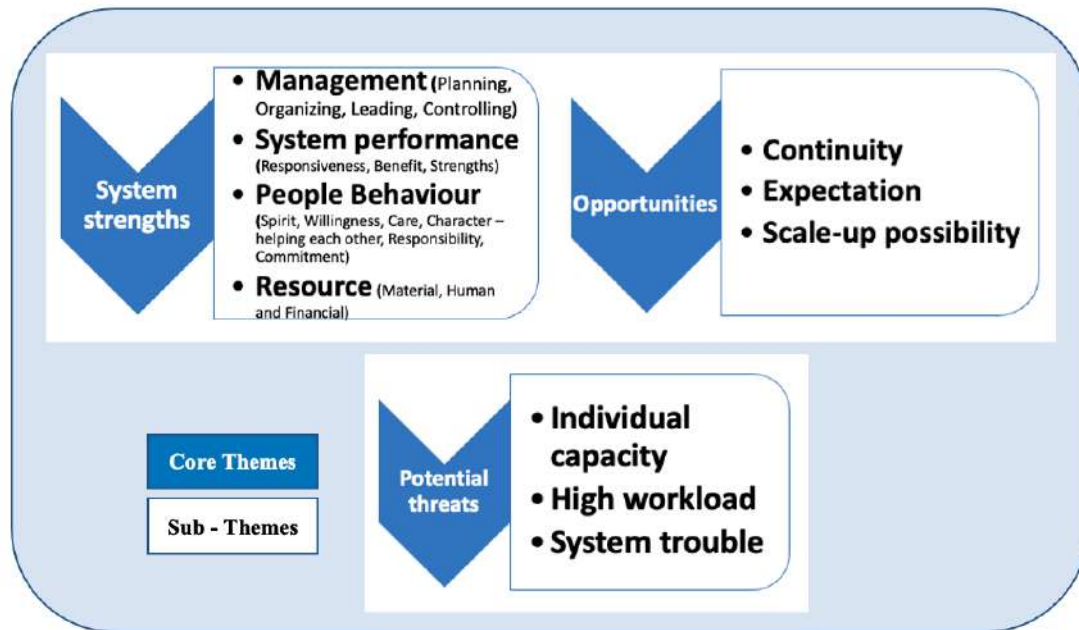


Figure 2. Strengths, potential threats, and opportunities for scale-up

### System's Strengths

Factors contributing to the success of SIMUNDU include management, system performance, people's behavior, and resources.

#### Management

Management factors relate to SIMUNDU development and all levels of the management chain (**planning, organizing, leading, and controlling**). SIMUNDU arose due to concerns from the DIY health office immunization section around data quality, including inaccurate data, duplicate or missing data and lack of timely data, and the need to support follow-up and appropriate planning. SIMUNDU was designed to address these challenges and needs.

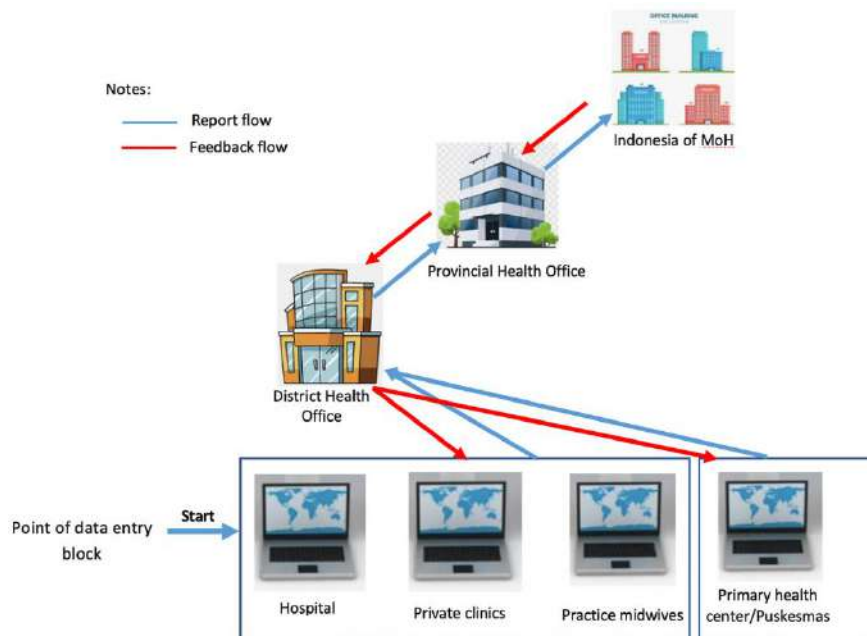
*To our knowledge, [SIMUNDU development] started with a problem: estimates of the target population varied depending on the data source.*

*Yes, I think [SIMUNDU management team] started to tire of managing a large volume of data with dubious validity. They need to know the situation in each district.*

1 Effective management of SIMUNDU from development to implementation has been  
2 highlighted as an essential determinant of its success. Here, we review its management  
3 across the critical functions of Planning, Organizing, Leading, and Controlling.  
4

5  
6 **Careful Planning** has been ensured at each stage of SIMUNDU development and  
7 implementation. These stages include an initial business plan, training on and  
8 socialization to SIMUNDU, and a staff replacement plan to respond to turnover or  
9 retirement of staff in charge of operating or entering data into SIMUNDU. The parties  
10 involved in planning included the head disease prevention and control department, IT  
11 personnel, and immunization program staff from the DIY health office.  
12  
13

14  
15 **Organizing** - the organization of SIMUNDU is carried out at several levels. The top-  
16 level is at the level of the DIY health office, the second level is at the district/city health  
17 office, and the third level is the level of the health facilities (figure 2). A third party was  
18 also involved in developing the system interface.  
19  
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44 **Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

45  
46 At the beginning of SIMUNDU development, essential functions included database  
47 administrators, interface designers, and server administrators, and their interplay  
48 facilitated the smooth operation of the system. Training specific to SIMUNDU was  
49 integrated with other training, typically immunization-related training. This enabled to  
50 sharing of resources with other programs, thus ensuring viability. The training was  
51 delivered in the district/city health office: 70% of survey respondents indicated they had  
52 benefited. Training typically consisted of short training and included practice on the  
53 trainee's device and how to operate the system both in online and offline mode. Day-to-  
54 day operations were carried out autonomously by the staff, through adjusting their work  
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1 to protect time to enter the data. Some informants reported that staff members divided  
2 tasks effectively to ensure work was carried out effectively.  
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4 **Leading** - the success of SIMUNDU implementation is arguably related to strong  
5 leadership. Informants noted that managers played a key role in bridging the  
6 immunization program with the system design, closely monitoring the initial  
7 implementation process, and creating an enabling environment.  
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10 *I try to combine supporting and managing the people involved and monitoring them.*  
11 *Currently, I monitor whether [SIMUNDU] can run optimally as our users are health*  
12 *facilities. I also monitor program development and the system's output.*  
13

14 *[SIMUNDU] was born from program managers, primary health centers, Districts, and*  
15 *DIY health offices wanting to build systems together. We – DIY health office - give them*  
16 *motivation in every meeting.*  
17

18 *I see that [management] is very good at networking. Staff data entry in the field always*  
19 *said that these people are very kind.*  
20

21 The role of IT in developing SIMUNDU was also reported to be significant. They helped  
22 develop the system and supported correct data entry by assisting data entry operators who  
23 experienced technical issues or helping resolve inconsistencies in the data records.  
24 Acknowledgment of staff efforts was also an important lever to maintain motivation and  
25 buy-in.  
26

27 *In the early days of SIMUNDU's development, the system was challenging to operate,*  
28 *as it wasn't as stable as it is now. I praise the enthusiasm and dedication of the users).*  
29

30 **Managing quality assurance** was critical to avoid data duplication or missing entries.  
31 This process was not regulated by specific Standard Operating Procedures but was  
32 addressed during training and monitored monthly. In addition, the DIY health office  
33 provided negative incentives to health facilities that were not providing complete records  
34 and provided regular feedback from monitoring and evaluation exercises.  
35

36 We found that 90%, 76%, and 100% of survey respondents in PHC, UPS, and DHO,  
37 respectively, reported their work had been monitored regarding SIMUNDU. More than  
38 half of the respondents in Puskesmas and UPS facilities were observed at least once in  
39 2019. At the PHC level, more than 50% reported that staff from the district/city level  
40 conducted the monitoring, and >40% reported that the DIY health office staff conducted  
41 monitoring. Furthermore, almost 40% of respondents from UPS facilities were monitored  
42 by Puskesmas. Nearly 100% of survey respondents stated they received feedback from  
43 the monitoring, mainly from the District/City and DIY health offices. Forty percent of  
44 respondents from UPS facilities reported receiving feedback from Puskesmas.  
45 Immunization coordinators from the District/City health offices reported that the DIY  
46 health office provided them with feedback.  
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1 *In a [evaluation] meeting, DIY health office or district health office showed the*  
2 *progress of our data entry – correct or not, proper or not*  
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4 Another resource that influences the successful implementation of SIMUNDU is the size  
5 of the DIY province. This province is quite a small geographic area. Because it consists  
6 of five districts and one city, this province is relatively easy to monitor across all phases,  
7 from planning through monitoring and evaluation.  
8  
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### 10 **System performance**

11 While SIMUNDU predominantly contains individual-level immunization records, it also  
12 serves as a source for aggregation and can synergize with other information systems.  
13 Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports  
14 as per Ministry of Health requirements. These reports are sent to the upper levels directly  
15 if SIMUNDU is operated online or submitted via email if SIMUNDU is operated offline.  
16 This functionality had an essential role in ensuring the acceptability and adoption of the  
17 system.  
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20 Informants noted how transitioning from paper-based tools to an electronic system made  
21 data entry easier and reduced errors. It also facilitated the implementation of protocols  
22 for data storage and security. It facilitated follow-up and defaulter tracking. Finally,  
23 integration with the DHIS2 meant reduced workload for the staff.  
24

25 *We can do faster tracking of children who may have immunizations in different*  
26 *locations. For example, when the first dose of a vaccine is given in Bantul, then the*  
27 *second immunization in Yogyakarta can be connected and detected with the SIMUNDU*  
28 *system.*  
29

30 *Using SIMUNDU makes it easier to detect what data and immunizations are missing*  
31 *since we enter data from the children's birth through the end of the immunization*  
32 *schedule. So, we will know where they missed any vaccine.*  
33

34 *The benefit of using SIMUNDU is first: we know the situation of immunizations more*  
35 *accurately....so, we say that our predictions are real for planning for the future... So,*  
36 *our budget, staff, facilities can be more effective and efficient in providing services.*  
37

38 *Colleagues from the mother and child health (KIA) program enter via the KIA*  
39 *"Sembada." So, this data will appear automatically in SIMUNDU because the two-*  
40 *system are connected.*  
41

42 SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the  
43 responsible staff to maintain data entry irrespective of connectivity. More than 80% of  
44 survey respondents indicated they use the online version of SIMUNDU, and less than  
45 20% of them operate the system offline.  
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1 **People behavior**  
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3 The survey showed that staff commitment was critical for the successful implementation  
4 of SIMUNDU, as indicated by their willingness to work overtime and bring home the  
5 data to enter into the system.  
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8 *I take it [the data] home too, for example, after immunization sessions– in my clinic,  
9 immunization runs four times per month, every week. So, when the session is finished,  
10 we can take it home, [and] do the entry at home while relaxing*  
11

12 Some determinants that facilitated the implementation of SIMUNDU were the societal  
13 culture of helping others and responsibility and commitment to the team. An enabling  
14 environment helped people view SIMUNDU as a shared responsibility and a collective  
15 endeavor. Informants also noted the high motivation of dedicated staff.  
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19 *That's all; we cannot judge by money [people kindness, culture, and behavior]; it's  
20 essential to explain how good people are in Yogyakarta. I was in another place before,  
21 and I could not find people's kindness like in Yogyakarta - different characters.*  
22

23  
24 *The second thing is that we need human resources who are concerned and love with  
25 data; otherwise, even though we have a good system, it will amount to nothing without  
26 good human resources. But when people are concerned about data, good  
27 implementation will come more easily.*  
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30 Other characteristics, such as the culture of helping others and responsibility and  
31 commitment to tasks, revealed from the interviews, were critical determinants in the  
32 successful implementation of SIMUNDU.  
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35 **Resource: human, financial, and material resources**  
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37 Infrastructure and equipment emerged as critical factors to introducing and sustaining  
38 SIMUNDU implementation. Some desktops were specifically allocated to the  
39 immunization program, and some had to be shared with other programs' staff. Other data  
40 entry officers reported using laptops or personal smartphones. The survey found that in  
41 Puskesmas, almost 40% of data entry clerks used their private laptops to enter data into  
42 SIMUNDU. In UPS facilities, nearly 41% reported using office-supplied PCs, and in the  
43 DHO, more than half of the respondents stated they used an office-supplied laptop. The  
44 majority of respondents reported their current device was sufficient to perform their work  
45 on SIMUNDU. Regarding internet access, more than 60% of PHC and UPS staff reported  
46 using the office internet connection to enter data into SIMUNDU. However, 75% of DHO  
47 respondents reported no internet source found during SIMUNDU monitoring.  
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50 Management of financial resources was also crucial. Key informant interviews revealed  
51 no special allocation of funds to SIMUNDU in the initial stages. Resources were  
52 leveraged by sharing activities such as monitoring visits or transportation with other  
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1 programs, thus allowing cost efficiencies. Integration with other programs proved critical  
2 to ensuring sustainability.  
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4 *SIMUNDU's budget comes from the state budget called as Anggaran Pendapatan dan*  
5 *Belanja Negara (APBN). Every year the APBN allocates funding envelop for*  
6 *immunization to DIY and other provinces, where the budget is apportioned across the*  
7 *program [not explicitly written for SIMUNDU]*  
8  
9

10 Human resources are critical to the operation of SIMUNDU. According to respondents,  
11 SIMUNDU data entry clerks must have patience, work carefully and not rush, be  
12 interested in data, be responsible, and have basic computer skills such as Ms word and  
13 Ms excel. Our survey showed that most data entry clerks in PHC and UPS facilities had  
14 a diploma level of education (>80%), while at the managerial level (DHO), 75% of  
15 respondents had a bachelor's degree, suggesting that they have good computer literacy.  
16 Our survey shows that less than 20% and 9% of respondents in PHC and UPS,  
17 respectively, had low computer literacy.  
18  
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20 Various data entry clerks looked for strategies to resolve their obstacles to entering data  
21 to SIMUNDU. Among them, they increased their computer skills by taking private  
22 computer courses. In addition, some of them learned from other colleagues at their  
23 offices. To deal with the accumulation of data needing to be entered in SIMUNDU, staff  
24 sometimes took data home for entry purposes because there is insufficient time during  
25 work hours since they have several other duties. If data entry clerks faced SIMUNDU  
26 trouble, informants said they asked for help from those who might have more information,  
27 for example, the district person in charge.  
28  
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30 *If we found obstacles, we asked people in charge in PHC – asking for a solution or*  
31 *sharing by WhatsApp – or sometimes I asked the IT person in the DIY health office.*  
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### 34 **Potential threats**

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40 The potential constraints on implementing SIMUNDU are individual capacity, technical  
41 or IT issues, and high workload. To date, SIMUNDU can be said to have had successful  
42 implementation. But it does not mean there were no obstacles faced. However, the  
43 important thing is how these obstacles were dealt with.  
44  
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46 Computer literacy of staff was identified as one of the main issues. Internet connectivity  
47 was another obstacle to implementation, as not a good network supported all health  
48 facilities equally. As shown by the survey, only about 60% of Puskesmas and UPS staff  
49 used office internet, while others had to rely on their home internet.  
50  
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52 Another issue that emerged was related to incomplete and inconsistent records; for  
53 example, the child's date of birth or name spelling not matching across different entries,  
54 making it difficult to have a unique and consistent record for each child. During the  
55 development stage, the system interface had to be incrementally finetuned, and some  
56 system failures made it challenging to enter the data. Even though these were temporary  
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1 and were promptly resolved, these system failures were an issue for staff, who were  
2 already juggling a very tight schedule in the office, as they caused some delay. As shown  
3 by the survey, for more than 97% of respondents, entering data in SIMUNDU was not  
4 their only responsibility or function – they also had other tasks.  
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## 7 **Opportunities**

8  
9 Informants said that SIMUNDU is a good system for immunization data. SIMUNDU has  
10 become necessary for program managers and policymakers because it facilitates  
11 monitoring coverage and informing planning and programming. Currently, SIMUNDU  
12 is stable, thus is easier to manage than when it was in the development phase. This means  
13 that the system is not as reliant on the core workforce that has been heavily involved since  
14 inception and will possibly accommodate changes in the workforce. The hopes expressed  
15 by data entry clerks are that SIMUNDU would be easier to operate, and system errors did  
16 not occur. In addition, informants revealed the need for refresher SIMUNDU training so  
17 that their understanding of SIMUNDU would not be lost.  
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23 *In my opinion, SIMUNDU is the best program in DIY which is a collaboration between*  
24 *program managers and IT. It will continue to be implemented because it is a necessity.*

25 *It has been stably used for more than five years, meaning this is needed.*

26  
27 *If I have the tool, in this case, SIMUNDU, when it is stable, whoever will hold it, I am*  
28 *sure that anyone can operate it. It means that it doesn't matter if we have people shifting*  
29 *(jobs).*  
30  
31

32  
33 *In the future, if SIMUNDU is still used, other reports are not necessary. Now we have*  
34 *two different reports: SIMUNDU and stock card of vaccine – each stand-alone and*  
35 *need a separate report.*  
36

37  
38 Based on the informants' statements, SIMUNDU is likely to be developed on a broader  
39 scale. The DIY health office is open to any party learning and implementing SIMUNDU  
40 in their region. However, informants advised that SIMUNDU must have a strong  
41 commitment from the data entry staff and management sides. The leadership in DIY has  
42 shown willingness to assign staff to other provinces who have expressed interest in  
43 SIMUNDU for orientation to the system,  
44  
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## 46 **Discussion**

47  
48 Robust health information systems (HIS) are essential components of strong health  
49 systems (12). Having a timely Immunization Information System (IIS) that collects  
50 individual information and vaccine recipient's history to improve immunization services  
51 is essential to personalize vaccination information, communicate targeted information as  
52 a decision support system, and record vaccination hesitancy (13). Here, we provide  
53 evidence of how an immunization information system has been implemented in practice.  
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1 Sistem Informasi Imunisasi Terpadu (SIMUNDU) or Integrated Immunization  
2 Information System in the DIY province enabled the creation of individual immunization  
3 records for children. SIMUNDU allows users and managers to collect, store and analyze  
4 data on utilization of immunization services, including following up individual children  
5 and creating cohort data. Currently, DIY is the only province in Indonesia – out thirty-  
6 four - that uses an IIS. This work has shed light on the strengths and underlying barriers  
7 of implementing an IIS in this context. The objective was to draw lessons that inform  
8 sustainable scale-up in other regions and possibly at the national level.  
9

10  
11  
12 This study studied the potential factors that facilitate or pose a barrier to SIMUNDU  
13 implementation. We identified management, system performance, people’s behavior, and  
14 resources as determinants for SIMUNDU’s strength that influenced implementation  
15 outcomes: the acceptability, implementation cost, and adoption of this innovation (14).  
16 Individual capacity, system trouble, and high workload were barriers to implementation.  
17

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21 Despite several obstacles encountered during the implementation of SIMUNDU, we see  
22 that this innovation is well accepted by the stakeholders involved. The first stakeholder  
23 group is data entry clerks, who accept several aspects of SIMUNDU: data entry content,  
24 ease of input to the system (not complex), and comfort using SIMUNDU compared to the  
25 previous system. The second stakeholder group is managers; they accepted this system  
26 well and felt there was a benefit in this innovation, namely the output in cohort data to  
27 help them monitor and improve immunization coverages.  
28

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31 Having an excellent managerial process – meaning proper planning, monitoring, and  
32 evaluation - is one reason SIMUNDU has survived and been viable for the last 5 years.  
33 Managers use their power to encourage the beliefs and actions of other people (15). This  
34 requires a dedicated and robust process for the whole of the management process cycle.  
35 SIMUNDU was born from the need for credible data at the DIY health office to assist in  
36 carrying out its duties at the managerial and operator levels. At the managerial level, the  
37 disease prevention and control department and the IT department collaborated to create a  
38 system readily accepted by users. Immunization and IT programmers played a central  
39 role from the beginning of the design throughout the implementation process with  
40 appropriate coordination and communication. Their ability to do so was facilitated by the  
41 full support of their respective superiors.  
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47 SIMUNDU is cost-effective in several ways. During the introductory period of  
48 SIMUNDU implementation, immunization programmers, IT officers, and other staff  
49 assisted in disseminating SIMUNDU to all existing districts. This was done side by side  
50 with other programs, making it cost and time-efficient for managers and staff. As  
51 mentioned, organizing activities is certainly not easy, but it can be carried out well, even  
52 sustainably, by sharing resources. Additionally, SIMUNDU maintenance does not require  
53 high costs because the DIY Health Office developed and maintained the system. Thus,  
54 the IT department can develop improvement processes and tailor them to user needs  
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1 without additional cost. In addition, the location of affordable services (health facilities)  
2 is also part of cost-effectiveness.  
3

4 A good program without good leadership could fail in its implementation, and even if it  
5 was initially successful, it might not be sustainable (16). In the context of SIMUNDU,  
6 support from leadership and the involvement of good people at managerial levels may  
7 have facilitated the program's adoption. The level of SIMUNDU uptake was good  
8 because all health facilities providing immunization services have successfully used this  
9 system, and it has been running well. The adoption of SIMUNDU was facilitated by the  
10 strong networks of the main person in charge of SIMUNDU. Communication, care, and  
11 attention to staff concerns positively affected staff performance. They feel well supported  
12 and are treated kindly – this means that they carry out their work joyfully. Several  
13 informants brought up this theme who stated that the person who played an essential role  
14 in SIMUNDU was the immunization program manager.  
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20 The monitoring and evaluation mechanisms of SIMUNDU were also important.  
21 Preferred monitoring and evaluation activities include monthly reports and direct  
22 discussion with staff during site monitoring visits. The immunization program manager  
23 suggested this approach to maintain data quality and system sustainability. These chosen  
24 mechanisms allow program managers to know the real conditions in the field and the  
25 obstacles faced to inform decisions about the follow-up actions that must be taken. This  
26 supports the ongoing development and learning of SIMUNDU as a tool for data  
27 collection, analysis, and visualization tool, provides benefits for managers to carry out  
28 monitoring and evaluation. The same point was stated by previous research in India about  
29 the innovation of health management information systems for primary health care agrees  
30 that this can provide essential benefits (17).  
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37 Human resources are determinants of the success of health information system  
38 implementation (18). The people's behavior affects how the system works, develops, and  
39 survives (19),(20). In the case of SIMUNDU, implementation was facilitated by the  
40 caring character, networks, and meticulous attitude towards data of both the program  
41 manager and IT team. From the staff's point of view, the local culture of helping each  
42 other and doing their job correctly and responsibly is translated into staff that carries out  
43 their duties with enthusiasm and high commitment. Although facilities, funding and  
44 volume of human resources are limited, the people involved are highly motivated and  
45 supportive. Socio-cultural values, attitudes and beliefs held by staff have contributed to  
46 the successful implementation of SIMUNDU.  
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51 Despite the clear strengths of SIMUNDU, there are potential obstacles to its sustainability  
52 in the future. These obstacles can be divided into human variables and technical variables.  
53 From the human variables side, unequal individual capacities at the operator level can  
54 cause obstructions during data entry in the field. Another potential future obstacle is the  
55 staff's high workload because generally, they have to do other tasks besides SIMUNDU  
56 data entry. From the interview results, the data entry clerks have tried finding strategies  
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1 to overcome this additional workload burden, such as doing data entry at home and  
2 overtime at the office. But from the health system perspective, if this is not anticipated  
3 and a strategy to address it is implemented, it may become unsustainable to expect staff  
4 to continue to do overtime. This will potentially interfere with the data's quality and  
5 overall harm SIMUNDU sustainability.  
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7

8 From this study, we know that SIMUNDU is a promising immunization reporting system.  
9 Although obstacles exist, the benefits and strengths outweigh them. In-depth interviews  
10 revealed the potential for scale-up of this program to other areas. Our findings show that  
11 to maintain the continuity of SIMUNDU, some actions should be taken, such as providing  
12 regular training to the data entry clerks, as the system is constantly being updated. In  
13 addition, there is a need to layering the management structure to anticipate staff rotation  
14 or retiring. Lastly, appropriate motivation, incentive, and support for data entry clerks  
15 need to be ensured.  
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## 21 **Conclusions**

22  
23 SIMUNDU was developed in 2014 by the DIY health office. It was introduced in 2015  
24 across the province and has been successfully implemented. However, there was no  
25 systematic evaluation of the data collected to date's accuracy, completeness, and  
26 timeliness. The benefit of SIMUNDU can be seen from the outputs generated, such as the  
27 cohort data that allows the immunization staff to track and observe each child's  
28 immunization progress, which may contribute to the increase in immunization coverage  
29 in this region.  
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32

33 Despite resource constraints, it was still possible to run SIMUNDU. Initially, there was  
34 no special allocation funding for SIMUNDU, so the program ran side-by-side with other  
35 health programs in the DIY health office. This mechanism allowed cost-efficiency. There  
36 were three prominent persons in charge of developing SIMUNDU: 1) IT person  
37 responsible for system creation and maintenance, 2) the immunization program manager  
38 responsible for the strategic development of SIMUNDU, and 3) data entry clerks who are  
39 accountable for careful data entry into SIMUNDU. When seen from a facility perspective,  
40 SIMUNDU does not require expensive equipment – all that is needed is a computer or  
41 phone and internet access. The fair managerial process influenced the success of  
42 SIMUNDU to date from the DIY province. This required appropriate planning,  
43 organizing, leading, and controlling.  
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49 Three recommendations stemmed from this study, addressed to the DIY health office, the  
50 national government, and researchers. First, to guarantee continuity and sustainability and  
51 reduce the system's dependency on the particular person or party, SIMUNDU  
52 management and maintenance should be related to others with the competency and  
53 interest in a good reporting system. Furthermore, existing human resources should be  
54 strengthened in preparation for scaling up SIMUNDU in other regions or at a national  
55 level; this is necessary to avoid vacant positions when DIY province staff are seconded  
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1 to requests for mentoring from other areas. Second, the bottom-up approach to developing  
2 and implementing SIMUNDU has shown that the system is feasible and viable. The  
3 approach to scaling up SIMUNDU should be stepwise, considering each region's specific  
4 characteristics and problems. Therefore, it is vital to develop a readiness map and a  
5 timeline for the roll-out of SIMUNDU in a particular region. Third, further research is  
6 needed on the impact of SIMUNDU on immunization coverage, for instance, through a  
7 before and after comparative study with a 2–3-year time window in a low-performing  
8 region.

## 13 **Declarations**

### 16 Ethics approval and consent to participate

17 This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan,  
18 Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began,  
19 consent to participate was obtained from research subjects (both survey and key informant  
20 interviews).

### 24 Adherence to national and international regulations

25 Not applicable

### 28 Consent for publication

29 Before data collection begins, an approval that data is taken for publication purposes is  
30 obtained from research subjects (both surveys and key informant interviews).

### 32 Availability of data and materials

33 The datasets generated and/or analyzed for this study can be requested to the  
34 corresponding author.

### 37 Competing interests

38 The authors declare that they have no competing interests

### 41 Funding

42 This study was supported by the Alliance for Health Policy and Systems Research  
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45 designated funding and support for this project, along with the Alliance's long-term core  
46 contributors from national governments and international institutions. For the full list of  
47 Alliance donors, please visit: <https://ahpsr.who.int/about-us/funders>.

### 51 Authors' contributions

52 SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the  
53 data. SS and RR conducted data analysis. SS developed the paper with inputs and  
54 comments from MF on each draft. All authors agree with the manuscript's results and  
55 conclusions.

## Acknowledgments

We are grateful to Mr. Suyani Hartono and Mrs. Ani Roswiani for assisting with the data collection. We also thank all immunization coordinators, managers, and data entry staff who participated in the survey and interviews. Finally, we thank Geetanjali Lamba for the editorial support.

## Authors' information:

The authors alone are responsible for the views expressed in this article. They do not necessarily represent the views, decisions, or policies of the institutions affiliated with them.

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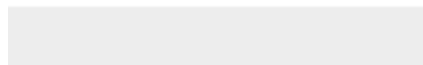
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# Revisi 2

## Reviewer 1

Dear Reviewer 1, thank you very much for your excellent comments and inputs to this manuscript; we appreciate it. Our response to all your comments and input is presented in the table below.

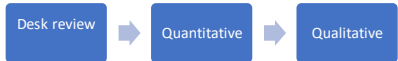
<p>Reviewer 1: Overall Comments: This article makes an important contribution by highlighting the transition and use of digital data systems in tracking childhood immunization in Indonesia. The authors provided a strong description of the system's rollout, enabling factors, challenges, and opportunities.</p> <p>The article could be strengthened by providing additional information from the survey to support the quotes presented. Also, the article would benefit from having short (1 paragraph) limitations and recommendations sections. (The last paragraph of the conclusion is well done and could be expanded for a recommendation section)</p>	<p>Study limitation has been added on Page 16 Line 1, and we have improved the link between conclusions and recommendations.</p>
<p>Abstract: Line 31 "To increase the coverage of immunization, valid and real-time data is needed. Accordingly, having a good report system is essential that rolled as defaulter tracking to prevent the children's immunization failure"</p> <p>Please reword this sentence, as it is difficult to understand the meaning of the word "rolled".</p>	<p><i>The sentence has been reworded to improve readability and understanding. See abstract, page 1, line 24</i></p>
<p>Line 40: Reword to: An explanatory sequential mixed-method design was used in this study which collected quantitative data from 142 participants and quantitative data from 9 participants.</p>	<p>Thank you for your input; the correction can be found in the methods section of the abstract – Page 1, line ??</p>
<p>Background: Pg 2 Line 22: Add "the" before provincial</p>	<p>Thank you for your correction. We made the change, see page 2, line 33</p>
<p>Pg 2 Line 44: Changes to "with 97.7% of children completing basic immunization coverage in 2019"</p>	<p>Thank you for your correction. We made the change, see page 2, line 43</p>
<p>Methods: Overall: Note the procedures that were used for transcription and translation of qualitative data (if not conducted in and analyzed in the same language). For quantitative data collection, was the survey</p>	<p>Thank you for your input. We improved clarity and added information on the transcription and translation process in the method section – Page 5.</p>
<p>* Pg 5 Line 12: The text states "All participants were invited to the DIY health office * to fill out the survey on their laptops. Having all participants in a room allowed * researchers to monitor potential gaps in responses in real-time and follow-up with * individual participants on-site to fill any gaps."</p>	<p>We have addressed this point in the methods session, page 5, line 15</p>

<p>It is important to note the potential for bias that this method introduces into the data collection - monitoring the answering of questions and asking participants to fill in gaps left.</p> <p>This can be noted in the discussion section or in limitations.</p>	
<p>* Pg 5 line 25: Was the interview guide semi-structured? Did the researchers ask probing questions (not on the interview guide) depending on the answers?</p>	<p>Yes, we used a semi-structured interview that allowed the interviewer to probe questions. This information has been added to Page 5.</p>
<p>* Add a few sentences/paragraphs on limitations of the study</p>	<p>Study limitation has been added on Page 16</p>
<p>Results: Overall: The data and information presented appears to rely heavily on the 9 qualitative interviews. The section refers very little the answers from the survey.</p>	<p>Thank you for flagging that findings from the survey seem under-represented in the results section. We have worked through this section to better highlight the contribution of survey data.</p>
<p>If possible, add more of the survey data into the results section, and attribute the information to the survey.</p>	<p>We have worked through the results section to better highlight the contribution of survey data, and attribute each finding to its source (either interviews or surveys).</p>
<p>Additionally, ensure that data is presented fully instead of rounding off the point estimates and writing "more than or less than 50%. Instead, state the true % - example 52.3%.</p>	<p>All percentages have been changed to the true %</p>
<p>Change the highlights/red text so it is consistent for each sub section of the results.</p>	<p>All red highlight has been changed to make it consistent all sections</p>
<p>* Pg 9 line 52 (and elsewhere where survey data is presented)" Present the quantitative results fully - instead of saying "More than 80% of survey respondents", give the actual statistic (for example 81.2%).</p>	<p>All percentages have been changed to the true %</p>
<p>* Pg 11 line 42-44: reword: A number of obstacles were encountered and addressed during implementation.</p>	<p>We have reworded as suggested. See page 13, line 4</p>
<p>* Pg 11 line 53: replace "," with "." After the first sentence. Then change sentence two to read: "An example of this inconsistency of child's date of birth or name spelling among different entries, making it difficult to consistently record immunization information.</p>	<p>We have reworded the sentence based on the suggestion. See page 13, lines 11</p>
<p>Discussion: Overall, gives a good overview of the results and opportunities, however, it can be difficult to follow at points.</p> <p>* Pg 15 lin 45: Reword: "The fair managerial</p>	<p>We have made an additional effort to improve clarity and readability throughout the manuscript.</p> <p>We have also addressed the specific point you are flagging at page 16, line 13 – clarifying</p>

process influenced the success of SIMUNDU to date from the DIY province." What does "the fair managerial process mean? Please reword or explain this better	that we are meaning the quality of the leadership.
* Pg 16 line 1-2: "Second, the bottom-up approach to developing and implementing SIMUNDU has shown that the system is feasible and viable." Can this be reworded?  It is difficult to understand as written.	We have made an additional effort to improve clarity and readability throughout the manuscript, and this specific point at page 16, line 25.
* Pg 16 line 8-9: How would the information from a study like this be useful? Please state it the paper. Third, further research is needed on the impact of SIMUNDU on immunization coverage, for instance, through a before and after comparative study with a 2-3-year time window in a low-performing region.	We are focusing on how information from this study can inform sustainability and recommendations for scale-up. Conclusions and recommendations are developed accordingly.

## Reviewer 2

Dear Reviewer 2, thank you very much for your excellent comments and inputs to this manuscript; we appreciate it. Our response to all your comments and input is presented in the table below.

<p>General Comments:</p> <p>Immunization information systems are an important infrastructure. Authors describe the implementation and evaluation of a system in Indonesia for children. However, methods are very unclear. Perhaps the manuscript could be restructured to describe the implementation first, because it is very unclear if the information was obtained from the methods or not?</p> <p>Seems some of the implementation data was obtained from documents review. Then use the survey and key informant information as an evaluation of the system?</p>	 <p>The manuscript starts indeed with describing how SIMUNDU was developed and implemented first (section on background), and then goes into detailing the data collection methods. In this section, we have outlined a sequential approach to data collection consisting of a desk review, followed by a survey followed by qualitative interviews.</p> <p>Your point about clarity is well taken: we have made an additional effort to improve clarity and readability throughout the manuscript.</p>
Title: Recommend changing to "Implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up	We followed your recommendations, though we also want to maintain the reference to introduction.
Abstract: Background - change safe to save	Thank you for flagging the typo. This was addressed in the abstract, page 1, line 23
Authors use abbreviations in the abstract that should be defined such as DIY, SIMUNDU	The acronyms DIY dan SIMUNDU have been spelled out in the abstract. See page 1, line 26 and 30
Background: Page 2, paragraph 2. Please provide a definition of the DHIS2 since it is used later	DHIS2 has been spelled out on Page 2, line 35 DHIS2 means The District Health Information System 2

Page 2, paragraph 3. Authors describe primary health centers as puskesmas or PHC in other areas of the manuscript.	Puskesmas has been changed to PHC throughout the manuscript
Please be consistent in terminology and if going to use PHC please define it here.	Puskesmas has been changed to PHC throughout the manuscript
Page 3, paragraph 2. This paragraph uses both puskesmas and PHCs	Puskesmas has been changed to PHC throughout the manuscript
Page 3, paragraph 3. Please use English diphtheria	Difteri has been changed to Diphtheria (page 3, line 33)
Page 3, paragraph 3, - please explain how the school information is being loaded into SIMUNDU in aggregate	This is clarified on page 3, line 34.  Vaccinations administered in schools are loaded into SIMUNDU in the form of aggregate data only, as opposed to individual children immunization history - as is the case in health facilities.  Aggregate as opposed to individual-based records.
Methods: Page 4, paragraph 2. Last sentence. Please explain the difference between staff responsible and immunization coordinator are they the same.  The table uses immunization coordinator. Also here use puskesmas versus PHC. Are you also using private clinics and hospitals as in the table.	Let me explain as follow:  Staff responsible for entering the data in PHC and UPS consist mainly of data entry clerks at the facility level.  Immunization coordinators are mainly found at district/city and provincial level, and have managerial responsibilities.  We have worked through the text to improve clarity on these different roles.  Yes, UPS consists of some health facilities such as private clinics and hospitals.
Table 1. Seems a small sample for the clinic and hospital versus PHC and UPS - is there a reason?	Based on the information that has been collected before we executed the survey and considering that the characteristics of each group are almost the same, together with the provincial health office, we agreed to take 2 units per district randomly. We consider this as one of our study limitations. See page 16, line 37
Page 5, paragraph 1. Again are the immunization coordinators the staff responsible and would all facilities have an immunization coordinator.	The modification has been made on Page 4. Immunization coordinator only in district/city, while data entry clerk in all health facility invited
Page 5, paragraph 1, last sentence. Authors state all staff involved with data entry and management. Authors need to be clearer who completed surveys - seems the samples are not consistent across all practices does that mean that private clinics for example had much fewer staff involved with SIMUNDU than UPS for example?	Immunization coordinator only in district/city, while data entry clerk in all health facility invited.  While all PHCs were included in the survey, and all data clerks working at this level invited to participate, only a sample of UPS clinics was selected and data clerks from these selected clinics invited. This explains why only a small



	<p>number of UPS staff, compared to staff from public sector, participated in the survey. Table 1 illustrates the sample process in detail.</p>
<p>Page 5, paragraph 2. Please describe the survey in more depth - how was it developed, how many questions, what types of questions? Any demographic data of the respondents?</p> <p>Usually, a key informant's interview would be done first to then inform the survey. So, methods are slightly different approach. How was the survey data used to drive the key informant interviews.</p>	<p>Detailed information about the survey has been added on Page 5, paragraph 1. Then how was information from the quantitative study used in qualitative study was completed on Page 5, Paragraph 2.</p> <p>Since we used to explain why a particular case like this or like that, we should know first the existing situation in the field, it is why in this research we used explanatory sequential mixed-method design, where quantitative data were completed first then the finding was used to inform the qualitative phase – referred to <i>Fetters MD, Curry LA, Creswell JW. Achieving integration in mixed methods designs - Principles and practices. Health Serv Res. 2013;48(6 PART2):2134–56.</i></p> <p>I have added more information about the approach in the methods section, Page 4, paragraph 1.</p>
<p>Results: Authors do not present any of the survey data from 146 respondents? Only key themes and not sure where the key themes are from - the survey or the key informant interviews. Were the themes already developed when the survey was developed?</p>	<p>Dear reviewer,</p> <p>We have added table 2 and table 3 for the informant's characteristics on Page 6 and 7. Regarding the survey result, we will add it as a supplementary file because it has many pages. This supplementary will replace the questionnaire that we attached before.</p> <p>We have worked through the results section to better highlight the contribution of survey data, and attribute each finding to its source (either interviews or surveys).</p> <p>The themes arose from the analysis of qualitative data. Yet, findings from both the survey and the interviews fed into the analysis of these core themes, to cross-validate the findings</p>
<p>Author reporting of the results seem to mix the introduction and the use of SIMUNDU.</p> <p>Perhaps authors could describe the implementation as part of the background and introduction and then use the survey data and key informants as the results of the system. But it is not clear because authors do not provide enough information to evaluate the survey and the key informant interviews.</p>	<p>We are not sure we understand this comment. The manuscript starts with describing how SIMUNDU was developed and implemented first (section on background), and then goes into detailing the data collection methods. In this section, we have outlined a sequential approach to data collection consisting of a desk review, followed by a survey followed by qualitative interviews.</p> <p>What we can appreciate from this feedback however, is that the manuscript would benefit from more clarity so we have made an additional effort to improve it.</p>

<p>Page 6, paragraph 2. This provides a lot of information about why the system was implemented. Did this come from the survey or the desk review?</p>	<p>Information from the different approaches is integrated in the analysis. While the 3 approaches were implemented sequentially for the stated reason (each step would inform the next), they all contribute to shed light on the process, and we use them as source of triangulation and integration.</p>
<p>Throughout the authors mentioned the survey showed? But how? What were the questions, how many respondents, etc.</p>	<p>Thank you for your question. We have added the requested information in the methods section Table 1, page 4. We also added the survey result will add as supplementary due to the page length.</p>
<p>Page 9, paragraph 3. The authors provide some survey data - this is helpful. Need to see this in all sections to understand.</p>	<p>We have worked through all sections to better highlight the contribution of survey data, and attribute each finding to its source (either interviews or surveys).</p>
<p>Page 11. Also has some survey data presented by the authors but it is difficult to interpret with not all sections containing survey data.</p>	<p>We have worked through all sections to better highlight the contribution of survey data, and attribute each finding to its source (either interviews or surveys).</p>
<p>Discussion Page 13, paragraph 1. Authors provide a nice summary here, but are these questions that were included in the survey.</p>	<p>Page 13, Par. 1: Sistem Informasi Imunisasi Terpadu (SIMUNDU) or Integrated Immunization Information System in the DIY province enabled the creation of individual immunization records for children. SIMUNDU allows users and managers to collect, store and analyze data on utilization of immunization services, including following up individual children and creating cohort data. Currently, DIY is the only province in Indonesia – out thirty-four - that uses an IIS. This work has shed light on the strengths and underlying barriers of implementing an IIS in this context. The objective was to draw lessons that inform sustainable scale-up in other regions and possibly at the national level.</p> <p>This is a background description of SIMUNDU; this is documentary information to set the foundations for the study.</p>
<p>Conclusion Authors should include recommendations and be identified as lessons for scale-up in the discussion instead of conclusion.</p> <p>Conclusion contains background information, that should be deleted. The conclusion should offer a succinct concl</p>	<p>We think that the conclusion is best suited for the recommendations we are putting forward as we intend them as sort of action points moving forward. We nonetheless accept the reviewer’s suggestion to streamline the conclusion and have addressed it.</p>

# 1 Introduction and implementation of an immunization information 2 system in Indonesia province of Daerah Istimewa Yogyakarta: lessons 3 for scale-up

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## 22 Abstract

23 **Background:** Immunization is undeniably critical to save children from infections. To  
24 increase vaccination coverage, valid and real-time data is needed. Accordingly, it is  
25 essential to have a good report system that serves as defaulter tracking to prevent  
26 children's immunization failure. Daerah Istimewa Yogyakarta (DIY) health office  
27 introduced an electronic immunization registry and successfully implemented it for more  
28 than five years. It is the only individual-based record system in Indonesia that has been  
29 sustainably operated for such a long time. Yet, no systematic assessment of this system  
30 had been conducted to date. This study examines Sistem Informasi Imunisasi Terpadu  
31 (SIMUNDU) introduction and implementation process in order to draw lessons that could  
32 inform scalability and sustainability across the country.

33 **Methods:** This study used an explanatory sequential mixed-method design, which  
34 collected quantitative data from 142 participants and qualitative data from 9 participants.  
35 Entry data clerk in health facility was systematically selected to participate in the survey.  
36 While in the key informant interview, the informant was selected based on the survey  
37 result. A descriptive and thematic approach was adopted to analyze the quantitative and  
38 qualitative data. Results from across the two approaches were integrated for comparison  
39 and contrast.

40 **Results:** Findings are presented according to three core themes emerged from the data:  
41 system strengths, potential threats, and opportunities for scale up. Strengths -i.e. factors  
42 contributing to the success of SIMUNDU - include management, system performance,  
43 people's behavior, and resources. Potential threats to sustaining the system include  
44 individual capacity, technical or system issues, and high workload. Opportunities – i.e  
45 promising factor that SIMUNDU can be operated sustainably – such as continuity,  
46 expectation and scale up possibility.

1  
2 **Conclusions:** SIMUNDU is a promising innovation for the entire country, beyond DIY.  
3 There is agreement about the potential for scale-up of this IIS to other provinces.  
4 Experience of implementing this system in DIY over the past five years has shown that  
5 the benefits outweigh the challenges, and SIMUNDU has grown into a robust and yet  
6 user-friendly system.

7  
8 **Keywords:** immunization, electronic immunization registry, immunization information  
9 system, interoperability, implementation research

## 10 **Background**

11  
12 Neonatal and childhood vaccination is an essential component of infectious disease  
13 prevention and an absolute human right (1),(2). Vaccination has been proven to reduce  
14 the burden of infectious disease globally (3). According to the WHO, in 2020 estimated  
15 23 million children under one year of age did not receive their essential vaccinations. Of  
16 these, 60% live in just ten countries, one of which is Indonesia (4). Indonesia is the fourth  
17 most populous country globally. It is composed of thousands of islands organized into 34  
18 provinces. Various geographical and cultural factors influence population inequalities to  
19 access to health services (5). In 2001, the Indonesian government's decentralization policy  
20 was enacted. This was an excellent strategy to foster development by engaging regional  
21 resources (6). However, this strategy was not without consequence. One primary concern  
22 was the fragmentation of the Health Information System (HIS).

23 Indonesia's federal structure results in provinces and districts being relatively independent  
24 of the national Ministry of Health. This means that information systems at the provincial  
25 and district levels are locally regulated (7). For instance, *Pemantauan Wilayah Setempat*  
26 (PWS) is a management tool used to monitor coverage of specific health services in an  
27 administrative boundary. Depending on the service and region, it can be paper- or  
28 electronic-based. PWS-KIA is the monitoring system specific to maternal and child  
29 health (KIA), including immunization. PWS-KIA data are reported to the District or City  
30 Health Office, go to Province Health Office, and finally report to the main level.  
31 Generally, the data is in excel; it will report via emails or various information systems,  
32 including Komdat, SiTT, SIHA, PISPK, SIKDA Generik. PWS-KIA data feeds into the  
33 District Health Information System 2 (DHIS2) in some provinces. Regional information  
34 systems have varying data quality, which reflects inequities in resources across regions.  
35 This adds to data integration challenges at the national level (7),(8) and affects strategic  
36 policymaking.

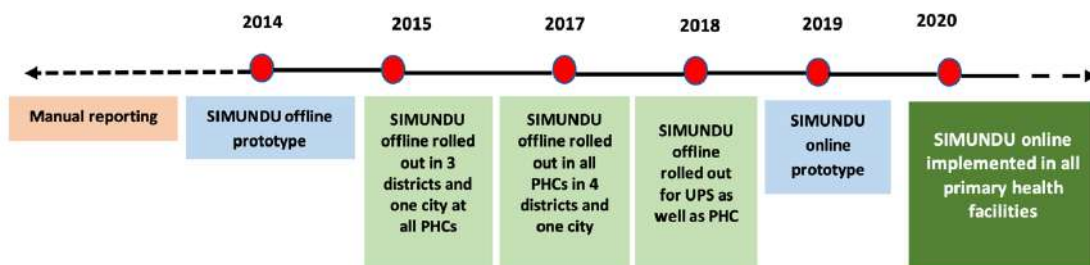
37 In the context of Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY)  
38 Province has the authority to regulate and use its budget within its four districts (Sleman,  
39 Gunungkidul, Bantul, Kulonprogo) and Yogyakarta city. Regarding childhood  
40 vaccination, DIY is among the top ten performing provinces in the country, with 97.7 %  
41 of children completing basic immunization coverage in 2019 (9). Immunization services  
42 are provided by Primary Health Centres or Puskesmas (PHC), as well as private clinics,  
43 hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* or  
44 UPS).

45 In 2014, the DIY Health Office introduced an electronic immunization registry named  
46 SIMUNDU (*Sistem Informasi Imunisasi Terpadu*/ Integrated Immunization Information

1 System). An electronic immunization registry is a tool for recording individual children’s  
2 immunization histories. An electronic registry serves essential functions at all levels of  
3 the health system. At the district and higher levels, it allows for monitoring vaccination  
4 coverage by the vaccine, dose, cohort, and other variables – and can support  
5 microplanning and vaccine management. The service delivery level can facilitate  
6 individual follow-up of vaccination status and enable health workers to identify children  
7 due for vaccination and those who missed their vaccinations (defaulters).

8 SIMUNDU was designed to link with the PWS-KIA for immunization and  
9 interoperability with the DHIS2. While it predominantly contains individual-level  
10 immunization records, SIMUNDU also serves as a source for aggregation and can  
11 synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this  
12 reason, it can be considered an Immunization Information System (IIS). This means that  
13 data from City and District levels feed into Provincial and National levels (*Personal  
14 communication with DIY immunization program officer*).

15 The original prototype was designed by the information and technology (IT) department  
16 of DIY Health Office to be operated offline. In DIY, three out of the four districts and the  
17 city introduced the system in 2015. The final district introduced it in 2017. At this stage,  
18 the point of data entry was the PHC only. By 2018, UPS facilities were also equipped  
19 with SIMUNDU and could enter data into the system. In 2019, the prototype was further  
20 developed to operate online. The online version was rolled out in 2020 (Figure 1). As of  
21 May 2021, 79.4% of all PHC and UPS facilities were complying. This average rate masks,  
22 however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce  
23 its use in UPC facilities (Suyani 2020, oral communication, 2020 May 11).



24  
25 **Figure 1.** SIMUNDU’s development and introduction

26 When a child receives a vaccination in a health facility, information on the child and the  
27 vaccination is entered in SIMUNDU as an individual child record. Each record includes  
28 a personal identifier, the child’s socio-demographic characteristics (e.g., name, gender,  
29 date of birth, name of parents, address), the antigen administered, and the date and place  
30 of vaccination. SIMUNDU has been recently updated to allow recording of vaccinations  
31 administered in schools (e.g., Human papillomavirus (HPV), Diphtheria Toxoid (DT),  
32 Tetanus-Diphtheria (TD), and Measles-Rubella (MR), though in the form of aggregate  
33 data only. Furthermore, SIMUNDU has being developed to record COVID-19  
34 vaccinations in health facilities and those carried out in masse.

35 Monitoring is conducted every month to assess data completeness across health facilities,  
36 while an evaluation is conducted every year. These exercises have allowed the  
37 identification of several challenges related to implementing the system (e.g., workload,  
38 staff turnover, and rotation) and data quality (e.g., accuracy and timeliness). However, no

1 systematic assessment of the system has been conducted to date. SIMUNDU is the first  
 2 immunization information system ever introduced in Indonesia. Other districts and  
 3 provinces have shown interest in rolling it out, and the Ministry of Health has  
 4 acknowledged the innovation. The objective of this work was to examine SIMUNDU’s  
 5 introduction and implementation process to draw lessons that could inform scalability  
 6 and sustainability across the country.

7 **Methods**

8 From May to October 2020, we examined the experience of introducing and  
 9 implementing an immunization information system in the DIY province using an  
 10 explanatory sequential mixed-method design, where each step informed the next (10).  
 11 First, we conducted a desk review of all relevant documentation available in the DIY  
 12 health office – e.g., staff notes, meeting notes and monitoring notes – documenting  
 13 SIMUNDU development and management processes. We also examined online  
 14 documents, including health profiles and regulations on health reporting systems in  
 15 Indonesia. This served as the initial source of data and provided an overview of who was  
 16 involved and how, in developing and implementing SIMUNDU. This informed the  
 17 survey design that we conducted as a second step. The survey targeted any staff  
 18 responsible for entering data in SIMUNDU (i. e. data clerks) across all PHC and selected  
 19 UPS facilities and anystaff responsible for managing the system at the district and city  
 20 level (i.e. immunization coordinators). Sampling and recruitment strategies are outlined  
 21 in Table 1.

22 **Table 1. Survey participant**

23

<b>Level of the data entry and reporting system</b>	<b>Total number of facilities/offices</b>	<b>Study population</b>	<b>Sampling strategy</b>	<b>Recruitment</b>	<b>Sample size</b>
<b>Primary Health Centre (PHC)</b>	121	Data entry clerks	All facilities	Open invitation across all facilities	113
<b>UPS - Central, General, Maternity and Pediatric Hospitals</b>	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
<b>UPS - Clinics</b>	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
<b>UPS - Midwives’ Practices</b>	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	10
<b>District/City Health Office</b>	5	Immunization coordinators	Total sampling	Open invitation	4*
<b>Total</b>					<b>142</b>

24 \*When the immunization coordinator had recently changed, the former was also invited.  
 25

1 All immunization coordinators in each district/city and data entry clerks from all primary  
2 health facilities (PHC) were invited to participate in this survey. As to UPS facilities, we  
3 randomly selected two clinics, two midwives' practices, and two hospitals per  
4 district/city, and invited all of their staff involved in SIMUNDU data entry and  
5 management.

6 We developed and pre-tested an online survey in Bahasa Indonesia to inquire about  
7 SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, district  
8 or city and province offices. [The questionnaire consisted of close-ended and Likert scale](#)  
9 [questions – ranging from 45 to 50 depending on the target type of facility and/or level of](#)  
10 [the health system – and enquired about respondents' socio-demographic characteristics](#)  
11 [as well as the process of implementing and managing SIMUNDU. Some questions](#)  
12 [provided an additional field for clarifying the reason for a particular choice of answer.](#)

13 All participants were invited to the DIY health office to fill out the survey on their laptops,  
14 with their prior consent. Having all participants in a room allowed researchers to monitor  
15 any missing or incomplete responses in real-time and follow-up with individual  
16 participants on-site to fill any gaps. We don't believe this may have introduced any  
17 significant bias as researchers would simply flag any missing response and invite  
18 respondents to address those. Data were then exported into and analyzed in Microsoft  
19 Excel. An exploratory analysis of the survey data informed the topic areas that qualitative  
20 interviews would delve into.

21 Similarly, some informants were purposefully selected among survey participants to  
22 follow up on the range of perspectives that had emerged from the survey. Other  
23 informants had been identified at the desk review stage, and chosen for their management  
24 functions. Selected informants were invited to the DIY Health Office for the purpose of the  
25 interview, and COVID-19 prevention protocol was observed. Every informant was  
26 informed about the study and asked to sign the informed consent. All invited informants  
27 agreed to participate. A total of nine 30-minute semi-structured interviews were  
28 conducted in Bahasa Indonesia language, and recorded with prior consent from  
29 participants. The interview team consisted of three researchers with the respective task of  
30 running the interview, observing and taking notes. A research assistant transcribed all  
31 interviews in Bahasa Indonesia language.

32 Thematic analysis was conducted using Quirkos qualitative tool following Braun and  
33 Clarke's approaches (11). Researchers familiarized themselves with the data, searching  
34 for initial codes and allowing themes to emerge. The principal investigator led the coding  
35 process, and led the research team in defining and naming the core themes emerging from  
36 the data, organizing and analyzing the data across the themes, and triangulating  
37 information from the desk review, the survey, and the interviews. This stage was also  
38 performed in Bahasa Indonesia. Data were translated to English only at sub-theme and  
39 core themes.

1 **Results**

2 **Characteristic participant**

3 a. Quantitative study

4 In total, 142 respondents participated in this study spread across five districts or cities in the DIY  
5 province. Most respondents came from Gunungkidul District, PHC, UPS, and DHO, 24.8%, 24%,  
6 and 25%, respectively. For all research units, the majority are women. At the UPS and DHO/CHO  
7 levels, most respondents aged 41-45 years, i.e., 28.3% and 75%, respectively, while at the UPS  
8 level, the majority aged 25-30 years (56.0%). For education level, PHC and UPS are dominated by  
9 Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, it is predominantly  
10 undergraduate graduates (75%) (Table 2)

11 **Table 2.** Characteristic respondent in three groups of respondents

12

Characteristic	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3 (2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25-30	3 (2.7)	14 (56.0)	0 (0.0)
31-35	30 (26.5)	3 (12.0)	0 (0.0)
36-40	19 (16.8)	1 (4.0)	0 (0.0)
41-45	32 (28.3)	0 (0.0)	3 (75.0)
46-50	18 (15.9)	0 (0.0)	1 (25.0)
>50	11 (9.7)	2 (8.0)	0 (0.0)
Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

13

14 b. Qualitative study

15 Nine informants were recruited to provide the required information to explore deeper  
16 into the quantitative study results. They hold roles as managers and staff at DHO/CHO,  
17 PHC, and UPS. Among the nine informants, 2 were men, and 7 were women. Three  
18 informants graduated from masters, one bachelor's, and five diploma graduates (Table  
19 3).

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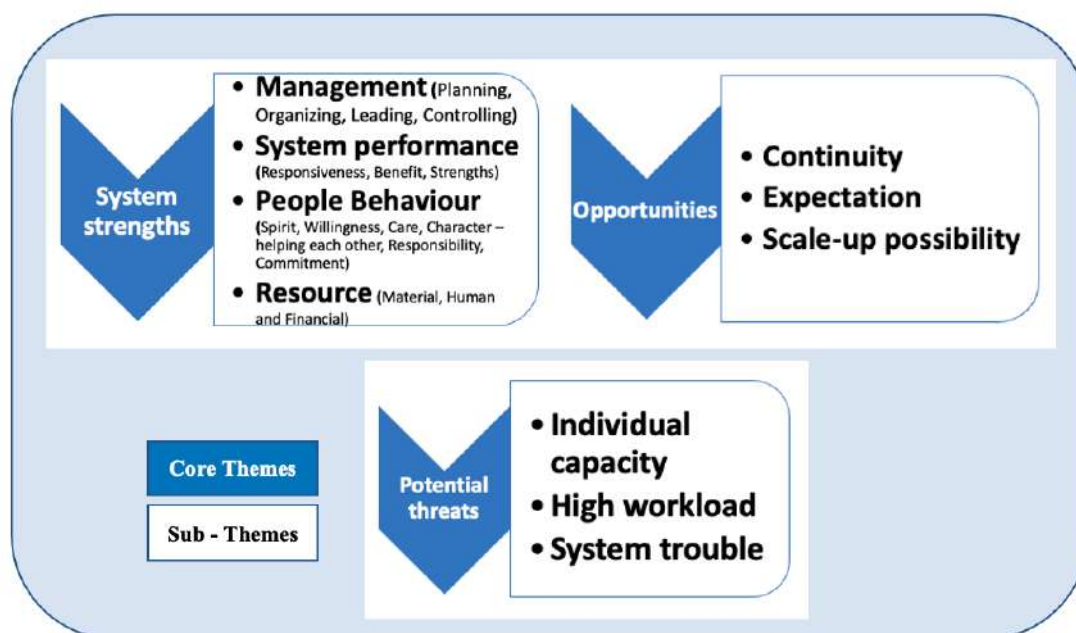
**Table 3.** Informants’ characteristics for the qualitative study

Sex	Age (years)	Education	Position	Subject group	Informant’s code
Female	56	Magister	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Magister	The former of disease prevention and control section at PHO level	Managerial	M 02
Male	54	Bachelor	Immunization programmer at PHO level	Managerial	M 03
Female	47	Magister	IT Person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at UPS level	Staff	S 02
Female	31	Diploma	Data entry at UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

3

4 c. Finding

5 Findings from the study are organized and presented across the three core themes that  
 6 emerged from the qualitative analysis, notably system strengths, potential threats, and  
 7 opportunities for scale-up. Yet, data from both the qualitative and quantitative data fed  
 8 into the analysis of these core themes, to cross-validate the findings (Figure 2. Detailed  
 9 findings from the survey are **presented in Table Supplement 1.**



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**Figure 2.** Strengths, potential threats, and opportunities for scale-up

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## System's Strengths

Factors contributing to the success of SIMUNDU include management, system performance, people's behavior, and resources.

### Management

SIMUNDU arose due to concerns from the DIY health office immunization section around data quality, notably the need to address issues related to data inaccuracy, duplicate or missing data and lack of timely data, and the need of quality data to support follow-up and appropriate planning. The need for SIMUNDU arose from these challenges and needs.

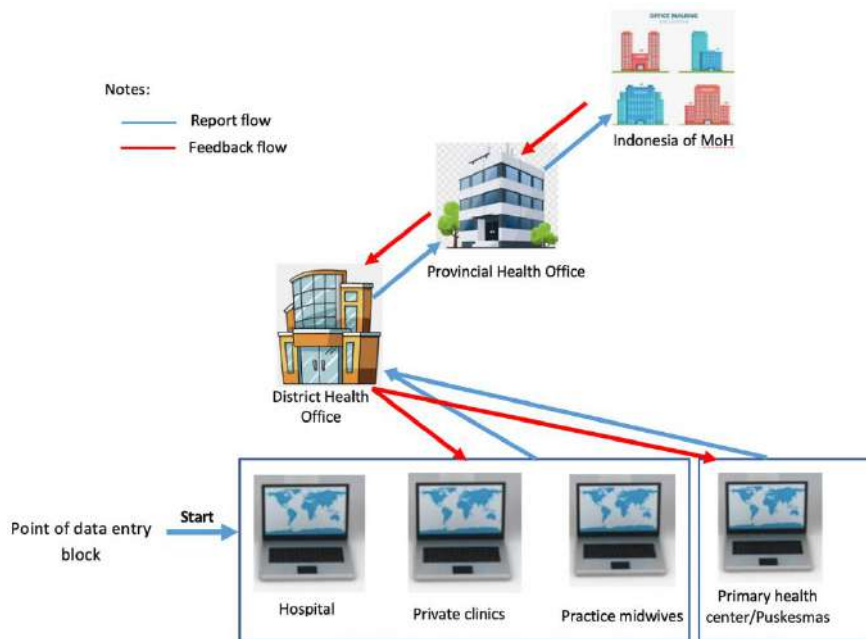
*To our knowledge, [SIMUNDU development] started with a problem: estimates of the target population varied depending on the data source.*

*Yes, I think [SIMUNDU management team] started to tire of managing a large volume of data with dubious validity. They need to know the situation in each district.*

Effective management of SIMUNDU from development to implementation was highlighted as an essential determinant of its success across the critical functions of Planning, Organizing, Leading, and Controlling.

Careful **Planning** was ensured at each stage of SIMUNDU development and implementation. These stages included developing an initial business plan, providing training on and socialization to SIMUNDU, and developing a staff replacement plan to respond to turnover or retirement of staff in charge of operating the system or entering data. The parties involved in planning included the head of disease prevention and control department, IT personnel, and immunization program staff from the DIY health office.

**Organizing** - the organization of SIMUNDU is carried out at several levels. The top level is the DIY health office, the second level is the district/city health office, and the third level is health facilities (Figure 2). A third party was also involved in developing the system interface.



**Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

At the beginning of SIMUNDU development, essential functions included database administrators, interface designers, and server administrators, and their interplay facilitated the smooth operation of the system. Training specific to SIMUNDU was integrated with other training, typically immunization-related training. This enabled to share resources with other programs, thus ensuring viability. The training was delivered in the district/city health office: 87.6%, 72% and 75% of survey respondents from PHC, UPS and DHO/CHO respectively had participated in in-house training. Training typically consisted of short sessions and included practice on the trainee's device on how to operate the system in both online and offline mode. Informants indicated that day-to-day operations were carried out autonomously by the staff, through flexibly adjusting their work to protect time to enter the data. And this seemed to work effectively.

**Leading** - the success of SIMUNDU implementation is arguably related to strong leadership. Informants noted that managers played a crucial role in bridging the needs of the immunization program with the system design, closely monitoring the initial implementation process, and creating an enabling environment.

*I try to combine supporting and managing the people involved and monitoring them.*

*Currently, I monitor whether [SIMUNDU] can run optimally as our users are health facilities. I also monitor program development and the system's output.*

*[SIMUNDU] was born from program managers, primary health centers, Districts, and DIY health offices wanting to build systems together. We – DIY health office - give them motivation in every meeting.*

*I see that [management] is very good at networking. Staff data entry in the field always said that these people are very kind.*

1 The role of IT in developing SIMUNDU was also reported to be significant. They helped  
2 develop the system and supported correct data entry by assisting data entry operators  
3 whenever these encountered technical issues or helping resolve inconsistencies in the data  
4 records. Acknowledgment of staff efforts was also an important lever to maintain  
5 motivation and buy-in.

6 *In the early days of SIMUNDU's development, the system was challenging to operate,*  
7 *as it wasn't as stable as it is now. I praise the enthusiasm and dedication of the users.*

8 The **controlling** function - consisting in **quality** assurance management - was critical to  
9 avoid data duplication or missing entries, and ultimately ensure data quality. This process  
10 was not regulated by specific Standard Operating Procedures but was addressed during  
11 training and monitored monthly. In addition, the DIY health office provided negative  
12 incentives to health facilities that were not submitting complete records and provided  
13 regular feedback from monitoring and evaluation exercises.

14 Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO  
15 respectively, reported their work had been subject to monitoring. More than half of the  
16 respondents in PHC and UPS facilities had been observed by supervisors while  
17 performing data entry at least once over the past year. At the PHC level, 48.3% of survey  
18 respondents had been subject to monitoring from the district/city office's team, and 45.7%  
19 received monitoring from DIY health office's staff. Conversely, 40% of respondents from  
20 UPS facilities were monitored by PHC's staff. Almost all survey respondents reported  
21 receiving feedback from the monitoring, mainly from the District/City and DIY health  
22 offices. Forty percent of respondents from UPS facilities reported receiving feedback  
23 from PHC. Immunization coordinators from the District/City health offices received  
24 feedback from the DIY health office.

25 *In a [evaluation] meeting, DIY health office or district health office showed the*  
26 *progress of our data entry – correct or not, proper or not*

27 It is worth noting that DIY province is quite a small geographic area. Because it consists  
28 of only five districts and one city, this province is relatively easy to monitor across all  
29 phases, from planning through monitoring and evaluation.

### 30 **System performance**

31 While SIMUNDU predominantly contains individual-level immunization records, it also  
32 serves as a source for aggregation and can synergize with other information systems.  
33 Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports  
34 as per Ministry of Health's requirements. These reports are sent to the upper levels  
35 automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is  
36 operated offline. This functionality has had an essential role in ensuring the acceptability  
37 and adoption of the system.

1 Informants noted how transitioning from paper-based tools to an electronic system made  
2 data entry easier and reduced errors. It also facilitated the implementation of protocols  
3 for data storage and security. It enabled follow-up and defaulter tracking. Finally,  
4 integration with the DHIS2 meant reduced workload for the staff.

5 *We can do faster tracking of children who may have received vaccinations in different*  
6 *locations. For example, when the first dose of a vaccine is given in Bantul and the*  
7 *second one in Yogyakarta, the record can be linked within SIMUNDU.*

8 *SIMUNDU makes it easier to detect what data and vaccinations are missing since we*  
9 *enter data from the children's birth through the end of the immunization schedule. So,*  
10 *we will know where they miss any vaccine.*

11 *The benefit of using SIMUNDU is first: we know the situation of immunizations more*  
12 *accurately....so our vaccine forecasting is more accurate .... and our budget, staff,*  
13 *facilities can be more effective and efficient in providing services.*

14 *Colleagues from the mother and child health (KIA) program enter the data via the KIA*  
15 *"Sembada." So, this data will appear automatically in SIMUNDU because the two-*  
16 *system are connected.*

17 SIMUNDU is user-friendly and can be flexibly operated either offline or online, allowing  
18 the responsible staff to maintain data entry irrespective of connectivity. 82.3%, 96% and  
19 100% of survey respondents from PHC, UPS and DHO respectively reported to operate  
20 SIMUNDU online.

## 21 **People's behavior**

22 The interview showed that staff commitment was critical for the successful  
23 implementation of SIMUNDU, as indicated by their willingness to work overtime and  
24 bring home the data to enter into the system.

25 *I take it [the data] home too, for example, after immunization sessions– in my clinic,*  
26 *immunization runs four times per month, every week. So, when the session is finished,*  
27 *we can take the data home, [and] do the entry at home while relaxing*

28 This dedication was confirmed by the interviews, which spoke to a societal culture of  
29 helping others and responsibility and commitment to the team. This contributed to shape  
30 an environment where people approach SIMUNDU as a shared responsibility and a  
31 collective endeavor. Informants also noted the high motivation of dedicated staff.

32 *That's all; we cannot judge by money [people kindness, culture, and behavior]; it's*  
33 *essential to explain how good people are in Yogyakarta. I was in another place before,*  
34 *and I could not find people's kindness like in Yogyakarta - different characters.*

35 *The second thing is that we need human resources concerned and love for data;*  
36 *otherwise, even though we have a good system, it will amount to nothing without good*

1 *human resources. But when people are concerned about data, good implementation will*  
2 *come more easily.*

### 3 **Resource: material, human and financial**

4 Infrastructure and equipment emerged as critical factors to introducing and sustaining  
5 SIMUNDU implementation. Some desktops were specifically allocated to the  
6 immunization program, and some had to be shared with other programs' staff. Other data  
7 entry officers reported using their own laptop or smartphone (36.3% of survey  
8 respondents from PHC). In UPS facilities, 40.7% reported using office desktops, and in  
9 the DHO, more than half of the respondents stated they used an office-supplied laptop.  
10 The majority of respondents – regardless the type of facility - said their current device  
11 was sufficient to perform their work on SIMUNDU. Regarding connectivity, 64.6% of  
12 PHC survey respondents and 67.7% of UPS's reported operating SIMUNDU online  
13 relying on the office's internet connection.

14 Management of financial resources was also crucial. According to the key informants, no  
15 special funds were allocated to SIMUNDU in the initial stages. Resources were leveraged  
16 through sharing activities – e.g. monitoring visits or transportation - with other programs,  
17 thus allowing cost efficiencies. Integration with other programs proved critical to  
18 ensuring sustainability.

19 *SIMUNDU's budget comes from the state budget called as Anggaran Pendapatan dan*  
20 *Belanja Negara (APBN). Every year the APBN allocates a funding envelop for*  
21 *immunization to DIY and other provinces, where the budget is apportioned across the*  
22 *program [not explicitly written budget for SIMUNDU]*

23 Human resources are critical to the operation of SIMUNDU. According to interview,  
24 SIMUNDU data entry clerks must have patience, work carefully and not rush, be  
25 interested in data, be responsible, and have basic computer skills such as Ms word and  
26 Ms excel. As shown by the survey, the large majority of SIMUNDU-operating staff was  
27 educated: at least 80% of data entry clerks in either PHC or UPS facilities have secondary  
28 education (>80%), while at the managerial level (DHO), 75% of respondents have a  
29 bachelor's degree (Table 2). Yet, 19.4% and 9.1% of respondents from PHC and UPS  
30 facilities, respectively have low computer literacy.

31 Various data entry clerks looked for strategies to resolve the obstacles they encountered  
32 when entering data to SIMUNDU. Based on the interviews, some clerks furthered their  
33 computer skills by taking private computer classes. Others learned from other colleagues  
34 at their offices, or reached out for help to the district person in charge. To deal with the  
35 accumulation of data needing to be entered in SIMUNDU, staff would sometimes work  
36 at home after office hours, as their busy schedule at work did not allow time for data  
37 entry.

1 *If we found obstacles, we asked people in charge in PHC – asking for a solution or*  
2 *sharing by WhatsApp – or sometimes I asked the IT person in the DIY health office.*

### 3 **Potential threats**

4 As of today, SIMUNDU can be said to be a successful experience. Yet, a number of  
5 obstacles were encountered and addressed during implementation. Potential threats to  
6 sustaining the system include individual capacity, technical or system issues, and high  
7 workload. Staff computer literacy was identified as one of the main challenges to  
8 sustainability. Internet connectivity was another obstacle, as not all health facilities were  
9 equally supported by a good network. The survey shows that 64.6% and 67.7% of PHC  
10 and UPS staff used office internet, while others had to rely on their home internet.

11 Further, incomplete and inconsistent records – such as differing child's date of birth or  
12 name spelling across relevant entries - make it challenging to consistently record  
13 immunization information. These challenges have arisen during implementation, and  
14 were promptly addressed. Yet, they had an impact on staff who was already juggling busy  
15 schedule in the office, causing delays in data entry. As shown by the survey, almost all  
16 respondents stated having other responsibilities besides operating SIMUNDU – notably  
17 97.3%, 88% and 100% of participants from PHC, UPS and district and city offices  
18 respectively.

### 19 **Opportunities**

20 Informants appreciated SIMUNDU as a good system for immunization data. SIMUNDU  
21 has become necessary for program managers and policymakers because it allows to  
22 monitor coverage and can inform planning and programming. Currently, SIMUNDU is  
23 stable, thus is easier to manage than when it was in the development phase. It is also  
24 viable, and no longer requires heavy reliance on the core workforce that started the  
25 system. The hopes expressed by data entry clerks in the interviews are that SIMUNDU is  
26 easier to operate, and system errors are less frequent. Informants also stressed the need  
27 for refresher training to ensure knowledge and practice of the system is not lost.

28 *In my opinion, SIMUNDU is the best program in DIY which is a collaboration between*  
29 *program managers and IT. It will continue to be implemented because it is a necessity.*

30 *It has been stably used for more than five years, meaning this is needed.*

31 *If I have the tool, in this case, SIMUNDU, when it is stable, whoever will be able to run*  
32 *it, I am sure that anyone can operate it. It means that it doesn't matter if we have people*  
33 *shifting (jobs).*

34 *In the future, if SIMUNDU is still used, other reports are not necessary. Now we have*  
35 *two different reports: SIMUNDU and stock card of vaccine – each stand-alone and*  
36 *need a separate report.*

1 Based on the key informants' interviewerskwkkwkw, SIMUNDU is likely to be  
2 developed further / or expanded to other provinces. The DIY health office is open to  
3 support other provinces interested in introducing the system, for instance through lending  
4 staff for training and orientation. However, informants advised that successful  
5 introduction requires a strong commitment from both staff and management.

## 6 **Discussion**

7 Robust health information systems (HIS) are essential components of strong health  
8 systems (12). At the most basic level, immunization registries are systems that collect and  
9 report individual-level vaccine administration record data, thus facilitating individual  
10 follow-up of vaccination status. Registries also allow for the monitoring of vaccination  
11 coverage and facilitate analysis of AEFIs and surveillance data to inform the design of  
12 coverage interventions and outbreak investigations. When an electronic registry has  
13 interoperability with other electronic systems – such as the case with SIMUNDU – it is  
14 considered an IIS. (13). This paper presents lessons learned from DIY's experience  
15 implementing an IIS.

16 DIY is the only province in Indonesia – out of thirty-four - that uses an IIS. This work  
17 has shed light on the strengths and underlying barriers of implementing an IIS in this  
18 context. The objective of this study was to draw lessons that inform sustainable scale-up  
19 in other provinces and possibly at the national level. This study highlighted individual  
20 capacity, technical or system issues, and high workload as the major barriers to  
21 sustainability whereas management, system performance, people's behavior, and  
22 resources emerged as the main determinants of SIMUNDU's successful implementation,  
23 notably in improving acceptability, implementation costs, and adoption of this innovation  
24 (14).

25 Despite several obstacles encountered during the implementation of SIMUNDU, this  
26 study showed that this innovation was well accepted by key stakeholders involved. On  
27 one hand, data entry clerks noted that the system is rather user-friendly and allows to  
28 better organize the data and enhance its quality. On the other hand, managers noted the  
29 benefits this innovation brought about, namely in terms of the potential for cohort data to  
30 support planning and monitoring and ultimately improve immunization coverage.

31 Effective management - across planning, organizing, leading and controlling functions –  
32 is a crucial reason why SIMUNDU has been viable for over 5 years. Managers use their  
33 control to encourage the beliefs and actions of the staff with a dedicated and robust  
34 managerial process (15). SIMUNDU was born from the need for credible data to assist in  
35 carrying out DIY health office duties at the managerial and operational level. At the  
36 managerial level, the disease prevention and control department and the IT department  
37 collaborated in designing a system that was readily accepted by intended users.  
38 Immunization officers and IT programmers played a central role from the early stages of



1 development through implementation with effective coordination and communication,  
2 and they were helped in this task by the full support of their respective superiors.

3 SIMUNDU is cost-effective in several ways. During the introductory period of its  
4 implementation, immunization programmers, IT officers, and other staff assisted in  
5 introducing SIMUNDU in all districts in the province. This was done through integrating  
6 some of the activities across programs, thus building efficiencies in terms of time and  
7 costs for both managers and staff. Sharing resources across programs was critical in the  
8 first years, for building sustainability. Additionally, SIMUNDU maintenance does not  
9 require high costs because the DIY Health Office itself has developed the system and thus  
10 possesses in-house technical skills. The IT department has the capacity to monitor and  
11 improve processes and tailor them to user needs without much additional cost.

12 A good program without good leadership could fail in its implementation, and even if it  
13 was initially successful, it might not be sustainable (16). In the context of SIMUNDU,  
14 support from leadership and effective management facilitated the program's adoption.  
15 Uptake of the new system was good and all health facilities providing immunization  
16 services have successfully transitioned to SIMUNDU. The strong network of the main  
17 persons in charge of SIMUNDU also facilitated adoption. Good communication, care  
18 and attention to staff concerns positively affected staff performance. They felt they were  
19 well supported and treated kindly, and this helped them carry out their work joyfully.  
20 According to several informants, the leadership of the DIY immunization program  
21 manager played an essential role to this effect.

22 The monitoring and evaluation mechanisms of SIMUNDU were also important.  
23 Preferred monitoring and evaluation activities include monthly reports and direct  
24 discussion with staff during site monitoring visits. The immunization program manager  
25 suggested this approach to maintain data quality and ensure system's sustainability. These  
26 chosen mechanisms allow program managers to assess the actual practice in the field and  
27 the challenges faced to inform decisions about the follow-up actions to be taken. These  
28 processes supported the ongoing development of and learning from SIMUNDU as a tool  
29 for data collection, analysis, and visualization, as well as the benefits for managers to  
30 carry out monitoring and evaluation. The same statement was revealed by previous  
31 research in India about the innovation of health management information systems for  
32 primary health care agrees that this can provide essential benefits (17).

33 Human resources are a key determinant of successful implementation of any HIS (18).  
34 People's behavior affects how the system works, develops, and survives (19),(20). In the  
35 case of SIMUNDU, implementation was facilitated by a culture of care, established  
36 networks, and positive attitude towards data of both the program manager and IT team.  
37 From the staff's point of view, the local culture of helping each other and doing their job  
38 correctly and responsibly translated into staff carrying out their duties with enthusiasm  
39 and high commitment. Although facilities, funding and human resources were limited,  
40 the individuals involved were highly motivated and supportive.

1 Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its  
2 sustainability in the long term. These obstacles can be divided into human variables and  
3 technical variables. From the human variables side, unequal distribution of capacity at  
4 the operational level can result in differing levels of data quality across facilities and  
5 districts. Staff workload is another challenge needing addressing, as their willingness to  
6 work overtime is not a sustainable strategy. System trouble was another obstacle during  
7 the introduction of SIMUNDU, but a qualified technician or developer solved it.

## 8 **Conclusion and recommendation**

9 SIMUNDU is a promising innovation for the entire country, beyond DIY. There is  
10 agreement about the potential for scale-up of this IIS to other provinces. Experience of  
11 implementing this system in DIY over the past five years has shown that the benefits  
12 outweigh the challenges, and SIMUNDU has grown into a robust and yet user-friendly  
13 system. Regular training to dedicated staff to strengthen their capacity as the system  
14 evolves and is updated, and a plan for anticipating and responding to staff turnover have  
15 proven critical strategies towards sustainability. SIMUNDU's success also rests on  
16 remarkable leadership, both in creating and enabling a supportive environment and in  
17 pursuing integration with other programs to share limited resources.

18 Recommendations stemming from this study address three different groups of  
19 stakeholders: the DIY health office, the national government, and researchers. First, to  
20 ensure continuity and sustainability and reduce the system's dependency on the particular  
21 person or party, SIMUNDU management and maintenance should be managed by people  
22 who have competency and interest in a good reporting system. Furthermore, a human  
23 resources plan should be developed in preparation for SIMUNDU roll-out in other  
24 provinces or at national level; this is necessary to avoid vacancies when DIY province  
25 staff are seconded to other areas for mentoring support. Second, the fact that SIMUNDU  
26 emerged from an actual need of immunization programme implementers, and saw these  
27 at the front-line of its development and implementation positively impacted its feasibility  
28 and viability. This suggests that the approach to scaling up SIMUNDU should be  
29 stepwise, considering each region's specific characteristics and needs. To this effect, a  
30 readiness map and a timeline may be developed for the roll-out of SIMUNDU in a  
31 particular region. Third, further research is needed to assess the impact of SIMUNDU on  
32 immunization coverage. Based on our conversations with stakeholders, it would be  
33 particularly relevant to focus on a low-performing region and observe the impact over a  
34 2 to 3-year time window.

## 35 **Study limitations**

36 The empirical results reported herein should be considered in light of limitations. First,  
37 in the quantitative study, the result should be considered in the study sample size mainly  
38 for UPS health facility. In qualitative research that aims to explore, caution is needed in

1 interpreting the interview results. From these results, there is still a need for in-depth  
2 studies with different approaches, such as focus group discussions to confirm the results.

### 3 **Declarations**

#### 4 Ethics approval and consent to participate

5 This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan,  
6 Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began,  
7 consent to participate was obtained from research subjects (both survey and key  
8 informant interviews).  
9

#### 10 Adherence to national and international regulations

11 Not applicable

#### 12 Consent for publication

13 Before data collection begins, approval that data is taken for publication purposes is  
14 obtained from research subjects (both surveys and key informant interviews).  
15

#### 16 Availability of data and materials

17 The datasets generated and or analyzed for this study can be requested to the  
18 corresponding author.

#### 19 Competing interests

20 The authors declare that they have no competing interests

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#### 28 Authors' contributions

29 SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the  
30 data. SS and RR conducted data analysis. SS developed the paper with inputs and  
31 comments from MF on each draft. All authors agree with the manuscript's results and  
32 conclusions.

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1 Authors' information:

2 The authors alone are responsible for the views expressed in this article. They do not  
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4 them.  
5

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- 34

**Table 1.** Respondent response duriWehang the survey

Questions	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
Among the two systems – Offline and Online – which one do you prefer? ONLINE OFFLINE	93 (82.3) 20 (17,7)	24 (96.0) 1 (4.0)	4 (100) 0 (0.0)
Do you carry out any other work/duties besides SIMUNDU? No Yes	3 (2,7) 110 (97,3)	3 (12.0) 22 (88.0)	0 (0.0) 4 (100)
Who is the main person in charge of doing data entry to SIMUNDU in your office? Myself Other	96 (85.0) 17 (15.0)	18 (72.0) 7 (28.0)	3 (75.0) 1 (25.0)
How long have you been in charge of entering immunization data using SIMUNDU? <1 year 1-2 year 2-3 year 3-4 year >4 year	8 (7.1) 7 (6.2) 16 (14.2) 17 (15.0) 65 (57.5)	5 (20.0) 15 (60.0) 1 (4.0) 1 (4.0) 3 (12.0)	*
How long have you been in charge of managing SIMUNDU? <1 year 1-2 year 2-3 year 3-4 year >4 year	*	*	1 (25.0) 0 (0.0) 0 (0.0) 0 (0.0) 3 (75.0)
23. Of the several items below, which ones you can operate to support work at SIMUNDU? Excel spreadsheet Extract file Export-import file Email/browsing Other <i>Respondent allows selecting more than one response.</i>	61 (23.6) 42 (16.3) 58 (22.5) 92 (35.7) 5 (1.9)	14 (32.6) 4 (9.3) 6 (14.0) 18 (41.9) 1 (2.3)	1 (20.0) 1 (20.0) 1 (20.0) 2 (40.0) 0 (0.0)
<b>Barrier perception</b>			
Have you ever had difficulty operating SIMUNDU? Yes No	93 (82.3) 20 (17.7)	16 (64.0) 9 (36.0)	2 (50.0) 2 (50.0)
When experienced with difficulties in operating SIMUNDU, with whom you discuss to ask solutions? Puskesmas / PHC District health office DIY health office Other (staff in other health facilities) <i>Respondent allows selecting more than one response.</i>	17 (9.6) 73 (41.0) 66 (37.1) 22 (12.4)	13 (56.6) 6 (26.1) 2 (8.7) 2 (8.7)	0 (0.0) 0 (0.0) 2 (100) 0 (0.0)

Are you satisfied with the follow-up taken from the results of the consultation?			
No	1 (1.1)	0 (0.0)	0 (0.0)
Yes	92 (98.9)	16 (100)	4 (100)
<b>Report Timeliness</b>			
In SIMUNDU OFFLINE that has been running so far, have you sent the report according to the specified date?			
No	17 (15.0)	4 (16.0)	1 (25.0)
Yes	87 (77.0)	21 (84.0)	3 (75.0)
I'm operating SIMUNDU online.	9 (8.0)	0	0 (0.0)
On the SIMUNDU OFFLINE. Did you experience any obstacles in the SIMUNDU data entry on time?			*
No	67 (59.3)	16 (64.0)	
Yes	46 (40.7)	9 (36.0)	
On the SIMUNDU OFFLINE. Did you have any obstacles in reporting SIMUNDU data on time?			*
Difficulties on the export file	10 (17.2)	4 (36.4)	
Difficulties on email or sending files	13 (22.4)	0	
Difficulties in the extracted file	9 (15.5)	2 (18.2)	
Other	26 (44.8)	5 (45.5)	
Pada SIMUNDU ONLINE, when do you input your baby/toddler data into SIMUNDU			*
The same day after the service is finished	37 (25.7)	4 (16.0)	
<1 week after service	50 (34.7)	10 (40.0)	
One week - 1 month after service	48 (33.3)	10 (40.0)	
> 1 month after service	9 (6.3)	1 (4.0)	
In the ONLINE system, do you have any obstacles in entering data in SIMUNDU timely?			*
No	52 (46.0)	14 (56.0)	
Yes	61 (54.0)	11 (44.0)	
In OFFLINE systems – in 5 scales. How many do you assess the timeliness of the reports you have provided so far?			
1	0 (0.0)	1 (4.0)	0
2	3 (2.7)	1 (4.0)	0
3	36 (31.9)	9 (36.0)	0
4	60 (53.1)	12 (48.0)	3 (75.0)
5	14 (12.4)	1 (8.0)	1 (25.0)
<b>Data Accuracy</b>			
Have you ever found the data entered at SIMUNDU to be different from the data in the immunization service register?			*
No	29 (25.7)	14 (56.0)	
Yes	84 (74.3)	11 (44.0)	
<b>Data verification</b>			
Have you ever verified the data between the data in SIMUNDU and the data in the immunization service register?			*
No	5 (4.4)	8 (32.0)	

Yes	108 (95.6)	17 (68.0)	
When is data verification done?			*
Monthly	42 (38.9)	10 (58.8)	
Bimonthly	4 (3.7)	2 (11.8)	
Three months	23 (21.3)	1 (5.9)	
Semester	17 (15.7)	1 (5.9)	
Other	22 (20.4)	3 (17.6)	
<b>Data completeness</b>			
According to you, are there a lot of menus/items to input into SIMUNDU?			*
No	51 (45.1)	18 (72.0)	
Yes	62 (54.9)	7 (28.0)	
In your opinion, is the completeness of the menu/item entries in SIMUNDU important?			*
No	1 (0.9)	2 (8.0)	
Yes	112 (99.1)	23 (92.0)	
<b>SIMUNDU accessibility</b>			
Do you agree with the statement that "SIMUNDU is easy to operate?"			
Agree	108 (95.6)	23 (92.0)	4 (100)
Disagree	5 (4.4)	2 (8.0)	0 (0.0)
Did you analyse the SIMUNDU data?		*	
No	26 (23.0)		0 (0.0)
Yes	88 (77.0)		(4 )100
<b>Over/Under reporting</b>			
Do you have any experience finding data on children/babies in the Immunization Service Register that are not reported to SIMUNDU?			
No	36 (31.9)	13 (52.0)	0 (0.0)
Yes	77 (68.1)	12 (48.0)	4 (100)
Do you have the experience of finding children data in the Immunization Service Register that entry with more than one?			
No	38 (33.6)	15 (60.0)	1 (25.0)
Yes	75 (66.4)	10 (40.0)	3 (75.0)
According to you, does under or over-reporting have an impact on the achievements of the immunization program?			
No	5 (4.4)	1 (4.0)	1 (25.0)
Yes	108 (95.6)	24 (96.0)	3 (75.0)
<b>Facility and infrastructure</b>			
What type of computer do you most use to enter data in SIMUNDU?			
Private laptop	41 (36.3)	4 (14.8)	1 (25.0)
Laptop – office facility	38 (33.6)	4 (14.8)	2 (50.0)
PC – office facility	32 (28.3)	11 (40.7)	1 (25.0)
PC - private	0	0 (0.0)	0 (0.0)
Handphone	0	7 (25.9)	0 (0.0)
Other	2 (1.8)	1 (3.7)	0 (0.0)
Does your current computer/handphone/laptop support your work on operating SIMUNDU?			
No	11 (9.7)	0 (0.0)	1 (25.0)
Yes	102 (90.3)	25 (100)	3 (75.0)



Where are your internet sources from?			
None	0 (0.0)	0 (0.0)	3 (75.0)
Office facility (Wifi)	102 (64.6)	21 (67.7)	1 (25.0)
Data packages pay with their own money	48 (30.4)	9 (29.0)	0
Data packages paid by the office	1 (0.6)	0	0
Other	7 (4.4)	1 (3.2)	0
<i>Respondent allows selecting more than one response</i>			
Is the internet facility that you use, suit your needs for data entry SIMUNDU?			
No	18 (15.9)	2 (8.0)	1 (25.0)
Yes	95 (84.1)	23 (92.0)	3 (75.0)
Where is the source of your electricity?			
PLN	114 (80.9)	25 (80.6)	4 (100)
Genset	27 (19.1)	6 (19.4)	0
None	0	0	0
Other	0	0	0
<i>Respondent allows selecting more than one response.</i>			
Do you have any problems with electricity during SIMUNDU entry?			
No	78 (69.0)	24 (96.0)	4 (100)
Yes	35 (31.0)	1 (4.0)	0
From your side, what are the obstacles in SIMUNDU reporting?			
It is difficult for data entry at SIMUNDU	7 (3.7)	2 (6.1)	0
Do not have time	18 (9.4)	7 (21.2)	1 (20.0)
Have another assignment	95 (49.7)	16 (48.5)	2 (40.0)
My computer skill is poor	37 (19.4)	3 (9.1)	0
Never received SIMUNDU training	11 (5.8)	2 (6.1)	1 (20.0)
Other	23 (12.0)	3 (9.1)	1 (20.0)
<i>Respondent allows selecting more than one response</i>			
<b>Managerial Process</b>			
Do you know the purpose of SIMUNDU development in DIY?			
No	18 (15.9)	6 (24.0)	0
Yes	95 (84.1)	19 (76.0)	4 (100)
Have you ever participated in SIMUNDU in house training?			
No	14 (12.4)	7 (28.0)	1 (25.0)
Yes	99 (87.6)	18 (72.0)	3 (75.0)
When did you last take part in the SIMUNDU in house training?			
< 1 year ago	42 (42.4)	11 (61.1)	0
> 1 year ago	57 (57.6)	7 (38.9)	2 (100)
Which institution conducts SIMUNDU in house training, that you ever attended?			
Puskesmas (PHC)	0 (0.0)	2 (8.0)	0
District/City health office	56 (38.9)	15 (60.0)	0
DIY health office	88 (61.1)	7 (28.0)	0
Other	0 (0.0)	1 (4.0)	2 (100)
<i>Respondent allows selecting more than one response</i>			
What training guides are used during training?			
PPT	80 (49.1)	12 (56.1)	2 (50.0)

Word – hard copy	32 (19.6)	2 (9.5)	1 (25.0)
Word - soft file	36 (22.1)	2 (9.5)	1 (25.0)
Other	15 (9.2)	5 (23.8)	0
Have you ever been monitored and evaluated regarding SIMUNDU?			
No	10 (8.8)	6 (24.0)	0
Yes	103 (91.2)	19 (76.0)	4 (100)
In the last year (July 2019-July 2020), how many times monitoring and evaluation been conducted?			
>2 times	17 (16.5)	2 (10.5)	2 (50.0)
One time	57 (55.3)	11 (57.9)	1 (25.0)
1-2 times	29 (28.2)	6 (31.6)	1 (25.0)
Who did monitor and evaluation SIMUNDU on your place?			
Puskesmas (PHC)	11 (7.0)	11 (39.3)	0
District/City health office	81 (51.3)	8 (28.6)	0
DIY health office	65 (41.1)	8 (28.6)	4 (100)
Other	1 (0.6)	2 (3.6)	0
<i>Respondent allows selecting more than one response</i>			
Did you receive any feedback on the results of the SIMUNDU monitoring and evaluation?			
No	6 (5.8)	0 (0.0)	0
Yes	97 (94.2)	19 (100)	4 (100)
Who gave feedback on the M&E results?			
Puskesmas (PHC)	7 (4.6)	10 (40.0)	0
District/City health office	73 (48.3)	8 (32.0)	0
DIY health office	69 (45.7)	6 (24.0)	4 (100)
Other	2 (1.3)	1 (4.0)	0
<i>Respondent allows selecting more than one response</i>			
In the last year ((July 2019 - July 2020), have you ever monitored the health facility under your supervision?			
Yes	*	*	4 (100)
No			0
Have you ever participated in the dissemination of M&E results as well as updating knowledge?			
No	28 (24.8)	16 (64.0)	0
Yes	85 (75.2)	9 (36.0)	4 (100)
Who is organizing the dissemination of M&E results as well as updating the knowledge?			
Puskesmas (PHC)	3 (2.5)	0 (0.0)	0
District/City health office	53 (44.2)	6 (60.0)	1 (25.0)
DIY health office	63 (52.5)	4 (40.0)	3 (75.0)
Other	1 (0.8)	0 (0.0)	0
<i>Respondent allows selecting more than one response</i>			

\*data not applicable

# Revisi 3

**Date:** 04 Jul 2022  
**To:** "Sulistiyawati Sulistiyawati" sulistiyawati.suyanto@ikm.uad.ac.id  
**From:** "BMC Health Services Research Editorial Office" Eloisa.HadeNolasco@springer.com  
**Subject:** Your submission to BMC Health Services Research - BHSR-D-21-00992R2

BHSR-D-21-00992R2

Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up  
Sulistiyawati Sulistiyawati; Trisno Agung Wibowo; Rokhmayanti Rokhmayanti; Andri Setyo Dwi Nugroho; Tri Wahyuni Sukes; Siti Kurnia Widi Hastuti; Surahma Asti Mulasari; Marta Feletto  
BMC Health Services Research

Dear Dr Sulistiyawati,

Your manuscript 'Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up' (BHSR-D-21-00992R2) has been assessed by our reviewers. They have raised a number of points which we believe would improve the manuscript and may allow a revised version to be published in BMC Health Services Research.

Their reports, together with any other comments, are below. Please also take a moment to check our website at <https://www.editorialmanager.com/bhsr/> for any additional comments that were saved as attachments.

If you are able to fully address these points, we would encourage you to submit a revised manuscript to BMC Health Services Research.

Once you have made the necessary corrections, please submit online at:

<https://www.editorialmanager.com/bhsr/>

If you have forgotten your password, please use the 'Send Login Details' link on the login page at <https://www.editorialmanager.com/bhsr/>. For security reasons, your password will be reset.

A point-by-point response letter must accompany your revised manuscript. This letter must provide a detailed response to each reviewer/editorial point raised, describing exactly what amendments have been made to the manuscript text and where these can be viewed (e.g. Methods section, line 12, page 5). Please also ensure that all changes to the manuscript are indicated in the text by highlighting or using track changes. If you disagree with any comments raised, please provide a detailed rebuttal to help explain and justify your decision.

Please also ensure that your revised manuscript conforms to the journal style, which can be found at the Submission Guidelines on the journal homepage.

A decision will be made once we have received your revised manuscript, which we expect by 03 Aug 2022.

Please note, if your manuscript is accepted you will not be able to make any changes to the authors, or order of authors, of your manuscript once the editor has accepted your manuscript for publication. If you wish to make any changes to authorship before you resubmit your revisions, please reply to this email and ask for a 'Request for change in authorship' form which should be completed by all authors (including those to be removed) and returned to this email address. Please ensure that any changes in authorship fulfil the criteria for authorship as outlined in BioMed Central's editorial policies (<http://www.biomedcentral.com/about/editorialpolicies#authorship>).

Once you have completed and returned the form, your request will be considered and you will be advised whether the requested changes will be allowed.

By resubmitting your manuscript you confirm that all author details on the revised version are correct, that all authors have agreed to authorship and order of authorship for this manuscript and that all authors have the appropriate permissions and rights to the reported data.

Please be aware that we may investigate, or ask your institute to investigate, any unauthorised attempts to change authorship or discrepancies in authorship between the submitted and revised versions of your manuscript.

I look forward to receiving your revised manuscript and please do not hesitate to contact us if you have any questions.

Best wishes,

Milena Pavlova  
BMC Health Services Research  
<https://bmchealthservres.biomedcentral.com/>

Technical Comments:

Editor Comments:

We had to asked a third reviewer to assess the paper.

Below the comments of this reviewer. Please addressed them carefully.

The revised paper will be sent to all three reviewers.

We operate a transparent peer review process for this journal where reviewer reports are published with the article but the reviewers are not named (unless they opt in to include their name).

#### Reviewer reports:

Reviewer 3: This manuscript examines the roll-out of an immunization information system, SIMUNDU, in the DIY province of Indonesia. The authors aim to derive lessons for further scale-up and roll-out to other regions of Indonesia. To this end, the authors have succeeded in discovering the factors influencing success, and the challenges faced, in the implementation of SIMUNDU. I believe the results and discussion presented in this manuscript will aid the implementation of such systems more broadly across Indonesia, and possibly, in comparable countries/settings.

#### Specific comments - major

I can see that the manuscript has undergone extensive prior editing. Nonetheless, there remains formatting, spelling, and grammatical issues remain throughout the text. However, these will be solvable with another round of attentive and thorough copy editing. Perhaps the authors could consider the services of a professional academic writing/editing service to help? The quality of writing should not over-ride the overwhelmingly good work that the authors have done here.

Redo Figure 2 so that the text on the diagram is clearer, particularly the smaller text under "System strengths". I suggest re-doing the diagram for a more professional look, perhaps asking a graphic designer to help.

The presentation of quotations could be improved. Include quotation marks around the text, and indicate who gave the quote using a de-identified participant ID.

In the Discussion section, there is much discussion of strengths and positives, but relatively little coverage given on the negative side - things that could have been done better, and ongoing challenges. I suggest revisiting the negatives and expanding the discussion of these aspects.

Can you comment on the similarity of dissimilarity of DIY with other provinces of Indonesia, and how this might influence the recommendations and lessons learned? How likely would an implementation of SIMUNDU succeed if it were rolled out in other areas, using the lessons learned from DIY?

Sample size is mentioned in the "Study limitations" section, particularly for UPS Health Facilities. Whilst it is good to raise this issue, the implications of small sample size require further discussion. What impact might this have on the findings, their accuracy, and broader relevance?

I am not confident that the formatting of the paper is compliant with BMC HSR guidelines. I suggest revisiting the BMC HSR manuscript template/guidelines and ensure that the manuscript follows those rules.

#### Specific comments - minor

Below are some example suggestions of editorial changes to make. This is not an exhaustive list, and a copy editor will be able to spot and address many more.

Page 1, line 23: avoid opinion-piece style language like "undeniably". Change the opening sentence to begin "Immunization is critical to save ..."

Page 1, line 26: here and throughout the manuscript, I think 'Health Office' should be capitalised. The sentence would then be "The Daerah Istimewa Yogyakarta (DIY) Health Office introduced ..."

Page 2, line 2: change to "SIMUNDU is a promising innovation for Indonesia, beyond DIY."

Page 2, line 14: change to "According to the WHO, in 2020, an estimated ..."

Page 2, line 31: change to "... data are in Microsoft Excel formats;"

Page 3, line 33: change to "Furthermore, SIMUNDU has been developed to ..."

Page 4, line 4: change to "The objective of the work presented here was to ..."

Page 4, line 19: space required between "any" and "staff"

Page 5, line 2: change to "For UPS facilities, we selected ..."

Page 5, line 19: change to "... qualitative interviews would delve into further."

Page 5, line 23-24: fix grammar and spelling mistake. Should be "... their management functions. Selected informants were invited ..."

Page 6, line 4: change "districts or cities" to "districts/cities"

Page 6, line 15: change to "... to explore the quantitative study results more deeply."

Page 7, line 7: change to "However, data from both ..."

Page 8, line 17: at this point and throughout the manuscript, I suggest renaming these functions. My suggestion is to use the terms Planning, Organization, Leadership, and Control.

Page 8, line 22: change to "the Head of the Disease Prevention and Control Department, ..."

Page 9, line 13: change to "This seemed to work effectively."

Page 10, line 1: change to "The role of IT workers in developing SIMUNDU was also significant. They helped develop the system and facilitated correct data entry by assisting data entry operators whenever technical issues arose. IT workers also helped resolve inconsistencies in data records."

Page 10, line 23: "health offices" should be capitalised, so it becomes "Health Offices"

Page 11, line 2: change to " SIMUNDU also facilitated ..."

Page 12, line 25-26: change to "... have basic computer skills in word processing and spreadsheet software tools such as Microsoft Word and Excel, respectively."

Page 12, line 28: change to "... have a Bachelor degree (see Table 2). However, 19.4% and ..."

Page 13, line 4: change to "However, a number of ..."

Page13, line 20: change to "Informants appreciated SIMUNDU as a good system to manage immunization data."

Page 13, line 21-22: change to "... for program managers and policymakers; it allows them to monitor coverage and can help inform planning and programming."

Page 14, line 1: delete erroneous typing "kwkkkw"

Page 14, line 19-24: change to "This study highlighted individual capacity, technical or system issues, and high workload as the major barriers to sustainability. Conversely, management, system performance, people's behavior, and available resources emerged as the main determinants of SIMUNDU's successful implementation - notably in improving acceptability, implementation costs, and adoption of this innovation (14)."

Page 15, line 18-19: change to "They felt that they were well-supported and treated kindly, and this helped them carry out their work joyfully."

Page 15, line 28: change to "... processes supported the ongoing development of, and learning from, SIMUNDU as a tool ..."

Page 15, line 30-32: change to "The same sentiment was reflected in previous research undertaken in the India (17)."

Page 16, line 6-7: change to "Technical problems were another obstacle during the introduction of SIMUNDU, but qualified technicians/developers were able to solve these issues."

Page 16, line 27: add comma after "implementation", so that it becomes "... its development and implementation, positively impacted ..."

Page 16, line 36-38: change to "First, the results of in the quantitative study must be considered with respect to the limited sample size, particularly for UPS Health Facilities."

Page 17, line 20: sentence is missing a full stop.

If you have been asked to edit the English language of the main text to improve readability and clarity, and would like the assistance of paid editing services to do this, we can recommend our affiliates, Nature Research Editing Service: <https://authorservices.springernature.com/language-editing> and American Journal Experts:

<https://www.aje.com/go/springernature>.

Please note that use of an editing service is neither a requirement nor a guarantee of publication. Free assistance is available from our resources page: <https://www.springernature.com/gp/researchers/campaigns/english-language-forauthors>

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Please read the following information and revise your manuscript as necessary. If your manuscript does not adhere to our editorial requirements this will cause a delay whilst the issue is addressed. Failure to adhere to our policies may result in rejection of your manuscript.

In accordance with BioMed Central editorial policies and formatting guidelines, all submissions to BMC Health Services Research must have a Declarations section which includes the mandatory sub-sections listed below. Please refer to the journal's Submission Guidelines web page for information regarding the criteria for each sub-section (<https://bmchealthservres.biomedcentral.com/>).

Where a mandatory section is not relevant to your study design or article type, for example, if your manuscript does not contain any individual persons data, please write 'Not applicable' in these sections.

For the 'Availability of data and materials' section, please provide information about where the data supporting your findings can be found. We encourage authors to deposit their datasets in publicly available repositories (where available and appropriate), or to be presented within the manuscript and/or additional supporting files. Please note that

identifying/confidential patient data should not be shared. Authors who do not wish to share their data must state that data will not be shared, and provide reasons for this in the manuscript text. For further guidance on how to format this section, please refer to BioMed Central's editorial policies page - <http://www.biomedcentral.com/submissions/editorial-policies#availability+of+data+and+materials>.

#### Declarations

- Ethics approval and consent to participate
- Consent to publish
- Availability of data and materials
- Competing interests
- Funding
- Authors' Contributions
- Acknowledgements
- Authors' Information

This letter contains confidential information, is for your own use, and should not be forwarded to third parties.

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**Response to reviewer's comment to the paper entitled "Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up"**

No	Reviewer's comment	Authors response
1	<p>Reviewer 3</p> <p>This manuscript examines the roll-out of an immunization information system, SIMUNDU, in the DIY province of Indonesia. The authors aim to derive lessons for further scale-up and roll-out to other regions of Indonesia. To this end, the authors have succeeded in discovering the factors influencing success, and the challenges faced, in the implementation of SIMUNDU. I believe the results and discussion presented in this manuscript will aid the implementation of such systems more broadly across Indonesia, and possibly, in comparable countries/settings.</p>	<p>Dear Reviewer,</p> <p>Thank you for your positive impression of this paper, and we highly appreciate your input.</p>
2	<p>Specific comments - major</p> <p>I can see that the manuscript has undergone extensive prior editing. Nonetheless, there remains formatting, spelling, and grammatical issues remain throughout the text. However, these will be solvable with another round of attentive and thorough copy editing. Perhaps the authors could consider the services of a professional academic writing/editing service to help? The quality of writing should not over-ride the overwhelmingly good work that the authors have done here.</p>	<p>Dear Reviewer,</p> <p>Thank you for your concern. We understand about it. Our last author is a native speaker, and she will work on it. We will go to the professional language editor if she does not have sufficient time.</p>
3	<p>Redo Figure 2 so that the text on the diagram is clearer, particularly the smaller text under "System strengths". I suggest re-doing the diagram for a more professional look, perhaps asking a graphic designer to help.</p>	<p>Figure 2 has been re-produced and inserted in Page 12</p>
4	<p>The presentation of quotations could be improved. Include quotation marks around the text, and indicate who gave the quote using a de-identified participant ID.</p>	<p>The quotation mark has been added in all quotations, with participant ID at the end of the quote.</p>
5	<p>In the Discussion section, there is much discussion of strengths and positives, but relatively little coverage given on the negative side - things that could have been done better and ongoing challenges. I suggest revisiting the negatives and expanding the discussion of these aspects.</p>	<p>In the result (figure 2), we discussed the negative side of SIMUNDU but used the term "potential threat." However, we have also added limitation of SIMUNDU on page 25, line 18</p>
6	<p>Can you comment on the similarity of dissimilarity of DIY with other provinces of Indonesia, and how this might influence the recommendations and lessons learned? How likely would an implementation of SIMUNDU succeed if it were rolled out in other areas, using the lessons learned from DIY?</p>	<p>A description of DIY has been added on page 4, line 17.</p> <p>The possibility of scaling up successfully has been added on page 25, line 22</p>
	<p>The sample size is mentioned in the "Study limitations" section, particularly for UPS Health Facilities. Whilst it is good to raise this issue, the implications of small sample size require further discussion. What impact might this have on the findings, their accuracy, and broader relevance?</p>	<p>Study limitation about limited sample size on UPS has more discussed on page 27, line 10</p>



7	I am not confident that the formatting of the paper is compliant with BMC HSR guidelines. I suggest revisiting the BMC HSR manuscript template/guidelines and ensure that the manuscript follows those rules.	The manuscript has now been adjusted with the author guideline in the journal, especially for using double line spacing
8	Specific comments - minor Below are some example suggestions of editorial changes to make. This is not an exhaustive list, and a copy editor will be able to spot and address many more.	
9	Page 1, line 23: avoid opinion-piece style language like "undeniably". Change the opening sentence to begin "Immunization is critical to save ..."	Thank you for your suggestion. A revision has been made Page: 2 Line: 2
10	Page 1, line 26: here and throughout the manuscript, I think 'Health Office' should be capitalised. The sentence would then be "The Daerah Istimewa Yogyakarta (DIY) Health Office introduced ..."	Thank you for your suggestion. A revision has been made Page: 2 Line: 5
11	Page 2, line 2: change to "SIMUNDU is a promising innovation for Indonesia, beyond DIY."	Thank you for your suggestion. A revision has been made Page: 2 Line: 2
12	Page 2, line 14: change to "According to the WHO, in 2020, an estimated ..."	Thank you for your suggestion. A revision has been made Page: 3 Line: 3
13	Page 2, line 31: change to "... data are in Microsoft Excel formats;"	Thank you for your suggestion. A revision has been made Page: 4 Line: 9
14	Page 3, line 33: change to "Furthermore, SIMUNDU has been developed to ..."	Thank you for your suggestion. A revision has been made Page: 6 Line: 14
15	Page 4, line 4: change to "The objective of the work presented here was to ..."	Thank you for your suggestion. A revision has been made Page: 7 Line: 3
16	Page 4, line 19: space required between "any" and "staff"	Thank you for your suggestion. A revision has been made Page: 7 Line: 18
17	Page 5, line 2: change to "For UPS facilities, we selected ..."	Thank you for your suggestion. A revision has been made Page: 8 Line: 5
18	Page 5, line 19: change to "... qualitative interviews would delve into further."	Thank you for your suggestion. A revision has been made Page: 9 Line: 7
19	Page 5, line 23-24: fix grammar and spelling mistake. Should be "... their management functions. Selected informants were invited ..."	Thank you for your suggestion. A revision has been made Page: 9 Line: 11
20	Page 6, line 4: change "districts or cities" to "districts/cities"	Thank you for your suggestion. A revision has been made Page: 10

		Line: 7
21	Page 6, line 15: change to "... to explore the quantitative study results more deeply."	Thank you for your suggestion. A revision has been made Page: 11 Line: 3
22	Page 7, line 7: change to "However, data from both ..."	Thank you for your suggestion. A revision has been made Page: 12 Line: 1
23	Page 8, line 17: at this point and throughout the manuscript, I suggest renaming these functions. My suggestion is to use the terms Planning, Organization, Leadership, and Control.	Thank you for your suggestion. A revision has been made Page: 13 Line: 7
24	Page 8, line 22: change to "the Head of the Disease Prevention and Control Department, ..."	Thank you for your suggestion. A revision has been made Page: 13 Line: 12
25	Page 9, line 13: change to "This seemed to work effectively."	Thank you for your suggestion. A revision has been made Page: 14 Line: 13
26	Page 10, line 1: change to "The role of IT workers in developing SIMUNDU was also significant. They helped develop the system and facilitated correct data entry by assisting data entry operators whenever technical issues arose. IT workers also helped resolve inconsistencies in data records."	Thank you for your suggestion. A revision has been made Page: 15 Line: 11
27	Page 10, line 23: "health offices" should be capitalised, so it becomes "Health Offices"	Thank you for your suggestion. A revision has been made Page: 15 Line: 21
28	Page 11, line 2: change to "SIMUNDU also facilitated ..."	Thank you for your suggestion. A revision has been made Page: 17 Line: 4
29	Page 12, line 25-26: change to "... have basic computer skills in word processing and spreadsheet software tools such as Microsoft Word and Excel, respectively."	Thank you for your suggestion. A revision has been made Page: 19 Line: 19
30	Page 12, line 28: change to "... have a Bachelor degree (see Table 2). However, 19.4% and ..."	Thank you for your suggestion. A revision has been made Page: 19 Line: 23
31	Page 13, line 4: change to "However, a number of ..."	Thank you for your suggestion. A revision has been made Page: 20 Line: 14
32	Page 13, line 20: change to "Informants appreciated SIMUNDU as a good system to manage immunization data."	Thank you for your suggestion. A revision has been made Page: 21 Line: 7
33	Page 14, line 1: delete erroneous typing "kwkkwkw"	Thank you for your suggestion. A revision has been made Page: 22 Line: 4

34	Page 14, line 19-24: change to "This study highlighted individual capacity, technical or system issues, and high workload as the major barriers to sustainability. Conversely, management, system performance, people's behavior, and available resources emerged as the main determinants of SIMUNDU's successful implementation - notably in improving acceptability, implementation costs, and adoption of this innovation (14)."	Thank you for your suggestion. A revision has been made Page: 22 Line: 22
35	Page 15, line 18-19: change to "They felt that they were well-supported and treated kindly, and this helped them carry out their work joyfully."	Thank you for your suggestion. A revision has been made Page: 24 Line: 13
36	Page 15, line 28: change to "... processes supported the ongoing development of, and learning from, SIMUNDU as a tool ..."	Thank you for your suggestion. A revision has been made Page: 24 Line: 23
37	Page 15, line 30-32: change to "The same sentiment was reflected in previous research undertaken in the India (17)."	Thank you for your suggestion. A revision has been made Page: 25 Line: 1
38	Page 16, line 6-7: change to "Technical problems were another obstacle during the introduction of SIMUNDU, but qualified technicians/developers were able to solve these issues."	Thank you for your suggestion. A revision has been made Page: 25 Line: 16
39	Page 16, line 27: add comma after "implementation", so that it becomes "... its development and implementation, positively impacted ..."	Thank you for your suggestion. A revision has been made Page: 26 Line: 22
40	Page 16, line 36-38: change to "First, the results of in the quantitative study must be considered with respect to the limited sample size, particularly for UPS Health Facilities."	Thank you for your suggestion. A revision has been made Page: 27 Line: 8
41	Page 17, line 20: sentence is missing a full stop.	Thank you for your suggestion. A revision has been made Page: 28 Line: 10

1 **Introduction and implementation of an immunization information**  
2 **system in Indonesia province of Daerah Istimewa Yogyakarta: lessons**  
3 **for scale-up**  
4

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21

22

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24

1 **Abstract**

2 **Background:** Immunization is critical to saving children from infections. To increase  
3 vaccination coverage, valid and real-time data is needed. Accordingly, it is essential to  
4 have a good report system that serves as defaulter tracking to prevent children's  
5 immunization failure. The Daerah Istimewa Yogyakarta (DIY) Health Office introduced  
6 an electronic immunization registry and successfully implemented it for over than five  
7 years. It is the only individual-based record system in Indonesia that has been sustainably  
8 operated for a long time. Yet, no systematic assessment of this system has been conducted  
9 to date. This study examines the Sistem Informasi Imunisasi Terpadu (SIMUNDU)  
10 introduction and implementation process to draw lessons that could inform scalability  
11 and sustainability across the country.

12 **Methods:** This study used an explanatory sequential mixed-method design, which  
13 collected quantitative data from 142 participants and qualitative data from 9 participants.  
14 Entry data clerk in a health facility was systematically selected to participate in the  
15 survey. While in the key informant interview, the informant was selected based on the  
16 survey result. A descriptive and thematic approach was adopted to analyze the  
17 quantitative and qualitative data. Results from across the two approaches were integrated  
18 for comparison and contrast.

19 **Results:** Findings are presented according to three core themes that emerged from the  
20 data: system strengths, potential threats, and opportunities for scale-up. Strengths -i.e.  
21 factors contributing to the success of SIMUNDU - include management, system  
22 performance, people's behavior, and resources. Potential threats to sustaining the system  
23 include individual capacity, technical or system issues, and high workload. Opportunities

1 – i.e promising factors that SIMUNDU can be operated sustainably – such as continuity,  
2 expectation and scale up possibility.

3 **Conclusions:** SIMUNDU is a promising innovation for Indonesia, beyond DIY. There  
4 is agreement about the potential for scale-up of this IIS to other provinces. Experience of  
5 implementing this system in DIY over the past five years has shown that the benefits  
6 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
7 system.

8

9 **Keywords:** immunization, electronic immunization registry, immunization information  
10 system, interoperability, implementation research

## 11 **Background**

12

13 Neonatal and childhood vaccination is essential to infectious disease prevention and an  
14 absolute human right (1),(2). Vaccination has been proven to reduce the burden of  
15 infectious diseases globally (3). According to the WHO, in 2020, an estimated 23 million  
16 children under one year did not receive their essential vaccinations. Of these, 60% live in  
17 just ten countries, one of which is Indonesia (4). Indonesia is the fourth most populous  
18 country globally. It is composed of thousands of islands organized into 34 provinces.  
19 Various geographical and cultural factors influence population inequalities to access  
20 health services (5). In 2001, the Indonesian government's decentralization policy was  
21 enacted. This was an excellent strategy to foster development by engaging regional  
22 resources (6). However, this strategy was not without consequence. One primary concern  
23 was the Health Information System (HIS) fragmentation.

1 Indonesia's federal structure results in provinces and districts being relatively independent  
2 of the national Ministry of Health. This means that provincial and district-levels  
3 information systems are locally regulated (7). For instance, *Pemantauan Wilayah*  
4 *Setempat* (PWS) is a management tool used to monitor coverage of specific health  
5 services in an administrative boundary. Depending on the service and region, it can be  
6 paper- or electronic-based. PWS-KIA is the monitoring system specific to maternal and  
7 child health (KIA), including immunization. PWS-KIA data are reported to the District  
8 or City Health Office, go to Province Health Office, and finally reported to the main level.  
9 Generally, the data are in Microsoft Excel formats; it will report via emails or various  
10 information systems, including Komdat, SiTT, SIHA, PISPK, and SIKDA Generik.  
11 PWS-KIA data feeds into District Health Information System 2 (DHIS2). Regional  
12 information systems have varying data quality, which reflects inequities in resources  
13 across regions. This adds to data integration challenges at the national level (7),(8) and  
14 affects strategic policymaking.

15 In Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) Province has the  
16 authority to regulate and use its budget within its four districts plus one city (Sleman,  
17 Gunungkidul, Bantul, Kulonprogo and Yogyakarta). This province is classified as a small  
18 province in terms of area size and the number of regions inside (9). However, this region  
19 can be considered a representation of Indonesia when viewed from the geographical,  
20 socio-economic and heterogeneous population. Regarding childhood vaccination, DIY is  
21 among the top ten performing provinces in the country, with 97.7 % of children  
22 completing basic immunization coverage in 2019 (10). Immunization services are  
23 provided by Primary Health Centres or Puskesmas (PHC), as well as private clinics,

1 hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* or  
2 UPS).

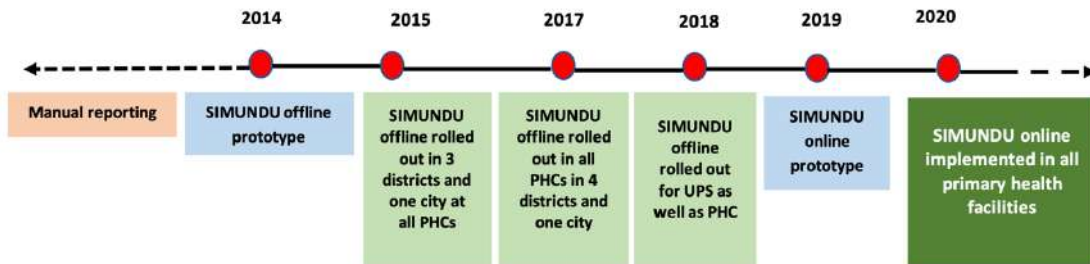
3 An electronic immunization registry is a tool for recording individual children's  
4 immunization histories. In 2014, the DIY Health Office introduced an electronic  
5 immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu/*  
6 *Integrated Immunization Information System*). An electronic registry serves essential  
7 functions at all levels of the health system. At the district and higher levels, it allows for  
8 monitoring vaccination coverage by the vaccine, dose, cohort, and other variables – and  
9 can support microplanning and vaccine management. The service delivery level can  
10 facilitate individual follow-up of vaccination status and enable health workers to identify  
11 children due for vaccination and those who missed their vaccinations (defaulters).

12 SIMUNDU was designed to link with the PWS-KIA for immunization and  
13 interoperability with the DHIS2. While it predominantly contains individual-level  
14 immunization records, SIMUNDU also serves as a source for aggregation and can  
15 synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this  
16 reason, it can be considered an Immunization Information System (IIS). This means that  
17 City and District levels feed into Provincial and National levels (*Personal communication*  
18 *with DIY immunization program officer*).

19 The original prototype was designed by the information and technology (IT) department  
20 of DIY Health Office to be operated offline. In DIY, three out of the four districts and the  
21 city introduced the system in 2015. The final district introduced it in 2017. At this stage,  
22 the point of data entry was the PHC only. By 2018, UPS facilities were also equipped  
23 with SIMUNDU and could enter data into the system. In 2019, the prototype was further



1 developed to operate online. The online version was rolled out in 2020 (Figure 1). As of  
2 May 2021, 79.4% of all PHC and UPS facilities complied. This average rate masks,  
3 however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce  
4 its use in UPC facilities (Suyani 2020, oral communication, 2020, May 11).



5

6 **Figure 1.** SIMUNDU’s development and introduction

7 When a child receives a vaccination in a health facility, information on the child and the  
8 vaccination is entered in SIMUNDU as an individual child record. Each record includes  
9 a personal identifier, the child’s socio-demographic characteristics (e.g., name, gender,  
10 date of birth, name of parents, address), the antigen administered, and the date and place  
11 of vaccination. SIMUNDU has been recently updated to allow the recording of  
12 vaccinations administered in schools (e.g., Human papillomavirus (HPV), Diphtheria  
13 Toxoid (DT), Tetanus-Diphtheria (TD), and Measles-Rubella (MR), though in the form  
14 of aggregate data only. Furthermore, SIMUNDU has been developed to record COVID-  
15 19 vaccinations in health facilities and those carried out in masse.

16 Monitoring is conducted monthly to assess data completeness across health facilities,  
17 while an evaluation is conducted yearly. These exercises have allowed the identification  
18 of several challenges related to implementing the system (e.g., workload, staff turnover,  
19 and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic  
20 assessment of the system has been conducted to date. SIMUNDU is the first

1 immunization information system ever introduced in Indonesia. Other districts and  
2 provinces have shown interest in rolling it out, and the Ministry of Health has  
3 acknowledged the innovation. The work presented here aims to examine SIMUNDU’s  
4 introduction and implementation process to draw lessons that could inform scalability  
5 and sustainability across the country.

## 6 **Methods**

7 From May to October 2020, we examined the experience of introducing and  
8 implementing an immunization information system in the DIY province using an  
9 explanatory sequential mixed-method design, where each step informed the next (11).  
10 First, we reviewed of all relevant documentation available in the DIY Health Office –  
11 e.g., staff notes, meeting notes and monitoring notes – documenting SIMUNDU  
12 development and management processes. We also examined online documents, including  
13 health profiles and regulations on health reporting systems in Indonesia. This served as  
14 the initial data source and provided an overview of who was involved and how in  
15 developing and implementing SIMUNDU. This informed the survey design that we  
16 conducted as a second step. The survey targeted any staff responsible for entering data in  
17 SIMUNDU (i. e. data clerks) across all PHC and selected UPS facilities and any staff  
18 responsible for managing the system at the district and city level (i. e., immunization  
19 coordinators). Sampling and recruitment strategies are outlined in Table 1.

20

21

22

23

**Table 1. Survey participant**

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
Primary Health Centre (PHC)	121	Data entry clerks	All facilities	Open invitation across all facilities	113
UPS - Central, General, Maternity and Pediatric Hospitals	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
UPS - Clinics	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
UPS - Midwives' Practices	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinators	Total sampling	Open invitation	4*
<b>Total</b>					<b>142</b>

1 \*When the immunization coordinator had recently changed, the former was also invited.

2

3 All immunization coordinators in each district/city and data entry clerks from all primary  
4 health facilities (PHC) were invited to participate in this survey. For UPS facilities, we  
5 selected two clinics, two midwives' practices, and two hospitals per district/city and  
6 invited all of their staff to be involved in SIMUNDU data entry and management.

7 We developed and pre-tested an online survey in Bahasa Indonesia to inquire about  
8 SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, district  
9 or city and province offices. The questionnaire consisted of close-ended and Likert scale  
10 questions – ranging from 45 to 50 depending on the target type of facility and/or level of  
11 the health system – and enquired about respondents' socio-demographic characteristics  
12 as well as the process of implementing and managing SIMUNDU. Some questions  
13 provided an additional field for clarifying the reason for a particular answer choice.

1 All participants were invited to the DIY Health Office to complete the survey on their  
2 laptops, with their prior consent. All participants in a room allowed researchers to monitor  
3 any missing or incomplete responses in real time and follow up with individual  
4 participants on-site to fill any gaps. We don't believe this may have introduced any  
5 significant bias as researchers would simply flag any missing responses and invite  
6 respondents to address those. Data were then exported and analyzed in Microsoft Excel.  
7 An exploratory analysis of the survey data informed the topic areas that qualitative  
8 interviews explore into further.

9 Similarly, some informants were purposefully selected among survey participants to  
10 follow up on the range of perspectives that had emerged from the survey. Other  
11 informants had been identified at the desk review stage and chosen for their management  
12 functions. Selected informants were invited to the DIY Health Office for the interview,  
13 and COVID-19 prevention protocol was observed. Every informant was informed about  
14 the study and asked to sign the informed consent. All invited informants agreed to  
15 participate. A total of nine 30-minute semi-structured interviews were conducted in  
16 Bahasa Indonesia language and recorded with prior consent from participants. The  
17 interview team consisted of three researchers with the respective task of running the  
18 interview, observing and taking notes. A research assistant transcribed all interviews in  
19 Bahasa Indonesia language.

20 Thematic analysis was conducted using Quirkos qualitative tool following Braun and  
21 Clarke's approaches (12). Researchers familiarized themselves with the data, searching  
22 for initial codes and allowing themes to emerge. The principal investigator led the coding  
23 process, and led the research team in defining and naming the core themes emerging from  
24 the data, organizing and analyzing the data across the themes, and triangulating

1 information from the desk review, the survey, and the interviews. This stage was also  
 2 performed in Bahasa Indonesia. Data were translated to English only at sub-theme and  
 3 core themes.

## 4 Results

### 5 Characteristic participant

#### 6 a. Quantitative study

7 In total, 142 respondents participated in this study spread across five districts/cities in the DIY  
 8 province. Most respondents came from Gunungkidul District, PHC, UPS, and DHO, 24.8%, 24%,  
 9 and 25%, respectively. For all research units, the majority are women. At the UPS and DHO/CHO  
 10 levels, most respondents were aged 41-45 years, i.e., 28.3% and 75%, respectively, while at the UPS  
 11 level, the majority were aged 25-30 years (56.0%). For education level, PHC and UPS are dominated  
 12 by Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, it is  
 13 predominantly undergraduate graduates (75%) (Table 2)

14 **Table 2.** Characteristic respondents in three groups of respondents

15

Characteristic	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3 (2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25-30	3 (2.7)	14 (56.0)	0 (0.0)
31-35	30 (26.5)	3 (12.0)	0 (0.0)
36-40	19 (16.8)	1 (4.0)	0 (0.0)
41-45	32 (28.3)	0 (0.0)	3 (75.0)
46-50	18 (15.9)	0 (0.0)	1 (25.0)
>50	11 (9.7)	2 (8.0)	0 (0.0)

Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

1

2 b. Qualitative study

3 Nine informants were recruited to provide the required information to explore the  
 4 quantitative study results more deeply. They serve as managers and staff at  
 5 DHO/CHO, PHC, and UPS. Among the nine informants, 2 were men, and 7 were  
 6 women. Three informants graduated with master's, one bachelor's, and five diplomas  
 7 graduates (Table 3).

8

9

**Table 3.** Informants' characteristics for the qualitative study

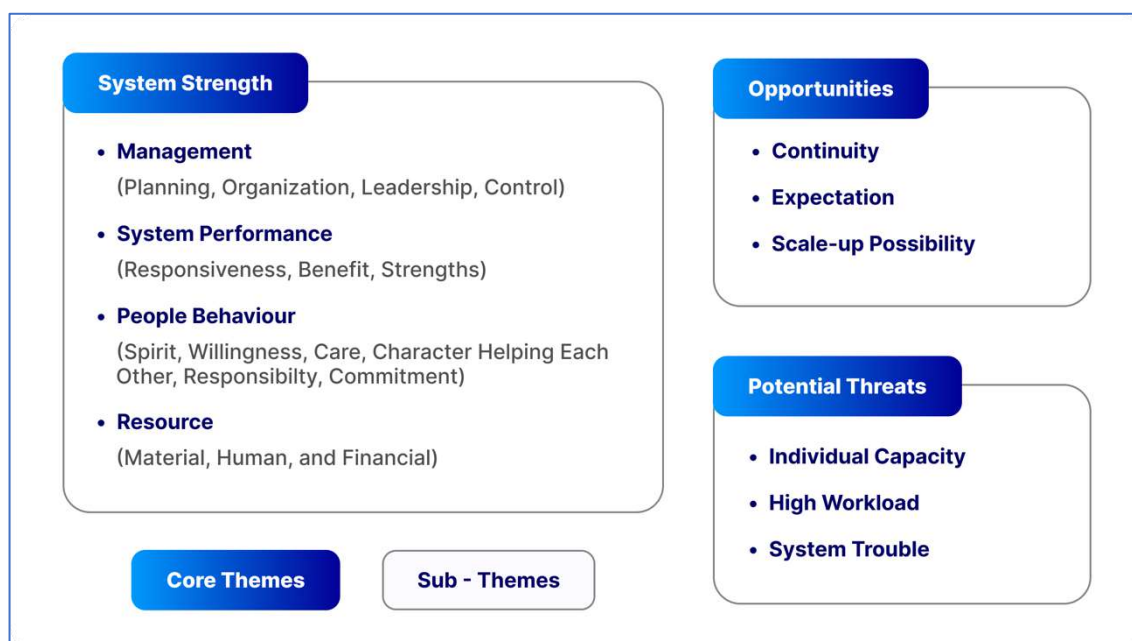
Sex	Age (years)	Education	Position	Subject group	Informant's code
Female	56	Magister	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Magister	The former of the disease prevention and control section at the PHO level	Managerial	M 02
Male	54	Bachelor	Immunization programmer at the PHO level	Managerial	M 03
Female	47	Magister	IT Person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at the UPS level	Staff	S 02
Female	31	Diploma	Data entry at the UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

10

11 c. Finding

12 Findings from the study are organized and presented across the three core themes that  
 13 emerged from the qualitative analysis, notably system strengths, potential threats, and

1 opportunities for scale-up. However, data from qualitative and quantitative data fed into  
2 the analysis of these core themes to cross-validate the findings (Figure 2. Detailed  
3 findings from the survey are presented in Table Supplement 1.



4

5

**Figure 2.** Strengths, potential threats, and opportunities for scale-up

6

### *System's Strengths*

7

Factors contributing to the success of SIMUNDU include management, system  
8 performance, people's behavior, and resources.

9

### **Management**

10

SIMUNDU arose due to concerns from the DIY Health Office immunization section  
11 around data quality, notably the need to address data inaccuracy, duplicate or missing  
12 data and lack of timely data, and the need for quality data to support follow-up and  
13 appropriate planning. The need for SIMUNDU arose from these challenges and needs.

1     *“To our knowledge, [SIMUNDU development] started with a problem: estimates of the*  
2             *target population varied depending on the data source” (M02)*

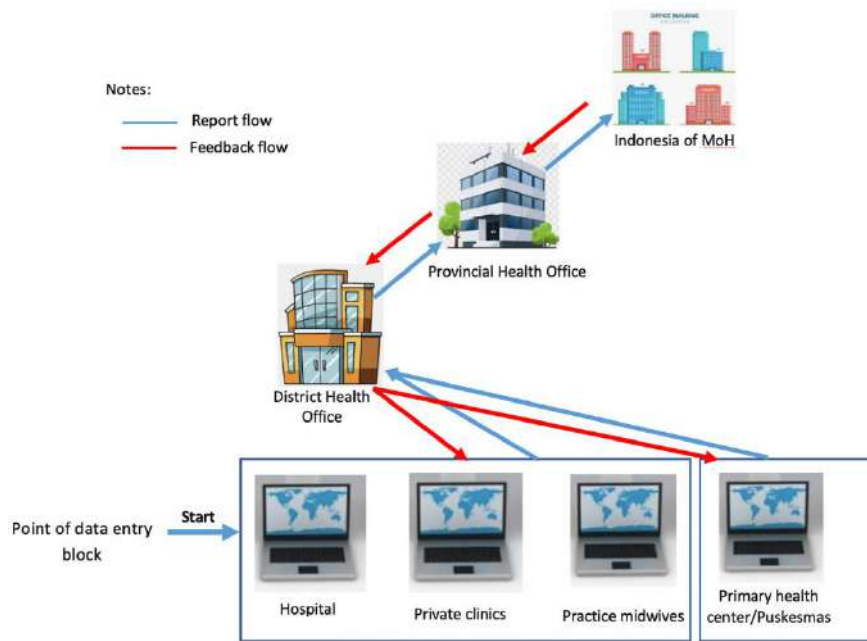
3     *“Yes, I think [SIMUNDU management team] started to tire of managing a large volume*  
4         *of data with dubious validity. They need to know the situation in each district”. (M04)*

5     Effective management of SIMUNDU from development to implementation was  
6     highlighted as an essential determinant of its success across the critical functions of  
7     Planning, Organization, Leadership, and Control.

8     Careful **Planning** was ensured at each stage of SIMUNDU development and  
9     implementation. These stages included developing an initial business plan, providing  
10    training on and socialization to SIMUNDU, and developing a staff replacement plan to  
11    respond to turnover or retirement of staff in charge of operating the system or entering  
12    data. The parties involved in planning included the Head of the Disease Prevention and  
13    Control Department, IT personnel, and from the DIY Health Office immunization  
14    program staff.

15    **Organization-** the organization of SIMUNDU, is carried out at several levels. The top  
16    level is the DIY Health Office, the second level is the district/city health office, and the  
17    third level is health facilities (Figure 2). A third party was also involved in developing  
18    the system interface.





1

2 **Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

3 At the beginning of SIMUNDU development, essential functions included database  
 4 administrators, interface designers, and server administrators, and their interplay  
 5 facilitated the system’s smooth operation. Training specific to SIMUNDU was integrated  
 6 with other training, typically immunization-related training. This enabled us to share of  
 7 resources with other programs, thus ensuring viability. The training was delivered in the  
 8 district/city health office: 87.6%, 72%, and 75% of survey respondents from PHC, UPS,  
 9 and DHO/CHO, respectively had participated in in-house training. Training typically  
 10 consisted of short sessions and included practice on the trainee's device to operate the  
 11 system in both online and offline mode. Informants indicated that day-to-day operations  
 12 were carried out autonomously by the staff through flexibly adjusting their work to  
 13 protect the time to enter the data. This seemed to work effectively.

14 **Leadership** - the success of SIMUNDU implementation is arguably related to strong  
 15 leadership. Informants noted that managers played a crucial role in bridging the needs of

1 the immunization program with the system design, closely monitoring the initial  
2 implementation process, and creating an enabling environment.

3 *“I try to combine supporting and managing and monitoring the people involved.  
4 Currently, I monitor whether [SIMUNDU] can run optimally as our users are health  
5 facilities. I also monitor program development and the system's output.” (M01)*

6 *“[SIMUNDU] was born from program managers, primary health centers, Districts, and  
7 DIY Health Offices wanting to build systems together. We – DIY Health Office - give  
8 them motivation in every meeting.” (M03)*

9 *“I see that [management] is very good at networking. Staff data entry in the field  
10 always said that these people are very kind.” (M02)*

11 The role of IT workers in developing SIMUNDU was also significant. They helped  
12 develop the system and facilitated correct data entry operators whenever technical issues  
13 arose. IT workers also helped resolve inconsistencies in data records. Acknowledgment  
14 of staff efforts was also important to maintain motivation and buy-in.

15 *“In the early days of SIMUNDU’s development, the system was challenging to operate,  
16 as it wasn’t as stable as it is now. I praise the enthusiasm and dedication of the users.”  
17 (M01)*

18 The **control** function - consisting of **quality** assurance management - was critical to avoid  
19 data duplication or missing entries and ultimately ensure data quality. This process was  
20 not regulated by specific Standard Operating Procedures but was addressed during  
21 training and monitored monthly. In addition, the DIY Health Office provided negative  
22 incentives to health facilities that were not submitting complete records and provided  
23 regular feedback from monitoring and evaluation exercises.

1 Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO,  
2 respectively, reported their work had been subject to monitoring. More than half of the  
3 respondents in PHC and UPS facilities had been observed by supervisors while  
4 performing data entry at least once over the past year. At the PHC level, 48.3% of survey  
5 respondents had been subject to monitoring from the district/city office’s team, and 45.7%  
6 received monitoring from DIY Health Office’s staff. Conversely, 40% of respondents  
7 from UPS facilities were monitored by PHC’s staff. Almost all survey respondents  
8 reported receiving feedback from the monitoring, mainly from the District/City and DIY  
9 Health Offices. Forty percent of respondents from UPS facilities reported receiving  
10 feedback from PHC. Immunization coordinators from the District/City Health Offices  
11 received feedback from the DIY Health Offices.

12 *“In a [evaluation] meeting, DIY Health Office or District Health Office showed the*  
13 *progress of our data entry – correct or not, proper or not.” (M02)*

14 It is worth noting that DIY Province is quite a small geographic area. Because it consists  
15 of only five districts and one city, this province is relatively easy to monitor across all  
16 phases, from planning through monitoring and evaluation.

## 17 **System performance**

18 While SIMUNDU predominantly contains individual-level immunization records, it also  
19 serves as a source for aggregation and can synergize with other information systems.  
20 Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports  
21 per the Ministry of Health’s requirements. These reports are sent to the upper levels  
22 automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is

1 operated offline. This functionality has had an essential role in ensuring the acceptability  
2 and adoption of the system.

3 Informants noted how transitioning from paper-based tools to an electronic system made  
4 data entry easier and reduced errors. SIMUNDU also facilitated the implementation of  
5 protocols for data storage and security. It enabled follow-up and defaulter tracking.  
6 Finally, integration with the DHIS2 meant reduced workload for the staff.

7 *“We can track children who may have received vaccinations in different locations*  
8 *faster. For example, when the first dose of a vaccine is given in Bantul and the second*  
9 *one in Yogyakarta, the record can be linked within SIMUNDU” (M01).*

10 *“SIMUNDU makes detecting what data and vaccinations are missing easier since we*  
11 *enter data from the children’s birth through the end of the immunization schedule. So,*  
12 *we will know where they miss any vaccine.” (S03)*

13 *“The benefit of using SIMUNDU is first: we know the situation of immunizations more*  
14 *accurately.....so our vaccine forecasting is more accurate .... and our budget, staff,*  
15 *facilities can be more effective and efficient in providing services.” (S05)*

16 *“Colleagues from the mother and child health (KIA) program enter the data via the KIA*  
17 *"Sembada." So, this data will appear automatically in SIMUNDU because the two*  
18 *system are connected.” (S01)*

19 SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the  
20 responsible staff to maintain data entry irrespective of connectivity. 82.3%, 96%, and  
21 100% of survey respondents from PHC, UPS, and DHO, respectively reported operating  
22 SIMUNDU online.

## 1 **People's behavior**

2 The interview showed that staff commitment was critical for the successful  
3 implementation of SIMUNDU, as indicated by their willingness to work overtime and  
4 bring home the data to enter into the system.

5 *“I take it [the data] home too, for example, after immunization sessions– in my clinic,*  
6 *immunization runs four times per month, every week. So, when the session is finished,*  
7 *we can take the data home, [and] do the entry at home while relaxing.” (S03)*

8 The interviews confirmed this dedication, which spoke to a societal culture of helping  
9 others and responsibility and commitment to the team. This contributed to shaping an  
10 environment where people approach SIMUNDU as a shared responsibility and a  
11 collective endeavor. Informants also noted the high motivation of dedicated staff.

12 *“That's all; we cannot judge by money [people's kindness, culture, and behavior];*  
13 *explaining how good people are in Yogyakarta is essential. I was in another place*  
14 *before, and could not find people's kindness like in Yogyakarta - different characters.”*  
15 *(M02)*

16 *“The second thing is that we need human resources concerned and love for data;*  
17 *otherwise, even though we have a good system, it will amount to nothing without good*  
18 *human resources. But good implementation will come more easily when people are*  
19 *concerned about data.” (M04)*

## 20 **Resource: material, human and financial**

21 Infrastructure and equipment emerged as critical factors in introducing and sustaining  
22 SIMUNDU implementation. Some desktops were explicitly allocated to the

1 immunization program, and some had to be shared with other staff. Other data entry  
2 officers reported using their laptop or smartphone (36.3% of survey respondents from  
3 PHC). In UPS facilities, 40.7% reported using office desktops; in the DHO, more than  
4 half of the respondents stated they used an office-supplied laptop. The majority of  
5 respondents – regardless of the type of facility - said their current device was sufficient  
6 to perform their work on SIMUNDU. Regarding connectivity, 64.6% of PHC survey  
7 respondents and 67.7% of UPS’s reported operating SIMUNDU online, relying on the  
8 office’s internet connection.

9 Management of financial resources was also crucial. According to the key informants, no  
10 special funds were allocated to SIMUNDU in the initial stages. Resources were leveraged  
11 through sharing activities – e.g., monitoring visits or transportation - with other programs,  
12 thus allowing cost efficiencies. Integration with other programs proved critical to  
13 ensuring sustainability.

14 *“SIMUNDU's budget comes from the state budget called as Anggaran Pendapatan dan*  
15 *Belanja Negara (APBN). Every year the APBN allocates funding envelope for*  
16 *immunization to DIY and other provinces, where the budget is apportioned across the*  
17 *program [not explicitly written budget for SIMUNDU].” (M02)*

18 Human resources are critical to the operation of SIMUNDU. According to interview,  
19 SIMUNDU data entry clerks must have patience, work carefully and not rush, be  
20 interested in data, be responsible, and have basic computer skills in word processing and  
21 spreadsheet software tools such as Microsoft Word and Excel, respectively. As shown by  
22 the survey, the large majority of SIMUNDU-operating staff was educated: at least 80%  
23 of data entry clerks in either PHC or UPS facilities have secondary education (>80%),

1 while at the managerial level (DHO), 75% of respondents have a Bachelor’s degree (see  
2 Table 2). However, 19.4% and 9.1% of respondents from PHC and UPS facilities, have  
3 low computer literacy.

4 Various data entry clerks looked for strategies to resolve the obstacles they encountered  
5 when entering data to SIMUNDU. Based on the interviews, some clerks furthered their  
6 computer skills by taking private computer classes. Others learned from colleagues at  
7 their offices, or reached out for help to the district person in charge. To deal with the  
8 accumulation of data needing to be entered in SIMUNDU, staff would sometimes work  
9 at home after office hours, as their busy schedule at work did not allow time for data  
10 entry.

11 *“If we found obstacles, we asked people in charge in PHC – asking for a solution or*  
12 *sharing by WhatsApp – or sometimes I asked the IT person in the DIY Health Office.”*  
13 *(S03)*

14 **Potential threats**

15 As of today, SIMUNDU can be said to be a successful experience. However, some  
16 obstacles were encountered and addressed during implementation. Potential system  
17 sustaining include individual capacity, technical or system issues, and high workload.  
18 Staff computer literacy was identified as one of the main sustainability challenges.  
19 Internet connectivity was another obstacle, as not a good network equally supported all  
20 health facilities. The survey shows that 64.6% and 67.7% of PHC and UPS staff used  
21 office internet, while others had to rely on their home internet.

22 Further, incomplete and inconsistent records – such as differing child's date of birth or  
23 name spelling across relevant entries - make it challenging to consistently record

1 immunization information. These challenges have arisen during implementation and were  
2 promptly addressed. Yet, they had an impact on staff who was already juggling busy  
3 schedule in the office, causing delays in data entry. As shown by the survey, almost all  
4 respondents stated having other responsibilities besides operating SIMUNDU – notably  
5 97.3%, 88%, and 100% of participants from PHC, UPS and district and city offices,  
6 respectively.

### 7 **Opportunities**

8 Informants appreciated SIMUNDU as an excellent system to manage immunization data.  
9 SIMUNDU has become necessary for program managers and policymakers; it allows  
10 them to monitor coverage and can help inform planning and programming. Currently,  
11 SIMUNDU is stable, thus is easier to manage than when it was in the development phase.  
12 It is also viable and no longer requires heavy reliance on the core workforce that started  
13 the system. The hopes expressed by data entry clerks in the interviews are that SIMUNDU  
14 is easier to operate and system errors are less frequent. Informants also stressed the need  
15 for refresher training to ensure knowledge and practice of the system is not lost.

16 *“In my opinion, SIMUNDU is the best program in DIY, a collaboration between*  
17 *program managers and IT. It will continue to be implemented because it is a necessity.*

18 *It has been stably used for more than five years, meaning this is needed.” (M01)*

19 *“If I have the tool, in this case, SIMUNDU, when it is stable, whoever will be able to*  
20 *run it, I am sure that anyone can operate it. It means that it doesn't matter if we have*

21 *people shifting (jobs).” (M01)*



1     *“In the future, if SIMUNDU is still used, other reports are not necessary. Now we have*  
2         *two different reports: SIMUNDU and stock card of vaccine – each stand-alone and*  
3                     *need a separate report.” (S05)*

4     Based on the key informants’ interviews, SIMUNDU is likely to be developed further /  
5     or expanded to other provinces. The DIY Health Office is open to supporting other  
6     provinces interested in introducing the system, for instance, through the lending staff for  
7     training and orientation. However, informants advised that a successful introduction  
8     requires a strong commitment from staff and management.

## 9     **Discussion**

10    Robust health information systems (HIS) are essential components of robust health  
11    systems (13). At the most basic level, immunization registries are systems that collect and  
12    report individual-level vaccine administration record data, thus facilitating individual  
13    follow-up of vaccination status. Registries also allow for the monitoring of vaccination  
14    coverage and enable analysis of AEFIs and surveillance data to inform the design of  
15    coverage interventions and outbreak investigations. When an electronic registry has  
16    interoperability with other electronic systems – such as in the case with SIMUNDU – it  
17    is considered an Immunization Information System (IIS) (14). This paper presents lessons  
18    learned from DIY’s experience implementing an IIS.

19    DIY is the only province in Indonesia – out of thirty-four - that uses an IIS. This work  
20    has shed light on the strengths and underlying barriers of implementing an IIS in this  
21    context. The objective of this study was to draw lessons that inform sustainable scale-up  
22    in other provinces and possibly at the national level. This study highlighted individual  
23    capacity, technical or system issues, and high workload as the major barriers to

1 sustainability. Conversely, management, system performance, people’s behavior, and  
2 available resources emerged as the main determinants of SIMUNDU’s successful  
3 implementation - notably in improving acceptability, implementation costs, and adoption  
4 of this innovation (15).

5 Despite several obstacles encountered during the implementation of SIMUNDU, this  
6 study showed that this innovation was well accepted by key stakeholders. On the one  
7 hand, data entry clerks noted that the system is relatively user-friendly and allows to  
8 organize the data better and enhance its quality. On the other hand, managers noted the  
9 benefits this innovation brought about, namely in the potential for cohort data to support  
10 planning and monitoring and ultimately improve immunization coverage.

11 Effective management - across planning, organization, leadership, and control functions  
12 – is a crucial reason why SIMUNDU has been viable for over 5 years. Managers use  
13 their control to encourage the beliefs and actions of the staff with a dedicated and robust  
14 managerial process (16). SIMUNDU was born from the need for credible data to assist in  
15 carrying out DIY Health Office duties at the managerial and operational levels. At the  
16 managerial level, the disease prevention and control department and the IT department  
17 collaborated in designing a system that intended users readily accepted. Immunization  
18 officers and IT programmers played a central role from the early stages of development  
19 through implementation with effective coordination and communication. They were  
20 helped in this task with the full support of their respective superiors.

21 SIMUNDU is cost-effective in several ways. During the introductory period of its  
22 implementation, immunization programmers, IT officers, and other staff assisted in  
23 introducing SIMUNDU in all districts in the province. This was done by integrating some

1 of the activities across programs, thus building efficiency in terms of time and costs for  
2 both managers and staff. Sharing resources across programs was critical in the first years  
3 of building sustainability. Additionally, SIMUNDU maintenance does not require high  
4 costs because the DIY Health Office has developed the system and thus possesses in-  
5 house technical skills. The IT department has the capacity to monitor and improve  
6 processes and tailor them to user needs without much additional cost.

7 A good program without good leadership could fail in its implementation, and even if it  
8 was initially successful, it might not be sustainable (17). In the context of SIMUNDU,  
9 leadership and effective management support facilitated the program's adoption. The  
10 uptake of the new system was good and all health facilities providing immunization  
11 services have successfully transitioned to SIMUNDU. The strong network of the  
12 prominent persons in charge of SIMUNDU also facilitated the adoption. Good  
13 communication, care, and attention to staff concern positively affected staff performance.  
14 They felt that they were well-supported and treated kindly, and this helped them carry out  
15 their work joyfully. According to several informants, the DIY immunization program  
16 manager's leadership played an essential role in this effect.

17 The monitoring and evaluation mechanisms of SIMUNDU were also important.  
18 Preferred monitoring and evaluation activities include monthly reports and staff  
19 discussions during site monitoring visits. The immunization program manager suggested  
20 this approach to maintain data quality and ensure the system sustainability. These chosen  
21 mechanisms allow program managers to assess the actual practice in the field and the  
22 challenges faced to inform decisions about the follow-up actions to be taken. These  
23 processes supported the ongoing development of and learning from, SIMUNDU as a tool  
24 for data collection, analysis, and visualization, as well as the benefits for managers to

1 carry out monitoring and evaluation. The same sentiment was reflected in previous  
2 research undertaken in the India (18).

3 Human resources are a key determinant of the successful implementation of any HIS (19).  
4 People's behavior affects how the system works, develops, and survives (20),(21). In the  
5 case of SIMUNDU, implementation was facilitated by a culture of care, established  
6 networks, and a positive attitude towards data of both the program manager and IT team.  
7 From the staff's point of view, the local culture of helping each other and doing their job  
8 correctly and responsibly translated into staff carrying out their duties with enthusiasm  
9 and high commitment. Although facilities, funding and human resources were limited,  
10 the individuals involved were highly motivated and supportive.

11 Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its  
12 sustainability in the long term. These obstacles can be divided into human variables and  
13 technical variables. From the human variables side, unequal capacity distribution at the  
14 operational level can result in differing levels of data quality across facilities and districts.  
15 Staff workload is another challenge need addressing, as their willingness to work  
16 overtime is not a sustainable strategy. Technical problems were another obstacle during  
17 the introduction of SIMUNDU, but qualified technicians/developers could solve these  
18 issues. During our research, we recognized the weakness of SIMUNDU that it had not  
19 used the person number as a unique code in data entry. This impacts SIMUNDU's  
20 inability to synchronize with other health programs that use a person's number as a unique  
21 code. However, this weakness can be seen as room for improvement for SIMUNDU  
22 shortly. Another thing that needs to be considered for other regions that will implement  
23 SIMUNDU that SIMUNDU is that implemented in the DIY province which consists of  
24 5 districts/cities with relatively easy regional accessibility. For areas with more difficult

1 access, the commitment of the leadership and subordinates is the key to successful  
2 implementation.

### 3 **Conclusion and recommendation**

4 SIMUNDU is a promising innovation for the entire country, beyond DIY. There is  
5 agreement about the potential for scale-up of this IIS to other provinces. Experience of  
6 implementing this system in DIY over the past five years has shown that the benefits  
7 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
8 system. Regular training to dedicated staff for strengthen their capacity as the system  
9 evolves and is updated, and a plan for anticipating and responding to staff turnover have  
10 proven critical strategies towards sustainability. SIMUNDU's success also rests on  
11 remarkable leadership, both in creating and enabling a supportive environment and  
12 pursuing integration with other programs to share limited resources.

13 This study's recommendations address three different stakeholders groups: the DIY  
14 Health Office, the national government, and researchers. First, to ensure continuity and  
15 sustainability and reduce the system's dependency on a particular person or party,  
16 SIMUNDU management and maintenance should be managed by people who have  
17 competency and interest in a good reporting system. Furthermore, a human resources plan  
18 should be developed in preparation for SIMUNDU roll-out in other provinces or at the  
19 national levels; this is necessary to avoid vacancies when DIY province staff are seconded  
20 to other areas for mentoring support. Second, the fact that SIMUNDU emerged from an  
21 actual need for immunization programme implementers and saw these at the front-line of  
22 its development and implementation, positively impacted its feasibility and viability. This  
23 suggests that the approach to scaling up SIMUNDU should be stepwise, considering each

1 region's specific characteristics and needs. To this effect, a readiness map and a timeline  
2 may be developed to roll out of SIMUNDU in a particular region. Third, further research  
3 is needed to assess the impact of SIMUNDU on immunization coverage. Based on our  
4 conversations with stakeholders, it would be particularly relevant to focus on a low-  
5 performing region and observe the impact over a 2 to the 3-year time window.

## 6 **Study limitations**

7 The empirical results reported herein should be considered in light of limitations. First,  
8 the results of the quantitative study must be considered concerning the limited sample  
9 size, particularly for UPS Health Facilities. However, considering the top-down  
10 immunization program and the characteristics of UPS, which will not be significantly  
11 different from each other, the results of this study are still valid and relevant to the  
12 existing. In qualitative research that aims to explore, caution is needed in interpreting the  
13 interview results. These results still a need in-depth studies with different approaches,  
14 such as focus group discussions to confirm the results.

## 15 **Declarations**

### 16 Ethics approval and consent to participate

17 This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan,  
18 Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began,  
19 consent to participate was obtained from research subjects (both survey and key  
20 informant interviews).

### 21 Adherence to national and international regulations

22 Not applicable

### 23 Consent for publication

1 Before data collection begins, an approval that data is taken for publication purposes is  
2 obtained from research subjects (both surveys and key informant interviews).

### 3 Availability of data and materials

4 The datasets generated and or analyzed for this study can be requested from the  
5 corresponding author.

### 6 Competing interests

7 The authors declare that they have no competing interests.

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### 15 Authors' contributions

16 SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the  
17 data. SS and RR conducted data analysis. SS developed the paper with inputs and  
18 comments from MF on each draft. All authors agree with the manuscript's results and  
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20

21

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5 Authors' information:

6 The authors alone are responsible for the views expressed in this article. They do not  
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13

# BMC Health Services Research

## Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up --Manuscript Draft--

<b>Manuscript Number:</b>	BHSR-D-21-00992R3	
<b>Full Title:</b>	Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up	
<b>Article Type:</b>	Research article	
<b>Section/Category:</b>	Health systems and services in low and middle income settings	
<b>Funding Information:</b>	Alliance for Health Policy and Systems Research (2020/1011143-0)	Mrs Sulistyawati Sulistyawati
<b>Abstract:</b>	<p><b>Background:</b> Immunization is critical to saving children from infections. To increase vaccination coverage, valid and real-time data is needed. Accordingly, it is essential to have a good report system that serves as defaulter tracking to prevent children's immunization failure. The Daerah Istimewa Yogyakarta (DIY) Health Office introduced an electronic immunization registry and successfully implemented it for over than five years. It is the only individual-based record system in Indonesia that has been sustainably operated for a long time. Yet, no systematic assessment of this system has been conducted to date. This study examines the Sistem Informasi Imunisasi Terpadu (SIMUNDU) introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.</p> <p><b>Methods:</b> This study used an explanatory sequential mixed-method design, which collected quantitative data from 142 participants and qualitative data from 9 participants. Entry data clerk in a health facility was systematically selected to participate in the survey. While in the key informant interview, the informant was selected based on the survey result. A descriptive and thematic approach was adopted to analyze the quantitative and qualitative data. Results from across the two approaches were integrated for comparison and contrast.</p> <p><b>Results:</b> Findings are presented according to three core themes that emerged from the data: system strengths, potential threats, and opportunities for scale-up. Strengths - i.e. factors contributing to the success of SIMUNDU - include management, system performance, people's behavior, and resources. Potential threats to sustaining the system include individual capacity, technical or system issues, and high workload. Opportunities - i.e promising factors that SIMUNDU can be operated sustainably - such as continuity, expectation and scale up possibility.</p> <p><b>Conclusions:</b> SIMUNDU is a promising innovation for Indonesia, beyond DIY. There is agreement about the potential for scale-up of this IIS to other provinces. Experience of implementing this system in DIY over the past five years has shown that the benefits outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly system.</p>	
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1 **Introduction and implementation of an immunization information**  
2 **system in Indonesia province of Daerah Istimewa Yogyakarta: lessons**  
3 **for scale-up**

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8 1 **Abstract**

9  
10 2 **Background:** Immunization is ~~undeniably~~critical to sav~~ing~~e children from infections.  
11 3 To increase vaccination coverage, valid and real-time data is needed. Accordingly, it is  
12 4 essential to have a good report system that serves as defaulter tracking to prevent  
13 5 children's immunization failure. ~~The~~ Daerah Istimewa Yogyakarta (DIY) ~~H~~health ~~O~~office  
14 6 introduced an electronic immunization registry and successfully implemented it for ~~more~~  
15 7 ~~over~~ than five years. It is the only individual-based record system in Indonesia that has  
16 8 been sustainably operated for ~~such~~-a long time. Yet, no systematic assessment of this  
17 9 system has~~e~~ been conducted to date. This study examines ~~the~~ Sistem Informasi Imunisasi  
18 10 Terpadu (SIMUNDU) introduction and implementation process ~~in order~~-to draw lessons  
19 11 that could inform scalability and sustainability across the country.

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28 12 **Methods:** This study used an explanatory sequential mixed-method design, which  
29 13 collected quantitative data from 142 participants and qualitative data from 9 participants.  
30 14 Entry data clerk in ~~a~~ health facility was systematically selected to participate in the  
31 15 survey. While in the key informant interview, the informant was selected based on the  
32 16 survey result. A descriptive and thematic approach was adopted to analyze the  
33 17 quantitative and qualitative data. Results from across the two approaches were integrated  
34 18 for comparison and contrast.

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41 19 **Results:** Findings are presented according to three core themes ~~that~~ emerged from the  
42 20 data: system strengths, potential threats, and opportunities for scale~~-~~up. Strengths -i.e.  
43 21 factors contributing to the success of SIMUNDU - include management, system  
44 22 performance, people's behavior, and resources. Potential threats to sustaining the system  
45 23 include individual capacity, technical or system issues, and high workload. Opportunities  
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1 – i.e promising factors that SIMUNDU can be operated sustainably – such as continuity,  
2 expectation and scale up possibility.

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5 **Conclusions:** SIMUNDU is a promising innovation for ~~the entire country~~Indonesia,  
6 beyond DIY. There is agreement about the potential for scale-up of this IIS to other  
7 provinces. Experience of implementing this system in DIY over the past five years has  
8 shown that the benefits outweigh the challenges, and SIMUNDU has grown into a robust  
9 ~~and~~ yet user-friendly system.

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11 **Keywords:** immunization, electronic immunization registry, immunization information  
12 system, interoperability, implementation research

### 13 **Background**

14  
15 Neonatal and childhood vaccination is ~~an~~ essential ~~component of~~to infectious disease  
16 prevention and an absolute human right (1),(2). Vaccination has been proven to reduce  
17 the burden of infectious diseases globally (3). According to the WHO, in 2020, ~~an~~  
18 estimated 23 million children under one year ~~of age~~ did not receive their essential  
19 vaccinations. Of these, 60% live in just ten countries, one of which is Indonesia (4).  
20 Indonesia is the fourth most populous country globally. It is composed of thousands of  
21 islands organized into 34 provinces. Various geographical and cultural factors influence  
22 population inequalities to access ~~to~~ health services (5). In 2001, the Indonesian  
23 government's decentralization policy was enacted. This was an excellent strategy to foster

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8 1 development by engaging regional resources (6). However, this strategy was not without  
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10 2 consequence. One primary concern was the ~~fragmentation of the~~ Health Information  
11 3 System (HIS) fragmentation.  
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14 4 Indonesia's federal structure results in provinces and districts being relatively independent  
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16 5 of the national Ministry of Health. This means that provincial and district-levels  
17 6 information systems ~~at the provincial and district levels~~ are locally regulated (7). For  
18 7 instance, *Pemantauan Wilayah Setempat* (PWS) is a management tool used to monitor  
19 8 coverage of specific health services in an administrative boundary. Depending on the  
20 9 service and region, it can be paper- or electronic-based. PWS-KIA is the monitoring  
21 10 system specific to maternal and child health (KIA), including immunization. PWS-KIA  
22 11 data are reported to the District or City Health Office, go to Province Health Office, and  
23 12 finally reported to the main level. Generally, the data ~~are in is in~~ Microsoft exeeel-Excel  
24 13 formats; it will report via emails or various information systems, including Komdat, SiTT,  
25 14 SIHA, PISPK, and SIKDA Generik. PWS-KIA data feeds into ~~the~~ District Health  
26 15 Information System 2 (DHIS2) ~~in some provinces~~. Regional information systems have  
27 16 varying data quality, which reflects inequities in resources across regions. This adds to  
28 17 data integration challenges at the national level (7),(8) and affects strategic policymaking.  
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31 18 In ~~the context of~~ Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY)  
32 19 Province has the authority to regulate and use its budget within its four districts plus one  
33 20 city (Sleman, Gunungkidul, Bantul, Kulonprogo and Yogyakarta). This province is  
34 21 classified as a small province in terms of area size and the number of regions inside (9).  
35 22 However, this region can be aforesaid to be considered a representation of Indonesia when  
36 23 viewed from the geographical, socio-economic and heterogeneous ~~of its~~ population.  
37 24 Regarding childhood vaccination, DIY is among the top ten performing provinces in the  
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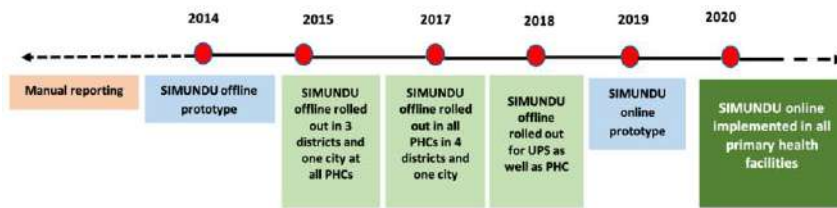
1 country, with 97.7 % of children completing basic immunization coverage in 2019 (10).  
2 Immunization services are provided by Primary Health Centres or Puskesmas (PHC), as  
3 well as private clinics, hospitals, and midwives' practices (typically referred to as *Unit*  
4 *Pelayanan Swasta* or UPS).

5 An electronic immunization registry is a tool for recording individual children's  
6 immunization histories. In 2014, the DIY Health Office introduced an electronic  
7 immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu/*  
8 *Integrated Immunization Information System*). ~~An electronic immunization registry is a~~  
9 ~~tool for recording individual children's immunization histories.~~ An electronic registry  
10 serves essential functions at all levels of the health system. At the district and higher  
11 levels, it allows for monitoring vaccination coverage by the vaccine, dose, cohort, and  
12 other variables – and can support microplanning and vaccine management. The service  
13 delivery level can facilitate individual follow-up of vaccination status and enable health  
14 workers to identify children due for vaccination and those who missed their vaccinations  
15 (defaulters).

16 SIMUNDU was designed to link with the PWS-KIA for immunization and  
17 interoperability with the DHIS2. While it predominantly contains individual-level  
18 immunization records, SIMUNDU also serves as a source for aggregation and can  
19 synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this  
20 reason, it can be considered an Immunization Information System (IIS). This means that  
21 ~~data from~~ City and District levels feed into Provincial and National levels (*Personal*  
22 *communication with DIY immunization program officer*).

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1 The original prototype was designed by the information and technology (IT) department  
2 of DIY Health Office to be operated offline. In DIY, three out of the four districts and the  
3 city introduced the system in 2015. The final district introduced it in 2017. At this stage,  
4 the point of data entry was the PHC only. By 2018, UPS facilities were also equipped  
5 with SIMUNDU and could enter data into the system. In 2019, the prototype was further  
6 developed to operate online. The online version was rolled out in 2020 (Figure 1). As of  
7 May 2021, 79.4% of all PHC and UPS facilities ~~were complying~~ complied. This average  
8 rate masks, however, the fact that while all PHCs adopt SIMUNDU, it is more  
9 challenging to enforce its use in UPC facilities (Suyani 2020, oral communication, 2020,  
10 May 11).



11  
12 **Figure 1.** SIMUNDU’s development and introduction

13 When a child receives a vaccination in a health facility, information on the child and the  
14 vaccination is entered in SIMUNDU as an individual child record. Each record includes  
15 a personal identifier, the child’s socio-demographic characteristics (e.g., name, gender,  
16 date of birth, name of parents, address), the antigen administered, and the date and place  
17 of vaccination. SIMUNDU has been recently updated to allow the recording of  
18 vaccinations administered in schools (e.g., Human papillomavirus (HPV), Diphtheria  
19 Toxoid (DT), Tetanus-Diphtheria (TD), and Measles-Rubella (MR), though in the form

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8 | 1 of aggregate data only. Furthermore, SIMUNDU has ~~being-been~~ developed to record  
9 | 2 COVID-19 vaccinations in health facilities and those carried out in masse.

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12 | 3 Monitoring is conducted ~~every-monthly~~ to assess data completeness across health  
13 | 4 facilities, while an evaluation is conducted ~~every-yearly~~. These exercises have allowed  
14 | 5 the identification of several challenges related to implementing the system (e.g.,  
15 | 6 workload, staff turnover, and rotation) and data quality (e.g., accuracy and timeliness).  
16 | 7 However, no systematic assessment of the system has been conducted to date. SIMUNDU  
17 | 8 is the first immunization information system ever introduced in Indonesia. Other districts  
18 | 9 and provinces have shown interest in rolling it out, and the Ministry of Health has  
19 | 10 acknowledged the innovation. The ~~objective of their~~ work ~~presented here aims was to~~  
20 | 11 examine SIMUNDU's introduction and implementation process to draw lessons that  
21 | 12 could inform scalability and sustainability across the country.

### 31 | 13 **Methods**

32  
33 | 14 From May to October 2020, we examined the experience of introducing and  
34 | 15 implementing an immunization information system in the DIY province using an  
35 | 16 explanatory sequential mixed-method design, where each step informed the next (11).  
36 | 17 First, we ~~conducted a desk~~ reviewed of all relevant documentation available in the DIY  
37 | 18 ~~H~~health ~~O~~ffice – e.g., staff notes, meeting notes and monitoring notes – documenting  
38 | 19 SIMUNDU development and management processes. We also examined online  
39 | 20 documents, including health profiles and regulations on health reporting systems in  
40 | 21 Indonesia. This served as the initial ~~data~~ source ~~of data~~ and provided an overview of who  
41 | 22 was involved and how; in developing and implementing SIMUNDU. This informed the  
42 | 23 survey design that we conducted as a second step. The survey targeted any staff  
43 | 24 responsible for entering data in SIMUNDU (i. e. data clerks) across all PHC and selected

UPS facilities and any staff responsible for managing the system at the district and city level (i.e., immunization coordinators). Sampling and recruitment strategies are outlined in Table 1.

**Table 1. Survey participant**

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
Primary Health Centre (PHC)	121	Data entry clerks	All facilities	Open invitation across all facilities	113
UPS - Central, General, Maternity and Pediatric Hospitals	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
UPS - Clinics	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
UPS - Midwives* Practices	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinators	Total sampling	Open invitation	4*
<b>Total</b>					<b>142</b>

\*When the immunization coordinator had recently changed, the former was also invited.

All immunization coordinators in each district/city and data entry clerks from all primary health facilities (PHC) were invited to participate in this survey. ~~For As to~~ UPS facilities, we ~~randomly~~ selected two clinics, two midwives' practices, and two hospitals per district/city, and invited all of their staff to be involved in SIMUNDU data entry and management.

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1 We developed and pre-tested an online survey in Bahasa Indonesia to inquire about  
2 SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, district  
3 or city and province offices. The questionnaire consisted of close-ended and Likert scale  
4 questions – ranging from 45 to 50 depending on the target type of facility and/or level of  
5 the health system – and enquired about respondents’ socio-demographic characteristics  
6 as well as the process of implementing and managing SIMUNDU. Some questions  
7 provided an additional field for clarifying the reason for a particular ~~answer choice~~  
8 ~~of~~ answer.

9 All participants were invited to the DIY ~~H~~health ~~O~~office to ~~complete~~~~fill-out~~ the survey  
10 on their laptops, with their prior consent. ~~A~~Having all participants in a room allowed  
11 researchers to monitor any missing or incomplete responses in real-time and follow-up  
12 with individual participants on-site to fill any gaps. We don’t believe this may have  
13 introduced any significant bias as researchers would simply flag any missing responses  
14 and invite respondents to address those. Data were then exported ~~into~~ and analyzed in  
15 Microsoft Excel. An exploratory analysis of the survey data informed the topic areas that  
16 qualitative interviews ~~would delve~~explore into further.

17 Similarly, some informants were purposefully selected among survey participants to  
18 follow up on the range of perspectives that had emerged from the survey. Other  
19 ~~informants had been identified at the desk review stage and chosen for their management~~  
20 ~~functions. Selected informants were~~ invited to the DIY Health Office for ~~the purpose of~~  
21 the interview, and COVID-19 prevention protocol was observed. Every informant was  
22 informed about the study and asked to sign the informed consent. All invited informants  
23 agreed to participate. A total of nine 30-minute semi-structured interviews were  
24 conducted in Bahasa Indonesia language, and recorded with prior consent from

1 participants. The interview team consisted of three researchers with the respective task of running the interview, observing and taking notes. A research assistant transcribed all interviews in Bahasa Indonesia language.

Thematic analysis was conducted using Quirkos qualitative tool following Braun and Clarke's approaches (12). Researchers familiarized themselves with the data, searching for initial codes and allowing themes to emerge. The principal investigator led the coding process, and led the research team in defining and naming the core themes emerging from the data, organizing and analyzing the data across the themes, and triangulating information from the desk review, the survey, and the interviews. This stage was also performed in Bahasa Indonesia. Data were translated to English only at sub-theme and core themes.

## Results

### Characteristic participant

#### a. Quantitative study

In total, 142 respondents participated in this study spread across five districts/~~or~~ cities in the DIY province. Most respondents came from Gunungkidul District, PHC, UPS, and DHO, 24.8%, 24%, and 25%, respectively. For all research units, the majority are women. At the UPS and DHO/CHO levels, most respondents were aged 41-45 years, i.e., 28.3% and 75%, respectively, while at the UPS level, the majority were aged 25-30 years (56.0%). For education level, PHC and UPS are dominated by Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, it is predominantly undergraduate graduates (75%) (Table 2)

Table 2. Characteristic respondents in three groups of respondents

Characteristic	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3 (2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25-30	3 (2.7)	14 (56.0)	0 (0.0)
31-35	30 (26.5)	3 (12.0)	0 (0.0)
36-40	19 (16.8)	1 (4.0)	0 (0.0)
41-45	32 (28.3)	0 (0.0)	3 (75.0)
46-50	18 (15.9)	0 (0.0)	1 (25.0)
>50	11 (9.7)	2 (8.0)	0 (0.0)
Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

## b. Qualitative study

Nine informants were recruited to provide the required information to explore ~~deeper~~ ~~into~~ the quantitative study results more deeply. They ~~hold a less~~ serve as managers and staff at DHO/CHO, PHC, and UPS. Among the nine informants, 2 were men, and 7 were women. Three informants graduated ~~from~~ with master's, one bachelor's, and five diplomas graduates (Table 3).

**Table 3.** Informants' characteristics for the qualitative study

Sex	Age (years)	Education	Position	Subject group	Informant's code
Female	56	Magister	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Magister	The former of <u>the</u> disease prevention and control section at <u>the</u> PHO level	Managerial	M 02
Male	54	Bachelor	Immunization programmer at <u>the</u> PHO level	Managerial	M 03
Female	47	Magister	IT Person	Managerial	M 04



Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at <u>the</u> UPS level	Staff	S 02
Female	31	Diploma	Data entry at <u>the</u> UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

c. Finding

Findings from the study are organized and presented across the three core themes that emerged from the qualitative analysis, notably system strengths, potential threats, and opportunities for scale-up. ~~However~~~~Yet~~, data from ~~both the~~ qualitative and quantitative data fed into the analysis of these core themes, to cross-validate the findings (Figure 2. Detailed findings from the survey are presented in Table Supplement 1.

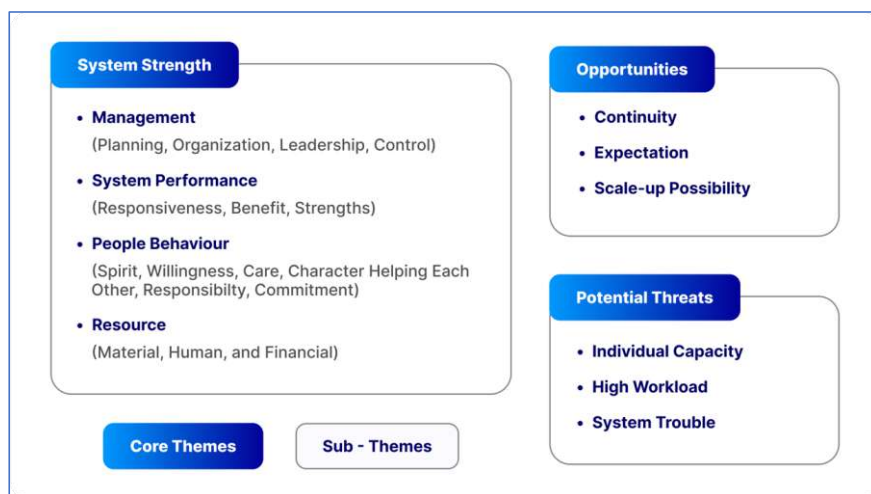


Figure 2. Strengths, potential threats, and opportunities for scale-up

*System's Strengths*

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1 Factors contributing to the success of SIMUNDU include management, system  
2 performance, people’s behavior, and resources.

3 **Management**

4 SIMUNDU arose due to concerns from the DIY ~~health-Health O~~ffice immunization  
5 section around data quality, notably the need to address ~~issues related to~~ data inaccuracy,  
6 duplicate or missing data and lack of timely data, and the need ~~for~~ quality data to  
7 support follow-up and appropriate planning. The need for SIMUNDU arose from these  
8 challenges and needs.

9 *“To our knowledge, [SIMUNDU development] started with a problem: estimates of the  
10 target population varied depending on the data source” (M02)*

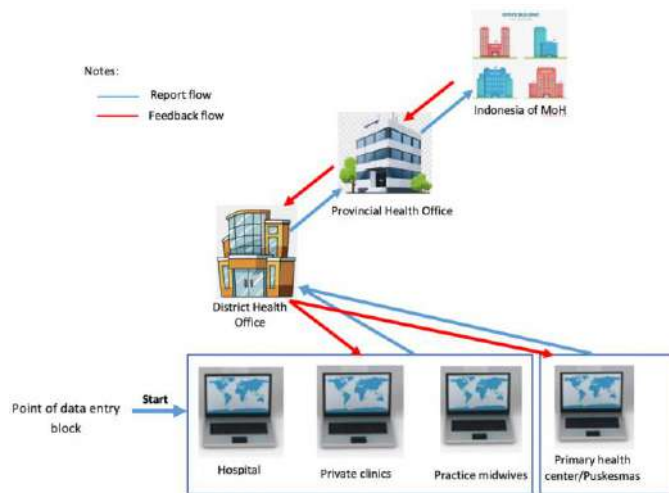
11 *“Yes, I think [SIMUNDU management team] started to tire of managing a large volume  
12 of data with dubious validity. They need to know the situation in each district”. (M04)*

13 Effective management of SIMUNDU from development to implementation was  
14 highlighted as an essential determinant of its success across the critical functions of  
15 Planning, ~~Organizationaling~~, ~~Leadershiping~~, and ~~Controlling~~.

16 Careful **Planning** was ensured at each stage of SIMUNDU development and  
17 implementation. These stages included developing an initial business plan, providing  
18 training on and socialization to SIMUNDU, and developing a staff replacement plan to  
19 respond to turnover or retirement of staff in charge of operating the system or entering  
20 data. The parties involved in planning included the ~~H~~ead of ~~the D~~eisease ~~P~~revention  
21 and ~~C~~ontrol ~~D~~epartment, IT personnel, and ~~immunization program staff~~ from the DIY  
22 ~~health-Health O~~ffice immunization program staff.

1 **Organizational** the organization of SIMUNDU is carried out at several levels. The  
 2 top level is the DIY Health Office, the second level is the district/city health office, and  
 3 the third level is health facilities (Figure 2). A third party was also involved in developing  
 4 the system interface.

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6 **Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

7 At the beginning of SIMUNDU development, essential functions included database  
 8 administrators, interface designers, and server administrators, and their interplay  
 9 facilitated the system's smooth operation of the system. Training specific to SIMUNDU  
 10 was integrated with other training, typically immunization-related training. This enabled  
 11 us to share of resources with other programs, thus ensuring viability. The training was  
 12 delivered in the district/city health office: 87.6%, 72%, and 75% of survey respondents  
 13 from PHC, UPS, and DHO/CHO, respectively had participated in in-house training.  
 14 Training typically consisted of short sessions and included practice on the trainee's device  
 15 on how to operate the system in both online and offline mode. Informants indicated that

1 day-to-day operations were carried out autonomously by the staff, through flexibly  
2 adjusting their work to protect the time to enter the data. ~~And~~ ~~†~~ This seemed ~~ed~~ to work  
3 effectively.

4 **Leadership** - the success of SIMUNDU implementation is arguably related to strong  
5 leadership. Informants noted that managers played a crucial role in bridging the needs of  
6 the immunization program with the system design, closely monitoring the initial  
7 implementation process, and creating an enabling environment.

8 *“I try to combine supporting and managing ~~the people involved~~ and monitoring ~~them~~ the  
9 people involved. Currently, I monitor whether [SIMUNDU] can run optimally as our  
10 users are health facilities. I also monitor program development and the system's  
11 output.” (M01)*

12 *“[SIMUNDU] was born from program managers, primary health centers, Districts, and  
13 ~~DIY health~~ Health Offices wanting to build systems together. We – ~~DIY H~~ health  
14 Office - give them motivation in every meeting.” (M03)*

15 *“I see that [management] is very good at networking. Staff data entry in the field  
16 always said that these people are very kind.” (M02)*

17 The role of IT workers in developing SIMUNDU was also ~~reported to be~~ significant.  
18 They helped develop the system and ~~facilitated~~ ~~supported~~ correct data entry operators  
19 ~~whenever by assisting data entry operators whenever these encountered~~ technical issues  
20 ~~arose. IT workers also~~ ~~or~~ ~~helped~~ resolve inconsistencies in ~~the~~ data records.  
21 Acknowledgment of staff efforts was also ~~an~~ important ~~lever~~ to maintain motivation and  
22 buy-in.

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1 “In the early days of SIMUNDU’s development, the system was challenging to operate,  
2 as it wasn’t as stable as it is now. I praise the enthusiasm and dedication of the users.”

3 (M01)

4 The **controlling** function - consisting ~~in~~ **of quality** assurance management - was critical  
5 to avoid data duplication or missing entries, and ultimately ensure data quality. This  
6 process was not regulated by specific Standard Operating Procedures but was addressed  
7 during training and monitored monthly. In addition, the DIY **Hhealth Ooffice** provided  
8 negative incentives to health facilities that were not submitting complete records and  
9 provided regular feedback from monitoring and evaluation exercises.

10 Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO,  
11 respectively, reported their work had been subject to monitoring. More than half of the  
12 respondents in PHC and UPS facilities had been observed by supervisors while  
13 performing data entry at least once over the past year. At the PHC level, 48.3% of survey  
14 respondents had been subject to monitoring from the district/city office’s team, and 45.7%  
15 received monitoring from DIY ~~health-Health~~ **Ooffice**’s staff. Conversely, 40% of  
16 respondents from UPS facilities were monitored by PHC’s staff. Almost all survey  
17 respondents reported receiving feedback from the monitoring, mainly from the  
18 District/City and DIY **Hhealth Ooffices**. Forty percent of respondents from UPS facilities  
19 reported receiving feedback from PHC. Immunization coordinators from the District/City  
20 **Hhealth Ooffices** received feedback from the DIY **Hhealth Ooffices**.

21 “In a [evaluation] meeting, DIY ~~health-Health~~ **Ooffice** or ~~District~~ **Hhealth Ooffice**  
22 showed the progress of our data entry – correct or not, proper or not.” (M02)

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8 | 1 It is worth noting that DIY ~~P~~province is quite a small geographic area. Because it consists  
9 | 2 of only five districts and one city, this province is relatively easy to monitor across all  
10 | 3 phases, from planning through monitoring and evaluation.

#### 14 | 4 **System performance**

16 | 5 While SIMUNDU predominantly contains individual-level immunization records, it also  
17 | 6 serves as a source for aggregation and can synergize with other information systems.  
18 | 7 Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports  
19 | 8 ~~as~~ per [the](#) Ministry of Health’s requirements. These reports are sent to the upper levels  
20 | 9 automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is  
21 | 10 operated offline. This functionality has had an essential role in ensuring the acceptability  
22 | 11 and adoption of the system.

29 | 12 Informants noted how transitioning from paper-based tools to an electronic system made  
30 | 13 data entry easier and reduced errors. [SIMUNDU](#) also facilitated the implementation of  
31 | 14 protocols for data storage and security. It enabled follow-up and defaulter tracking.  
32 | 15 Finally, integration with the DHIS2 meant reduced workload for the staff.

38 | 16 “We can ~~track~~ [faster tracking](#) of children who may have received vaccinations in  
39 | 17 different locations [faster](#). For example, when the first dose of a vaccine is given in  
40 | 18 Bantul and the second one in Yogyakarta, the record can be linked within SIMUNDU”

43 | 19 (M01).

46 | 20 “SIMUNDU makes ~~it easier to detect~~ [ing](#) what data and vaccinations are missing [easier](#)  
47 | 21 since we enter data from the children’s birth through the end of the immunization  
48 | 22 schedule. So, we will know where they miss any vaccine.” (S03)

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1 “The benefit of using SIMUNDU is first: we know the situation of immunizations more  
2 accurately....so our vaccine forecasting is more accurate .... and our budget, staff,  
3 facilities can be more effective and efficient in providing services.” (S05)

4 “Colleagues from the mother and child health (KIA) program enter the data via the KIA  
5 “Sembada.” So, this data will appear automatically in SIMUNDU because the two-  
6 system are connected.” (S01)

7 SIMUNDU is user-friendly and can be flexibly operated either offline or online, allowing  
8 the responsible staff to maintain data entry irrespective of connectivity. 82.3%, 96% and  
9 100% of survey respondents from PHC, UPS and DHO respectively reported to  
10 operating SIMUNDU online.

11 **People’s behavior**

12 The interview showed that staff commitment was critical for the successful  
13 implementation of SIMUNDU, as indicated by their willingness to work overtime and  
14 bring home the data to enter into the system.

15 “I take it [the data] home too, for example, after immunization sessions– in my clinic,  
16 immunization runs four times per month, every week. So, when the session is finished,  
17 we can take the data home, [and] do the entry at home while relaxing.” (S03)

18 ~~The interviews confirmed this. This dedication–dedication was confirmed by the~~  
19 ~~interviews,~~ which spoke to a societal culture of helping others and responsibility and  
20 commitment to the team. This contributed to shaping an environment where people  
21 approach SIMUNDU as a shared responsibility and a collective endeavor. Informants  
22 also noted the high motivation of dedicated staff.

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8 1 “That’s all; we cannot judge by money [~~f~~people’s kindness, culture, and behavior]; ~~it’s~~  
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10 2 ~~essential to~~ explaining how good people are in Yogyakarta is essential. I was in another  
11  
12 3 place before, and ~~I could not find~~ people’s kindness like in Yogyakarta - different  
13  
14 4 characters.” (M02)

15  
16 5 “The second thing is that we need human resources concerned and love for data;  
17  
18 6 otherwise, even though we have a good system, it will amount to nothing without good  
19  
20 7 human resources. But good implementation will come more easily when people are  
21  
22 8 concerned about data, ~~good implementation will come more easily~~.” (M04)

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24 9 **Resource: material, human and financial**

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26 10 Infrastructure and equipment emerged as critical factors ~~to~~ in introducing and sustaining  
27  
28 11 SIMUNDU implementation. Some desktops were ~~specifically~~ explicitly allocated to the  
29  
30 12 immunization program, and some had to be shared with other ~~programs’~~ staff. Other data  
31  
32 13 entry officers reported using their ~~own~~ laptop or smartphone (36.3% of survey  
33  
34 14 respondents from PHC). In UPS facilities, 40.7% reported using office desktops, ~~and~~ in  
35  
36 15 the DHO, more than half of the respondents stated they used an office-supplied laptop.  
37  
38 16 The majority of respondents – regardless of the type of facility - said their current device  
39  
40 17 was sufficient to perform their work on SIMUNDU. Regarding connectivity, 64.6% of  
41  
42 18 PHC survey respondents and 67.7% of UPS’s reported operating SIMUNDU online, and  
43  
44 19 relying on the office’s internet connection.

45  
46 20 Management of financial resources was also crucial. According to the key informants, no  
47  
48 21 special funds were allocated to SIMUNDU in the initial stages. Resources were leveraged  
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50 22 through sharing activities – e.g., and monitoring visits or transportation - with other



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1 programs, thus allowing cost efficiencies. Integration with other programs proved critical  
2 to ensuring sustainability.

3 “SIMUNDU's budget comes from the state budget called as *Anggaran Pendapatan dan*  
4 *Belanja Negara (APBN)*. Every year the APBN allocates ~~a~~ *funding envelope* for  
5 *immunization to DIY and other provinces, where the budget is apportioned across the*  
6 *program [not explicitly written budget for SIMUNDU].” (M02)*

7 Human resources are critical to the operation of SIMUNDU. According to interview,  
8 SIMUNDU data entry clerks must have patience, work carefully and not rush, be  
9 interested in data, be responsible, and have basic computer skills ~~in such as Ms~~ word  
10 ~~processing~~ and ~~spreadsheet software tools such as Microsoft Word and Ms eExcel,~~  
11 ~~respectively~~. As shown by the survey, the large majority of SIMUNDU-operating staff  
12 was educated: at least 80% of data entry clerks in either PHC or UPS facilities have  
13 secondary education (>80%), while at the managerial level (DHO), 75% of respondents  
14 have a ~~B~~bachelor's degree (see Table 2). ~~However~~~~Yet~~, 19.4% and 9.1% of respondents  
15 from PHC and UPS facilities, ~~respectively~~ have low computer literacy.

16 Various data entry clerks looked for strategies to resolve the obstacles they encountered  
17 when entering data to SIMUNDU. Based on the interviews, some clerks furthered their  
18 computer skills by taking private computer classes. Others learned from ~~other~~ colleagues  
19 at their offices, or reached out for help to the district person in charge. To deal with the  
20 accumulation of data needing to be entered in SIMUNDU, staff would sometimes work  
21 at home after office hours, as their busy schedule at work did not allow time for data  
22 entry.

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1 “If we found obstacles, we asked people in charge in PHC – asking for a solution or  
2 sharing by WhatsApp – or sometimes I asked the IT person in the DIY ~~H~~health  
3 ~~office~~Office.” (S03)

#### Potential threats

5 As of today, SIMUNDU can be said to be a successful experience. ~~However~~Yet, a  
6 ~~number~~some of obstacles were encountered and addressed during implementation.  
7 Potential ~~system sustaining threats to sustaining the system~~include individual capacity,  
8 technical or system issues, and high workload. Staff computer literacy was identified as  
9 one of the main ~~challenges to sustainability~~challenges. Internet connectivity was another  
10 obstacle, as ~~not a good network not all health facilities were~~equally supported ~~all health~~  
11 ~~facilities~~by a good network. The survey shows that 64.6% and 67.7% of PHC and UPS  
12 staff used office internet, while others had to rely on their home internet.

13 Further, incomplete and inconsistent records – such as differing child's date of birth or  
14 name spelling across relevant entries - make it challenging to consistently record  
15 immunization information. These challenges have arisen during implementation, and  
16 were promptly addressed. Yet, they had an impact on staff who was already juggling busy  
17 schedule in the office, causing delays in data entry. As shown by the survey, almost all  
18 respondents stated having other responsibilities besides operating SIMUNDU – notably  
19 97.3%, 88% and 100% of participants from PHC, UPS and district and city offices,  
20 respectively.

#### Opportunities

22 Informants appreciated SIMUNDU as ~~an good~~excellent system ~~for~~to manage  
23 immunization data. SIMUNDU has become necessary for program managers and

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8 | 1 policymakers; ~~because~~ it allows them to monitor coverage and can help inform planning  
9 | 2 and programming. Currently, SIMUNDU is stable, thus is easier to manage than when it  
10 | 3 was in the development phase. It is also viable, and no longer requires heavy reliance on  
11 | 4 the core workforce that started the system. The hopes expressed by data entry clerks in  
12 | 5 the interviews are that SIMUNDU is easier to operate, and system errors are less frequent.  
13 | 6 Informants also stressed the need for refresher training to ensure knowledge and practice  
14 | 7 of the system is not lost.

21 | 8 *“In my opinion, SIMUNDU is the best program in DIY, ~~which is a collaboration~~*  
22 | 9 *between program managers and IT. It will continue to be implemented because it is a*  
23 | 10 *necessity. It has been stably used for more than five years, meaning this is needed.”*

27 | 11 (M01)

29 | 12 *“If I have the tool, in this case, SIMUNDU, when it is stable, whoever will be able to*  
30 | 13 *run it, I am sure that anyone can operate it. It means that it doesn't matter if we have*  
31 | 14 *people shifting (jobs).” (M01)*

35 | 15 *“In the future, if SIMUNDU is still used, other reports are not necessary. Now we have*  
36 | 16 *two different reports: SIMUNDU and stock card of vaccine – each stand-alone and*  
37 | 17 *need a separate report.” (S05)*

41 | 18 Based on the key informants' interviews ~~erskwkww~~, SIMUNDU is likely to be  
42 | 19 developed further / or expanded to other provinces. The DIY ~~H~~health ~~O~~office is open to  
43 | 20 supporting other provinces interested in introducing the system, for instance, through the  
44 | 21 lending staff for training and orientation. However, informants advised that a successful  
45 | 22 introduction requires a strong commitment from ~~both~~ staff and management.

## 1 Discussion

2 Robust health information systems (HIS) are essential components of ~~strong-robust~~ health  
3 systems (13). At the most basic level, immunization registries are systems that collect and  
4 report individual-level vaccine administration record data, thus facilitating individual  
5 follow-up of vaccination status. Registries also allow for the monitoring of vaccination  
6 coverage and ~~facilitate-enable~~ analysis of AEFIs and surveillance data to inform the  
7 design of ~~-coverage~~ interventions and outbreak investigations. When an electronic  
8 registry has interoperability with other electronic systems – such as ~~in~~ the case with  
9 SIMUNDU – it is considered an Immunization Information System (IIS) (14). This paper  
10 presents lessons learned from DIY’s experience implementing an IIS.

11 DIY is the only province in Indonesia – out of thirty-four - that uses an IIS. This work  
12 has shed light on the strengths and underlying barriers of implementing an IIS in this  
13 context. The objective of this study was to draw lessons that inform sustainable scale-up  
14 in other provinces and possibly at the national level. This study highlighted individual  
15 capacity, technical or system issues, and high workload as the major ~~-barriers~~ to  
16 sustainability. ~~Conversely, -whereas-~~ management, system performance, people’s  
17 behavior, and ~~available~~ resources emerged as the main determinants of SIMUNDU’s  
18 successful implementation ~~-~~ notably in improving acceptability, implementation costs,  
19 and adoption of this innovation (15).

20 Despite several obstacles encountered during the implementation of SIMUNDU, this  
21 study showed that this innovation was well accepted by key stakeholders ~~involved~~. On  
22 ~~the~~ one hand, data entry clerks noted that the system is ~~rather-relatively~~ user-friendly and  
23 allows to ~~better~~ organize the data ~~better~~ and enhance its quality. On the other hand,

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8 | 1 managers noted the benefits this innovation brought about, namely in ~~terms of~~ the  
9 | 2 potential for cohort data to support planning and monitoring and ultimately improve  
10 | 3 immunization coverage.

14 | 4 Effective management - across planning, ~~organizationing~~, ~~leadershiping~~ and ~~controlling~~  
15 | 5 functions – is a crucial reason why SIMUNDU has been viable for over 5 years.  
17 | 6 Managers use their control to encourage the beliefs and actions of the staff ~~with~~ a  
18 | 7 dedicated and robust managerial process (16). SIMUNDU was born from the need for  
21 | 8 credible data to assist in carrying out DIY ~~H~~health ~~O~~ffice duties at the managerial and  
22 | 9 operational ~~levels~~. At the managerial level, the disease prevention and control department  
23 | 10 and the IT department collaborated in designing a system that ~~was readily accepted by~~  
24 | 11 intended users ~~readily accepted~~. Immunization officers and IT programmers played a  
25 | 12 central role from the early stages of development through implementation with effective  
26 | 13 coordination and communication, ~~and they~~ ~~They~~ were helped in this task ~~by~~ ~~with~~ the full  
27 | 14 support of their respective superiors.

35 | 15 SIMUNDU is cost-effective in several ways. During the introductory period of its  
36 | 16 implementation, immunization programmers, IT officers, and other staff assisted in  
37 | 17 introducing SIMUNDU in all districts in the province. This was done ~~through~~ ~~by~~  
38 | 18 integrating some of the activities across programs, thus building ~~efficiencyes~~ in terms of  
39 | 19 time and costs for both managers and staff. Sharing resources across programs was critical  
40 | 20 in the first years, ~~for~~ ~~of~~ building sustainability. Additionally, SIMUNDU maintenance  
41 | 21 does not require high costs because the DIY Health Office ~~itself~~ has developed the system  
42 | 22 and thus possesses in-house technical skills. The IT department has the capacity to  
43 | 23 monitor and improve processes and tailor them to user needs without much additional  
44 | 24 cost.

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1 A good program without good leadership could fail in its implementation, and even if it  
2 was initially successful, it might not be sustainable (17). In the context of SIMUNDU,  
3 ~~support from~~ leadership and effective management ~~support~~ facilitated the program's  
4 adoption. ~~The Uptake~~ uptake of the new system was good and all health facilities  
5 providing immunization services have successfully transitioned to SIMUNDU. The  
6 strong network of the ~~main~~ prominent persons in charge of SIMUNDU also facilitated  
7 ~~the~~ adoption. Good communication, care, and attention to staff concerns positively  
8 affected staff performance. They felt ~~that~~ they were well-supported and ~~treated~~ kindly,  
9 and this helped them carry out their work joyfully. According to several informants, the  
10 ~~leadership of the~~ DIY immunization program manager's leadership played an essential  
11 role ~~to~~ in this effect.

12 The monitoring and evaluation mechanisms of SIMUNDU were also important.  
13 Preferred monitoring and evaluation activities include monthly reports and ~~staff direct~~  
14 discussions ~~with staff~~ during site monitoring visits. The immunization program manager  
15 suggested this approach to maintain data quality and ensure ~~the~~ system's sustainability.  
16 These chosen mechanisms allow program managers to assess the actual practice in the  
17 field and the challenges faced to inform decisions about the follow-up actions to be taken.  
18 These processes supported the ongoing development of ~~it~~ and learning from ~~it~~, SIMUNDU  
19 as a tool for data collection, analysis, and visualization, as well as the benefits for  
20 managers to carry out monitoring and evaluation. The same ~~statement~~ sentiment was  
21 ~~revealed~~ reflected by in previous research ~~undertaken~~ in ~~the~~ India ~~about the innovation of~~  
22 ~~health management information systems for primary health care agrees that this can~~  
23 ~~provide essential benefits~~ (18).

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1 Human resources are a key determinant of [the](#) successful implementation of any HIS (19).  
2 People's behavior affects how the system works, develops, and survives (20),(21). In the  
3 case of SIMUNDU, implementation was facilitated by a culture of care, established  
4 networks, and [a](#) positive attitude towards data of both the program manager and IT team.  
5 From the staff's point of view, the local culture of helping each other and doing their job  
6 correctly and responsibly translated into staff carrying out their duties with enthusiasm  
7 and high commitment. Although facilities, funding and human resources were limited,  
8 the individuals involved were highly motivated and supportive.

9 Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its  
10 sustainability in the long term. These obstacles can be divided into human variables and  
11 technical variables. From the human variables side, unequal [capacity](#) distribution ~~of~~  
12 ~~capacity~~ at the operational level can result in differing levels of data quality across  
13 facilities and districts. Staff workload is another challenge need~~ing~~ addressing, as their  
14 willingness to work overtime is not a sustainable strategy. ~~Technical problems were~~  
15 ~~another obstacle during the introduction of SIMUNDU, but qualified~~  
16 ~~technicians/developers were able to~~ could solve these issues. ~~System trouble was another~~  
17 ~~obstacle during the introduction of SIMUNDU, but a qualified technician or developer~~  
18 ~~solved it.~~ [During our research, we recognized the weakness of SIMUNDU that it had not](#)  
19 [used the person number as a unique code in data entry. This impacts SIMUNDU's](#)  
20 [inability to synchronize with other health programs that use a person's number as a unique](#)  
21 [code. However, this weakness can be seen as room for improvement for SIMUNDU](#)  
22 [shortly. Another thing that needs to be considered for other regions that will implement](#)  
23 [SIMUNDU that SIMUNDU is that implemented in the DIY province which consists of](#)  
24 [5 districts/cities with relatively easy regional accessibility. For areas with more difficult](#)

1 [access, the commitment of the leadership and subordinates is the key to successful](#)  
2 [implementation.](#)

### 3 **Conclusion and recommendation**

4 SIMUNDU is a promising innovation for the entire country, beyond DIY. There is  
5 agreement about the potential for scale-up of this IIS to other provinces. Experience of  
6 implementing this system in DIY over the past five years has shown that the benefits  
7 outweigh the challenges, and SIMUNDU has grown into a robust ~~and~~-yet user-friendly  
8 system. Regular training to dedicated staff ~~to~~-for strengthen their capacity as the system  
9 evolves and is updated, and a plan for anticipating and responding to staff turnover have  
10 proven critical strategies towards sustainability. SIMUNDU's success also rests on  
11 remarkable leadership, both in creating and enabling a supportive environment and ~~in~~  
12 pursuing integration with other programs to share limited resources.

13 ~~This study's Recommendations~~[recommendations stemming from this study](#) address three  
14 different ~~groups of~~ stakeholders [groups](#): the DIY ~~H~~health ~~O~~office, the national  
15 government, and researchers. First, to ensure -continuity and sustainability and reduce the  
16 system's dependency on ~~the a~~ particular person or party, SIMUNDU management and  
17 maintenance should be managed by people who have competency and interest in a good  
18 reporting system. Furthermore, a human resources plan should be developed in  
19 preparation for SIMUNDU roll-out in other provinces or at [the national level](#)s; this is  
20 necessary to avoid vacancies when DIY province staff are seconded to other areas for  
21 mentoring support. Second, the fact that SIMUNDU emerged from an actual need ~~of~~  
22 immunization programme implementers, and saw these at the front-line of its  
23 development and implementation, positively impacted its feasibility and viability. This



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1 suggests that the approach to scaling up SIMUNDU should be stepwise, considering each  
2 region's specific characteristics and needs. To this effect, a readiness map and a timeline  
3 may be developed ~~to roll for the roll~~-out of SIMUNDU in a particular region. Third,  
4 further research is needed to assess the impact of SIMUNDU on immunization coverage.  
5 Based on our conversations with stakeholders, it would be particularly relevant to focus  
6 on a low-performing region and observe the impact over a 2 to ~~the~~ 3-year time window.

7 **Study limitations**

8 The empirical results reported herein should be considered in light of limitations. First,  
9 ~~the results of in the quantitative study must be considered with respect to concerning the~~  
10 ~~limited sample size, particularly for UPS Health Facilities in the quantitative study, the~~  
11 ~~result should be considered in the study sample size mainly for UPS health facility.~~  
12 However, considering the top-down immunization program and the characteristics of  
13 UPS, which will not be significantly different from each other, the results of this study  
14 are still valid and relevant to the existing. In qualitative research that aims to explore,  
15 caution is needed in interpreting the interview results. ~~From these results, there is~~ still a  
16 need ~~for~~ in-depth studies with different approaches, such as focus group discussions to  
17 confirm the results.

18 **Declarations**

19 Ethics approval and consent to participate

20 This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan,  
21 Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began,  
22 consent to participate was obtained from research subjects (both survey and key informant  
23 interviews).

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1 Adherence to national and international regulations

2 Not applicable

3 Consent for publication

4 Before data collection begins, [an](#) approval that data is taken for publication purposes is  
5 obtained from research subjects (both surveys and key informant interviews).

6 Availability of data and materials

7 The datasets generated and or analyzed for this study can be requested ~~from~~ the  
8 corresponding author.

9 Competing interests

10 The authors declare that they have no competing interests.

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17 Alliance donors, please visit: <https://ahpsr.who.int/about-us/funders>.

18 Authors' contributions

19 SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the  
20 data. SS and RR conducted data analysis. SS developed the paper with inputs and  
21 comments from MF on each draft. All authors agree with the manuscript's results and  
22 conclusions.

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7 Lamba for the editorial support.

8 Authors' information:

9 The authors alone are responsible for the views expressed in this article. They do not  
10 necessarily represent the views, decisions, or policies of the institutions affiliated with  
11 them.

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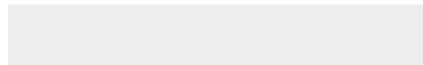
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# Revisi 4

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**From:** "BMC Health Services Research Editorial Office" Eloisa.HadeNolasco@springer.com  
**Subject:** Your submission to BMC Health Services Research - BHSR-D-21-00992R3

BHSR-D-21-00992R3

Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up  
Sulistyawati Sulistyawati; Trisno Agung Wibowo; Rokhmayanti Rokhmayanti; Andri Setyo Dwi Nugroho; Tri Wahyuni Sukesji; Siti Kurnia Widi Hastuti; Surahma Asti Mulasari; Marta Feletto  
BMC Health Services Research

Dear Dr Sulistyawati,

Your manuscript 'Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up' (BHSR-D-21-00992R3) has been assessed by our reviewers. Based on these reports, and my own assessment as Editor, I am pleased to inform you that it is potentially acceptable for publication in BMC Health Services Research, once you have carried out some essential revisions suggested by our reviewers.

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We request that a point-by-point response letter accompanies your revised manuscript. This letter must provide a detailed response to each reviewer/editorial point raised, describing what amendments have been made to the manuscript text and where these can be found (e.g. Methods section, line 12, page 5). If you disagree with any comments raised, please provide a detailed rebuttal to help explain and justify your decision.

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We look forward to receiving your revised manuscript and please do not hesitate to contact us if you have any questions.

Best wishes,

Milena Pavlova  
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In addition to the comments of the reviewer, please also carefully check the text for typos and language errors.

We operate a transparent peer review process for this journal where reviewer reports are published with the article but the reviewers are not named (unless they opt in to include their name).

Reviewer reports:

Reviewer 2: Manuscript is much improved. A very few minor edits

Authors have organized into strengths, threats and opportunities. To be consistent with a SWOT analysis. Perhaps adding the weakness section to results. Otherwise, seems that authors are introducing new information into discussion for example obstacles that are not found in the results section. In the discussion section, the authors introduce human and technical variables, but this is the first mention of this.

Page 8, lines 13-14. It seems as if "to be" involved is not correct, because the authors wanted staff already involved in SIMUNDU data entry and management?

Page 9, paragraph 3, line 16, delete "into"

Another suggestion is to separate conclusion and recommendations with recommendations first, then conclusion.

Reviewer 3: Thank you for submitting this revised manuscript and the itemised response to review feedback. I am glad to see that you have addressed both major and minor issues raised previously.

You have provided reasonable responses to the major comments and the paper is more robust for it. The numerous small editorial changes have also improved readability of the paper. I am also satisfied that the figures are legible now. Some relatively small issues with the text remain, however this should be easily addressed with a further round of copy editing.

I believe this work is relevant to BMC HSR, and that it will advance the literature in its domain.

If you have been asked to edit the English language of the main text to improve readability and clarity, and would like the assistance of paid editing services to do this, we can recommend our affiliates, Nature Research Editing Service: <https://authorservices.springernature.com/language-editing> and American Journal Experts:

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#### Ethics approval and consent to participate

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#### Consent to publish

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#### Availability of data and materials

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#### Competing interests

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#### Authors' Contributions

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Response to reviewer comment to paper entitled

"Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up"

No	Reviewer's comment	Author's response
1	<p>Reviewer 2</p> <p>Authors have organized into strengths, threats and opportunities. To be consistent with a SWOT analysis. Perhaps adding the weakness section to results.</p>	<p>Dear Reviewer 2,</p> <p>Thank you for reading our paper with your valuable input. We have added the weakness section to the result (page 21, line 7) and Figure 2 (page 12, line 2). Simultaneously, we have added weaknesses in the abstract.</p>
	<p>Otherwise, seems that authors are introducing new information into discussion for example obstacles that are not found in the results section.</p>	<p>In the result section, we put information about obstacles under the potential threats on page 20, line 15.</p>
	<p>In the discussion section, the authors introduce human and technical variables, but this is the first mention of this.</p>	<p>Human is written on page 18, line 20, in the Result section (Resource). While technical variable is mentioned in Result Section under potential threats (page 15, line 12, line 17)</p>
	<p>Page 8, lines 13-14. It seems as if "to be" involved is not correct, because the authors wanted staff already involved in SIMUNDU data entry and management?</p>	<p>Thank you for your detailed input. We changed "into" to "who"</p>
	<p>Page 9, paragraph 3, line 16, delete "into"</p> <p>Another suggestion is to separate conclusion and recommendations with recommendations first, then conclusion.</p>	<p>"Into" has been deleted Page 8, line 8</p> <p>We have separated the conclusion and recommendation, Page 27-line 3</p>
2	<p>Reviewer 3</p> <p>Thank you for submitting this revised manuscript and the itemised response to review feedback. I am glad to see that you have addressed both major and minor issues raised previously.</p> <p>You have provided reasonable responses to the major comments and the paper is more robust for it. The numerous small editorial changes have also improved readability of the paper. I am also satisfied that the figures are legible now. Some relatively small issues with the text remain, however this should be easily addressed with a further round of copy editing.</p>	<p>Dear reviewer 3</p> <p>We thank you infinitely for providing feedback to this article so that it is worthy of consideration for publication in BMC HSR. I hope you are always healthy.</p>

1 **Introduction and implementation of an immunization information**  
2 **system in Indonesia province of Daerah Istimewa Yogyakarta: lessons**  
3 **for scale-up**  
4

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20 Kampus 3 - Jl. Prof Dr Soepomo, Janturan, Umbulharjo, Yogyakarta, Indonesia.

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1 **Abstract**

2 **Background:** Immunization is critical to saving children from infections. To increase  
3 vaccination coverage, valid and real-time data is needed. Accordingly, it is essential to  
4 have a good report system that serves as defaulter tracking to prevent children's  
5 immunization failure. The Daerah Istimewa Yogyakarta (DIY) Health Office introduced  
6 an electronic immunization registry and successfully implemented it for over than five  
7 years. It is the only individual-based record system in Indonesia that has been sustainably  
8 operated for a long time. Yet, no systematic assessment of this system has been conducted  
9 to date. This study examines the Sistem Informasi Imunisasi Terpadu (SIMUNDU)  
10 introduction and implementation process to draw lessons that could inform scalability  
11 and sustainability across the country.

12 **Methods:** This study used an explanatory sequential mixed-method design, which  
13 collected quantitative data from 142 participants and qualitative data from 9 participants.  
14 Entry data clerk in a health facility was systematically selected to participate in the  
15 survey. While in the key informant interview, the informant was selected based on the  
16 survey result. A descriptive and thematic approach was adopted to analyze the  
17 quantitative and qualitative data. Results from across the two approaches were integrated  
18 for comparison and contrast.

19 **Results:** Findings are presented according to three core themes that emerged from the  
20 data: system strengths, potential threats, weakness and opportunities for scale-up.  
21 Strengths -i.e. factors contributing to the success of SIMUNDU - include management,  
22 system performance, people's behavior, and resources. Potential threats to sustaining the  
23 system include individual capacity, technical or system issues, and high workload.



1 Opportunities – i.e promising factors that SIMUNDU can be operated sustainably – such  
2 as continuity, expectation and scale up possibility.

3 **Conclusions:** SIMUNDU is a promising innovation for Indonesia, beyond DIY. There  
4 is agreement about the potential for scale-up of this IIS to other provinces. Experience of  
5 implementing this system in DIY over the past five years has shown that the benefits  
6 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
7 system.

8

9 **Keywords:** immunization, electronic immunization registry, immunization information  
10 system, interoperability, implementation research

## 11 **Background**

12 Neonatal and childhood vaccination is essential to infectious disease prevention and an  
13 absolute human right (1),(2). Vaccination has been proven to reduce the burden of  
14 infectious diseases globally (3). According to the WHO, in 2020, an estimated 23 million  
15 children under one year did not receive their essential vaccinations. Of these, 60% live in  
16 just ten countries, one of which is Indonesia (4). Indonesia is the fourth most populous  
17 country globally. It is composed of thousands of islands organized into 34 provinces.  
18 Various geographical and cultural factors influence population inequalities to access  
19 health services (5). In 2001, the Indonesian government's decentralization policy was  
20 enacted. This was an excellent strategy to foster development by engaging regional  
21 resources (6). However, this strategy was not without consequence. One primary concern  
22 was the Health Information System (HIS) fragmentation.

1 Indonesia's federal structure results in provinces and districts being relatively independent  
2 of the national Ministry of Health. This means that provincial and district-levels  
3 information systems are locally regulated (7). For instance, *Pemantauan Wilayah*  
4 *Setempat* (PWS) is a management tool used to monitor coverage of specific health  
5 services in an administrative boundary. Depending on the service and region, it can be  
6 paper- or electronic-based. PWS-KIA is the monitoring system specific to maternal and  
7 child health (KIA), including immunization. PWS-KIA data are reported to the District  
8 or City Health Office, go to Province Health Office, and finally reported to the main level.  
9 Generally, the data are in Microsoft Excel formats; it will report via emails or various  
10 information systems, including Komdat, SiTT, SIHA, PISPK, and SIKDA Generik.  
11 PWS-KIA data feeds into District Health Information System 2 (DHIS2). Regional  
12 information systems have varying data quality, which reflects inequities in resources  
13 across regions. This adds to data integration challenges at the national level (7),(8) and  
14 affects strategic policymaking.

15 In Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) Province has the  
16 authority to regulate and use its budget within its four districts plus one city (Sleman,  
17 Gunungkidul, Bantul, Kulonprogo and Yogyakarta). This province is classified as a small  
18 province in terms of area size and the number of regions inside (9). However, this region  
19 can be considered a representation of Indonesia when viewed from the geographical,  
20 socio-economic and heterogeneous population. Regarding childhood vaccination, DIY is  
21 among the top ten performing provinces in the country, with 97.7 % of children  
22 completing basic immunization coverage in 2019 (10). Immunization services are  
23 provided by Primary Health Centres or Puskesmas (PHC), as well as private clinics,

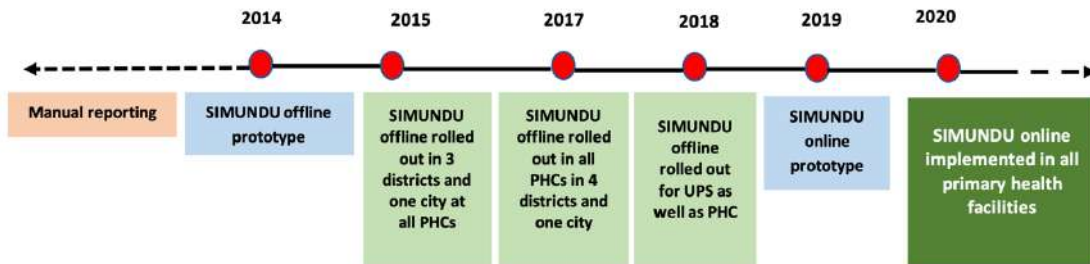
1 hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* or  
2 UPS).

3 An electronic immunization registry is a tool for recording individual children's  
4 immunization histories. In 2014, the DIY Health Office introduced an electronic  
5 immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu/*  
6 *Integrated Immunization Information System*). An electronic registry serves essential  
7 functions at all levels of the health system. At the district and higher levels, it allows for  
8 monitoring vaccination coverage by the vaccine, dose, cohort, and other variables – and  
9 can support microplanning and vaccine management. The service delivery level can  
10 facilitate individual follow-up of vaccination status and enable health workers to identify  
11 children due for vaccination and those who missed their vaccinations (defaulters).

12 SIMUNDU was designed to link with the PWS-KIA for immunization and  
13 interoperability with the DHIS2. While it predominantly contains individual-level  
14 immunization records, SIMUNDU also serves as a source for aggregation and can  
15 synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this  
16 reason, it can be considered an Immunization Information System (IIS). This means that  
17 City and District levels feed into Provincial and National levels (*Personal communication*  
18 *with DIY immunization program officer*).

19 The original prototype was designed by the information and technology (IT) department  
20 of DIY Health Office to be operated offline. In DIY, three out of the four districts and the  
21 city introduced the system in 2015. The final district introduced it in 2017. At this stage,  
22 the point of data entry was the PHC only. By 2018, UPS facilities were also equipped  
23 with SIMUNDU and could enter data into the system. In 2019, the prototype was further

1 developed to operate online. The online version was rolled out in 2020 (Figure 1). As of  
2 May 2021, 79.4% of all PHC and UPS facilities complied. This average rate masks,  
3 however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce  
4 its use in UPC facilities (Suyani 2020, oral communication, 2020, May 11).



5

6 **Figure 1.** SIMUNDU’s development and introduction

7 When a child receives a vaccination in a health facility, information on the child and the  
8 vaccination is entered in SIMUNDU as an individual child record. Each record includes  
9 a personal identifier, the child’s socio-demographic characteristics (e.g., name, gender,  
10 date of birth, name of parents, address), the antigen administered, and the date and place  
11 of vaccination. SIMUNDU has been recently updated to allow the recording of  
12 vaccinations administered in schools (e.g., Human papillomavirus (HPV), Diphtheria  
13 Toxoid (DT), Tetanus-Diphtheria (TD), and Measles-Rubella (MR), though in the form  
14 of aggregate data only. Furthermore, SIMUNDU has been developed to record COVID-  
15 19 vaccinations in health facilities and those carried out in masse.

16 Monitoring is conducted monthly to assess data completeness across health facilities,  
17 while an evaluation is conducted yearly. These exercises have allowed the identification  
18 of several challenges related to implementing the system (e.g., workload, staff turnover,  
19 and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic  
20 assessment of the system has been conducted to date. SIMUNDU is the first

1 immunization information system ever introduced in Indonesia. Other districts and  
2 provinces have shown interest in rolling it out, and the Ministry of Health has  
3 acknowledged the innovation. The work presented here aims to examine SIMUNDU’s  
4 introduction and implementation process to draw lessons that could inform scalability  
5 and sustainability across the country.

## 6 **Methods**

7 From May to October 2020, we examined the experience of introducing and  
8 implementing an immunization information system in the DIY province using an  
9 explanatory sequential mixed-method design, where each step informed the next (11).  
10 First, we reviewed of all relevant documentation available in the DIY Health Office –  
11 e.g., staff notes, meeting notes and monitoring notes – documenting SIMUNDU  
12 development and management processes. We also examined online documents, including  
13 health profiles and regulations on health reporting systems in Indonesia. This served as  
14 the initial data source and provided an overview of who was involved and how in  
15 developing and implementing SIMUNDU. This informed the survey design that we  
16 conducted as a second step. The survey targeted any staff responsible for entering data in  
17 SIMUNDU (i. e. data clerks) across all PHC and selected UPS facilities and any staff  
18 responsible for managing the system at the district and city level (i. e., immunization  
19 coordinators). Sampling and recruitment strategies are outlined in Table 1.

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**Table 1. Survey participant**

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
Primary Health Centre (PHC)	121	Data entry clerks	All facilities	Open invitation across all facilities	113
UPS - Central, General, Maternity and Pediatric Hospitals	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
UPS - Clinics	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
UPS - Midwives' Practices	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinators	Total sampling	Open invitation	4*
<b>Total</b>					<b>142</b>

2

\*When the immunization coordinator had recently changed, the former was also invited.

3

4 All immunization coordinators in each district/city and data entry clerks from all primary  
5 health facilities (PHC) were invited to participate in this survey. For UPS facilities, we  
6 selected two clinics, two midwives' practices, and two hospitals per district/city and  
7 invited all of their staff who involved in SIMUNDU data entry and management.

8 We developed and pre-tested an online survey in Bahasa Indonesia to inquire about  
9 SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, district  
10 or city and province offices. The questionnaire consisted of close-ended and Likert scale  
11 questions – ranging from 45 to 50 depending on the target type of facility and/or level of  
12 the health system – and enquired about respondents' socio-demographic characteristics  
13 as well as the process of implementing and managing SIMUNDU. Some questions  
14 provided an additional field for clarifying the reason for a particular answer choice.

1 All participants were invited to the DIY Health Office to complete the survey on their  
2 laptops, with their prior consent. All participants in a room allowed researchers to monitor  
3 any missing or incomplete responses in real time and follow up with individual  
4 participants on-site to fill any gaps. We don't believe this may have introduced any  
5 significant bias as researchers would simply flag any missing responses and invite  
6 respondents to address those. Data were then exported and analyzed in Microsoft Excel.  
7 An exploratory analysis of the survey data informed the topic areas that qualitative  
8 interviews explore further.

9 Similarly, some informants were purposefully selected among survey participants to  
10 follow up on the range of perspectives that had emerged from the survey. Other  
11 informants had been identified at the desk review stage and chosen for their management  
12 functions. Selected informants were invited to the DIY Health Office for the interview,  
13 and COVID-19 prevention protocol was observed. Every informant was informed about  
14 the study and asked to sign the informed consent. All invited informants agreed to  
15 participate. A total of nine 30-minute semi-structured interviews were conducted in  
16 Bahasa Indonesia language and recorded with prior consent from participants. The  
17 interview team consisted of three researchers with the respective task of running the  
18 interview, observing and taking notes. A research assistant transcribed all interviews in  
19 Bahasa Indonesia language.

20 Thematic analysis was conducted using Quirkos qualitative tool following Braun and  
21 Clarke's approaches (12). Researchers familiarized themselves with the data, searching  
22 for initial codes and allowing themes to emerge. The principal investigator led the coding  
23 process, and led the research team in defining and naming the core themes emerging from  
24 the data, organizing and analyzing the data across the themes, and triangulating

1 information from the desk review, the survey, and the interviews. This stage was also  
 2 performed in Bahasa Indonesia. Data were translated to English only at sub-theme and  
 3 core themes.

## 4 Results

### 5 Characteristic participant

#### 6 a. Quantitative study

7 In total, 142 respondents participated in this study spread across five districts/cities in the DIY  
 8 province. Most respondents came from Gunungkidul District, PHC, UPS, and DHO, 24.8%, 24%,  
 9 and 25%, respectively. For all research units, the majority are women. At the UPS and DHO/CHO  
 10 levels, most respondents were aged 41-45 years, i.e., 28.3% and 75%, respectively, while at the UPS  
 11 level, the majority were aged 25-30 years (56.0%). For education level, PHC and UPS are dominated  
 12 by Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, it is  
 13 predominantly undergraduate graduates (75%) (Table 2)

14 **Table 2.** Characteristic respondents in three groups of respondents

15

Characteristic	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3 (2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25-30	3 (2.7)	14 (56.0)	0 (0.0)
31-35	30 (26.5)	3 (12.0)	0 (0.0)
36-40	19 (16.8)	1 (4.0)	0 (0.0)
41-45	32 (28.3)	0 (0.0)	3 (75.0)
46-50	18 (15.9)	0 (0.0)	1 (25.0)
>50	11 (9.7)	2 (8.0)	0 (0.0)



Education				
Master	0 (0.0)	1 (4.0)	1 (25.0)	
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)	
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)	
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)	
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)	

1

2 b. Qualitative study

3 Nine informants were recruited to provide the required information to explore the  
 4 quantitative study results more deeply. They serve as managers and staff at  
 5 DHO/CHO, PHC, and UPS. Among the nine informants, 2 were men, and 7 were  
 6 women. Three informants graduated with master’s, one bachelor's, and five diplomas  
 7 graduates (Table 3).

8

**Table 3.** Informants’ characteristics for the qualitative study

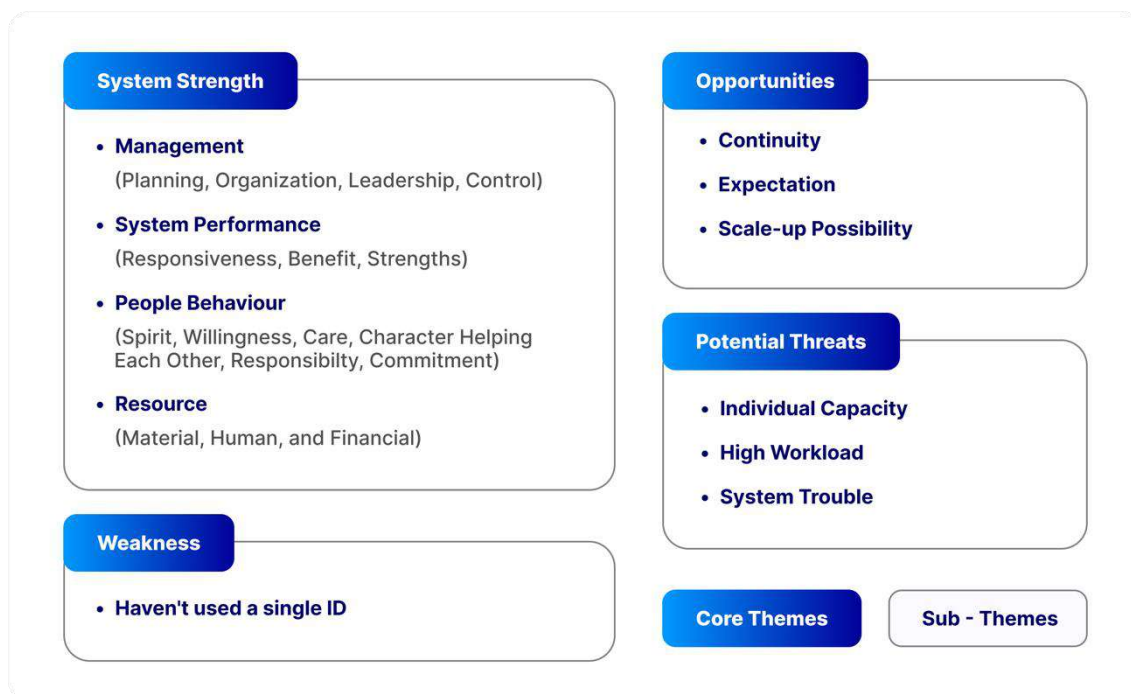
Sex	Age (years)	Education	Position	Subject group	Informant’s code
Female	56	Magister	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Magister	The former of the disease prevention and control section at the PHO level	Managerial	M 02
Male	54	Bachelor	Immunization programmer at the PHO level	Managerial	M 03
Female	47	Magister	IT Person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at the UPS level	Staff	S 02
Female	31	Diploma	Data entry at the UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

9

10 c. Finding

11 Findings from the study are organized and presented across the three core themes that  
 12 emerged from the qualitative analysis, notably system strengths, potential threats, and  
 13 opportunities for scale-up. However, data from qualitative and quantitative data fed into

1 the analysis of these core themes to cross-validate the findings (Figure 2. Detailed  
2 findings from the survey are presented in Table Supplement 1.



3

4

**Figure 2.** Strengths, potential threats, and opportunities for scale-up

5

### **System's Strengths**

6

Factors contributing to the success of SIMUNDU include management, system  
7 performance, people's behavior, and resources.

8

### **Management**

9

SIMUNDU arose due to concerns from the DIY Health Office immunization section  
10 around data quality, notably the need to address data inaccuracy, duplicate or missing  
11 data and lack of timely data, and the need for quality data to support follow-up and  
12 appropriate planning. The need for SIMUNDU arose from these challenges and needs.

13

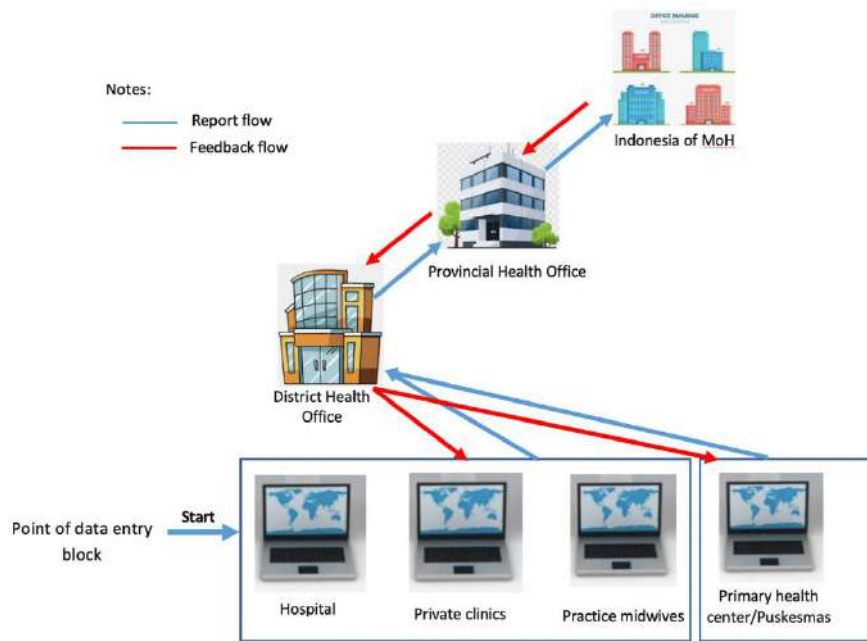
*“To our knowledge, [SIMUNDU development] started with a problem: estimates of the  
14 target population varied depending on the data source” (M02)*

1 “Yes, I think [SIMUNDU management team] started to tire of managing a large volume  
2 of data with dubious validity. They need to know the situation in each district”. (M04)

3 Effective management of SIMUNDU from development to implementation was  
4 highlighted as an essential determinant of its success across the critical functions of  
5 Planning, Organization, Leadership, and Control.

6 Careful **Planning** was ensured at each stage of SIMUNDU development and  
7 implementation. These stages included developing an initial business plan, providing  
8 training on and socialization to SIMUNDU, and developing a staff replacement plan to  
9 respond to turnover or retirement of staff in charge of operating the system or entering  
10 data. The parties involved in planning included the Head of the Disease Prevention and  
11 Control Department, IT personnel, and from the DIY Health Office immunization  
12 program staff.

13 **Organization**- the organization of SIMUNDU, is carried out at several levels. The top  
14 level is the DIY Health Office, the second level is the district/city health office, and the  
15 third level is health facilities (Figure 2). A third party was also involved in developing  
16 the system interface.



1

2 **Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

3 At the beginning of SIMUNDU development, essential functions included database  
 4 administrators, interface designers, and server administrators, and their interplay  
 5 facilitated the system’s smooth operation. Training specific to SIMUNDU was integrated  
 6 with other training, typically immunization-related training. This enabled us to share of  
 7 resources with other programs, thus ensuring viability. The training was delivered in the  
 8 district/city health office: 87.6%, 72%, and 75% of survey respondents from PHC, UPS,  
 9 and DHO/CHO, respectively had participated in in-house training. Training typically  
 10 consisted of short sessions and included practice on the trainee's device to operate the  
 11 system in both online and offline mode. Informants indicated that day-to-day operations  
 12 were carried out autonomously by the staff through flexibly adjusting their work to  
 13 protect the time to enter the data. This seemed to work effectively.

14 **Leadership** - the success of SIMUNDU implementation is arguably related to strong  
 15 leadership. Informants noted that managers played a crucial role in bridging the needs of

1 the immunization program with the system design, closely monitoring the initial  
2 implementation process, and creating an enabling environment.

3 *“I try to combine supporting and managing and monitoring the people involved.  
4 Currently, I monitor whether [SIMUNDU] can run optimally as our users are health  
5 facilities. I also monitor program development and the system's output.” (M01)*

6 *“[SIMUNDU] was born from program managers, primary health centers, Districts, and  
7 DIY Health Offices wanting to build systems together. We – DIY Health Office - give  
8 them motivation in every meeting.” (M03)*

9 *“I see that [management] is very good at networking. Staff data entry in the field  
10 always said that these people are very kind.” (M02)*

11 The role of IT workers in developing SIMUNDU was also significant. They helped  
12 develop the system and facilitated correct data entry operators whenever technical issues  
13 arose. IT workers also helped resolve inconsistencies in data records. Acknowledgment  
14 of staff efforts was also important to maintain motivation and buy-in.

15 *“In the early days of SIMUNDU’s development, the system was challenging to operate,  
16 as it wasn’t as stable as it is now. I praise the enthusiasm and dedication of the users.”  
17 (M01)*

18 The **control** function - consisting of **quality** assurance management - was critical to avoid  
19 data duplication or missing entries and ultimately ensure data quality. This process was  
20 not regulated by specific Standard Operating Procedures but was addressed during  
21 training and monitored monthly. In addition, the DIY Health Office provided negative  
22 incentives to health facilities that were not submitting complete records and provided  
23 regular feedback from monitoring and evaluation exercises.

1 Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO,  
2 respectively, reported their work had been subject to monitoring. More than half of the  
3 respondents in PHC and UPS facilities had been observed by supervisors while  
4 performing data entry at least once over the past year. At the PHC level, 48.3% of survey  
5 respondents had been subject to monitoring from the district/city office’s team, and 45.7%  
6 received monitoring from DIY Health Office’s staff. Conversely, 40% of respondents  
7 from UPS facilities were monitored by PHC’s staff. Almost all survey respondents  
8 reported receiving feedback from the monitoring, mainly from the District/City and DIY  
9 Health Offices. Forty percent of respondents from UPS facilities reported receiving  
10 feedback from PHC. Immunization coordinators from the District/City Health Offices  
11 received feedback from the DIY Health Offices.

12 *“In a [evaluation] meeting, DIY Health Office or District Health Office showed the*  
13 *progress of our data entry – correct or not, proper or not.” (M02)*

14 It is worth noting that DIY Province is quite a small geographic area. Because it consists  
15 of only five districts and one city, this province is relatively easy to monitor across all  
16 phases, from planning through monitoring and evaluation.

## 17 **System performance**

18 While SIMUNDU predominantly contains individual-level immunization records, it also  
19 serves as a source for aggregation and can synergize with other information systems.  
20 Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports  
21 per the Ministry of Health’s requirements. These reports are sent to the upper levels  
22 automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is

1 operated offline. This functionality has had an essential role in ensuring the acceptability  
2 and adoption of the system.

3 Informants noted how transitioning from paper-based tools to an electronic system made  
4 data entry easier and reduced errors. SIMUNDU also facilitated the implementation of  
5 protocols for data storage and security. It enabled follow-up and defaulter tracking.  
6 Finally, integration with the DHIS2 meant reduced workload for the staff.

7 *“We can track children who may have received vaccinations in different locations*  
8 *faster. For example, when the first dose of a vaccine is given in Bantul and the second*  
9 *one in Yogyakarta, the record can be linked within SIMUNDU” (M01).*

10 *“SIMUNDU makes detecting what data and vaccinations are missing easier since we*  
11 *enter data from the children’s birth through the end of the immunization schedule. So,*  
12 *we will know where they miss any vaccine.” (S03)*

13 *“The benefit of using SIMUNDU is first: we know the situation of immunizations more*  
14 *accurately.....so our vaccine forecasting is more accurate .... and our budget, staff,*  
15 *facilities can be more effective and efficient in providing services.” (S05)*

16 *“Colleagues from the mother and child health (KIA) program enter the data via the KIA*  
17 *"Sembada." So, this data will appear automatically in SIMUNDU because the two*  
18 *system are connected.” (S01)*

19 SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the  
20 responsible staff to maintain data entry irrespective of connectivity. 82.3%, 96%, and  
21 100% of survey respondents from PHC, UPS, and DHO, respectively reported operating  
22 SIMUNDU online.

## 1 **People's behavior**

2 The interview showed that staff commitment was critical for the successful  
3 implementation of SIMUNDU, as indicated by their willingness to work overtime and  
4 bring home the data to enter into the system.

5 *“I take it [the data] home too, for example, after immunization sessions– in my clinic,*  
6 *immunization runs four times per month, every week. So, when the session is finished,*  
7 *we can take the data home, [and] do the entry at home while relaxing.” (S03)*

8 The interviews confirmed this dedication, which spoke to a societal culture of helping  
9 others and responsibility and commitment to the team. This contributed to shaping an  
10 environment where people approach SIMUNDU as a shared responsibility and a  
11 collective endeavor. Informants also noted the high motivation of dedicated staff.

12 *“That's all; we cannot judge by money [people's kindness, culture, and behavior];*  
13 *explaining how good people are in Yogyakarta is essential. I was in another place*  
14 *before, and could not find people's kindness like in Yogyakarta - different characters.”*  
15 *(M02)*

16 *“The second thing is that we need human resources concerned and love for data;*  
17 *otherwise, even though we have a good system, it will amount to nothing without good*  
18 *human resources. But good implementation will come more easily when people are*  
19 *concerned about data.” (M04)*

## 20 **Resource: material, human and financial**

21 Infrastructure and equipment emerged as critical factors in introducing and sustaining  
22 SIMUNDU implementation. Some desktops were explicitly allocated to the



1 immunization program, and some had to be shared with other staff. Other data entry  
2 officers reported using their laptop or smartphone (36.3% of survey respondents from  
3 PHC). In UPS facilities, 40.7% reported using office desktops; in the DHO, more than  
4 half of the respondents stated they used an office-supplied laptop. The majority of  
5 respondents – regardless of the type of facility - said their current device was sufficient  
6 to perform their work on SIMUNDU. Regarding connectivity, 64.6% of PHC survey  
7 respondents and 67.7% of UPS’s reported operating SIMUNDU online, relying on the  
8 office’s internet connection.

9 Management of financial resources was also crucial. According to the key informants, no  
10 special funds were allocated to SIMUNDU in the initial stages. Resources were leveraged  
11 through sharing activities – e.g., monitoring visits or transportation - with other programs,  
12 thus allowing cost efficiencies. Integration with other programs proved critical to  
13 ensuring sustainability.

14 *“SIMUNDU's budget comes from the state budget called as Anggaran Pendapatan dan*  
15 *Belanja Negara (APBN). Every year the APBN allocates funding envelope for*  
16 *immunization to DIY and other provinces, where the budget is apportioned across the*  
17 *program [not explicitly written budget for SIMUNDU].” (M02)*

18 Human resources are critical to the operation of SIMUNDU. According to interview,  
19 SIMUNDU data entry clerks must have patience, work carefully and not rush, be  
20 interested in data, be responsible, and have basic computer skills in word processing and  
21 spreadsheet software tools such as Microsoft Word and Excel, respectively. As shown by  
22 the survey, the large majority of SIMUNDU-operating staff was educated: at least 80%  
23 of data entry clerks in either PHC or UPS facilities have secondary education (>80%),

1 while at the managerial level (DHO), 75% of respondents have a Bachelor’s degree (see  
2 Table 2). However, 19.4% and 9.1% of respondents from PHC and UPS facilities, have  
3 low computer literacy.

4 Various data entry clerks looked for strategies to resolve the obstacles they encountered  
5 when entering data to SIMUNDU. Based on the interviews, some clerks furthered their  
6 computer skills by taking private computer classes. Others learned from colleagues at  
7 their offices, or reached out for help to the district person in charge. To deal with the  
8 accumulation of data needing to be entered in SIMUNDU, staff would sometimes work  
9 at home after office hours, as their busy schedule at work did not allow time for data  
10 entry.

11 *“If we found obstacles, we asked people in charge in PHC – asking for a solution or*  
12 *sharing by WhatsApp – or sometimes I asked the IT person in the DIY Health Office.”*  
13 *(S03)*

14 **Potential threats**

15 As of today, SIMUNDU can be said to be a successful experience. However, some  
16 obstacles were encountered and addressed during implementation. Potential system  
17 sustaining include individual capacity, technical or system issues, and high workload.  
18 Staff computer literacy was identified as one of the main sustainability challenges.  
19 Internet connectivity was another obstacle, as not a good network equally supported all  
20 health facilities. The survey shows that 64.6% and 67.7% of PHC and UPS staff used  
21 office internet, while others had to rely on their home internet.

22 Further, incomplete and inconsistent records – such as differing child's date of birth or  
23 name spelling across relevant entries - make it challenging to consistently record

1 immunization information. These challenges have arisen during implementation and were  
2 promptly addressed. Yet, they had an impact on staff who was already juggling busy  
3 schedule in the office, causing delays in data entry. As shown by the survey, almost all  
4 respondents stated having other responsibilities besides operating SIMUNDU – notably  
5 97.3%, 88%, and 100% of participants from PHC, UPS and district and city offices,  
6 respectively.

### 7 **Weakness**

8 The informant said that SIMUNDU assisted in their daily work, but they also reported  
9 that sometimes they needed more time to find the children's names on the next visit. It is  
10 because SIMUNDU data entry did not use a single national ID that could be valid  
11 anywhere. As a result, when a name input error occurs, the officer will need time to check  
12 with the name of the child's parents or the manual register.

13 *“Sometimes, there was an incorrect name during the data entry; for example, Dita was*  
14 *written as Dieta. So, it is difficult for us to find them. If that happens, we must look back*  
15 *at the register or medical record data. ” (S04)*

16 *“I experienced difficulty entering data on SIMUNDU when a new patient came from*  
17 *another health facility to us. It was challenging to find their record on*  
18 *SIMUNDU” (S05)*

### 19 **Opportunities**

20 Informants appreciated SIMUNDU as an excellent system to manage immunization data.  
21 SIMUNDU has become necessary for program managers and policymakers; it allows  
22 them to monitor coverage and can help inform planning and programming. Currently,  
23 SIMUNDU is stable, thus is easier to manage than when it was in the development phase.

1 It is also viable and no longer requires heavy reliance on the core workforce that started  
2 the system. The hopes expressed by data entry clerks in the interviews are that SIMUNDU  
3 is easier to operate and system errors are less frequent. Informants also stressed the need  
4 for refresher training to ensure knowledge and practice of the system is not lost.

5 *“In my opinion, SIMUNDU is the best program in DIY, a collaboration between*  
6 *program managers and IT. It will continue to be implemented because it is a necessity.*

7 *It has been stably used for more than five years, meaning this is needed.” (M01)*

8 *“If I have the tool, in this case, SIMUNDU, when it is stable, whoever will be able to*  
9 *run it, I am sure that anyone can operate it. It means that it doesn't matter if we have*  
10 *people shifting (jobs).” (M01)*

11 *“In the future, if SIMUNDU is still used, other reports are not necessary. Now we have*  
12 *two different reports: SIMUNDU and stock card of vaccine – each stand-alone and*  
13 *need a separate report.” (S05)*

14 Based on the key informants' interviews, SIMUNDU is likely to be developed further /  
15 or expanded to other provinces. The DIY Health Office is open to supporting other  
16 provinces interested in introducing the system, for instance, through the lending staff for  
17 training and orientation. However, informants advised that a successful introduction  
18 requires a strong commitment from staff and management.

## 19 **Discussion**

20 Robust health information systems (HIS) are essential components of robust health  
21 systems (13). At the most basic level, immunization registries are systems that collect and  
22 report individual-level vaccine administration record data, thus facilitating individual

1 follow-up of vaccination status. Registries also allow for the monitoring of vaccination  
2 coverage and enable analysis of AEFIs and surveillance data to inform the design of  
3 coverage interventions and outbreak investigations. When an electronic registry has  
4 interoperability with other electronic systems – such as in the case with SIMUNDU – it  
5 is considered an Immunization Information System (IIS) (14). This paper presents lessons  
6 learned from DIY’s experience implementing an IIS.

7 DIY is the only province in Indonesia – out of thirty-four - that uses an IIS. This work  
8 has shed light on the strengths and underlying barriers of implementing an IIS in this  
9 context. The objective of this study was to draw lessons that inform sustainable scale-up  
10 in other provinces and possibly at the national level. This study highlighted individual  
11 capacity, technical or system issues, and high workload as the major barriers to  
12 sustainability. Conversely, management, system performance, people’s behavior, and  
13 available resources emerged as the main determinants of SIMUNDU’s successful  
14 implementation - notably in improving acceptability, implementation costs, and adoption  
15 of this innovation (15).

16 Despite several obstacles encountered during the implementation of SIMUNDU, this  
17 study showed that this innovation was well accepted by key stakeholders. On the one  
18 hand, data entry clerks noted that the system is relatively user-friendly and allows to  
19 organize the data better and enhance its quality. On the other hand, managers noted the  
20 benefits this innovation brought about, namely in the potential for cohort data to support  
21 planning and monitoring and ultimately improve immunization coverage.

22 Effective management - across planning, organization, leadership, and control functions  
23 – is a crucial reason why SIMUNDU has been viable for over 5 years. Managers use

1 their control to encourage the beliefs and actions of the staff with a dedicated and robust  
2 managerial process (16). SIMUNDU was born from the need for credible data to assist in  
3 carrying out DIY Health Office duties at the managerial and operational levels. At the  
4 managerial level, the disease prevention and control department and the IT department  
5 collaborated in designing a system that intended users readily accepted. Immunization  
6 officers and IT programmers played a central role from the early stages of development  
7 through implementation with effective coordination and communication. They were  
8 helped in this task with the full support of their respective superiors.

9 SIMUNDU is cost-effective in several ways. During the introductory period of its  
10 implementation, immunization programmers, IT officers, and other staff assisted in  
11 introducing SIMUNDU in all districts in the province. This was done by integrating some  
12 of the activities across programs, thus building efficiency in terms of time and costs for  
13 both managers and staff. Sharing resources across programs was critical in the first years  
14 of building sustainability. Additionally, SIMUNDU maintenance does not require high  
15 costs because the DIY Health Office has developed the system and thus possesses in-  
16 house technical skills. The IT department has the capacity to monitor and improve  
17 processes and tailor them to user needs without much additional cost.

18 A good program without good leadership could fail in its implementation, and even if it  
19 was initially successful, it might not be sustainable (17). In the context of SIMUNDU,  
20 leadership and effective management support facilitated the program's adoption. The  
21 uptake of the new system was good and all health facilities providing immunization  
22 services have successfully transitioned to SIMUNDU. The strong network of the  
23 prominent persons in charge of SIMUNDU also facilitated the adoption. Good  
24 communication, care, and attention to staff concern positively affected staff performance.

1 They felt that they were well-supported and treated kindly, and this helped them carry out  
2 their work joyfully. According to several informants, the DIY immunization program  
3 manager's leadership played an essential role in this effect.

4 The monitoring and evaluation mechanisms of SIMUNDU were also important.  
5 Preferred monitoring and evaluation activities include monthly reports and staff  
6 discussions during site monitoring visits. The immunization program manager suggested  
7 this approach to maintain data quality and ensure the system sustainability. These chosen  
8 mechanisms allow program managers to assess the actual practice in the field and the  
9 challenges faced to inform decisions about the follow-up actions to be taken. These  
10 processes supported the ongoing development of and learning from, SIMUNDU as a tool  
11 for data collection, analysis, and visualization, as well as the benefits for managers to  
12 carry out monitoring and evaluation. The same sentiment was reflected in previous  
13 research undertaken in the India (18).

14 Human resources are a key determinant of the successful implementation of any HIS (19).  
15 People's behavior affects how the system works, develops, and survives (20),(21). In the  
16 case of SIMUNDU, implementation was facilitated by a culture of care, established  
17 networks, and a positive attitude towards data of both the program manager and IT team.  
18 From the staff's point of view, the local culture of helping each other and doing their job  
19 correctly and responsibly translated into staff carrying out their duties with enthusiasm  
20 and high commitment. Although facilities, funding and human resources were limited,  
21 the individuals involved were highly motivated and supportive.

22 Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its  
23 sustainability in the long term. These obstacles can be divided into human variables and

1 technical variables. From the human variables side, unequal capacity distribution at the  
2 operational level can result in differing levels of data quality across facilities and districts.  
3 Staff workload is another challenge need addressing, as their willingness to work  
4 overtime is not a sustainable strategy. Technical problems were another obstacle during  
5 the introduction of SIMUNDU, but qualified technicians/developers could solve these  
6 issues. During our research, we recognized the weakness of SIMUNDU that it had not  
7 used the person number as a unique (single) code (ID) in data entry. This impacts on the  
8 challenging on finding a person when the previous entry was inaccurate. The in absence  
9 SIMUNDU single ID also affect the SIMUNDU's inability to synchronize with other  
10 health programs that use a person's number as a unique code. However, this weakness  
11 can be seen as room for improvement for SIMUNDU shortly. Another thing that needs  
12 to be considered for other regions that will implement SIMUNDU that SIMUNDU is that  
13 implemented in the DIY province which consists of 5 districts/cities with relatively easy  
14 regional accessibility. For areas with more difficult access, the commitment of the  
15 leadership and subordinates is the key to successful implementation.

## 16 **Conclusion**

17 SIMUNDU is a promising innovation for the entire country, beyond DIY. There is  
18 agreement about the potential for scale-up of this IIS to other provinces. Experience of  
19 implementing this system in DIY over the past five years has shown that the benefits  
20 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
21 system. Regular training to dedicated staff for strengthen their capacity as the system  
22 evolves and is updated, and a plan for anticipating and responding to staff turnover have  
23 proven critical strategies towards sustainability. SIMUNDU's success also rests on



1 remarkable leadership, both in creating and enabling a supportive environment and  
2 pursuing integration with other programs to share limited resources.

### 3 **Recommendation**

4 This study's recommendations address three different stakeholders' groups: the DIY  
5 Health Office, the national government, and researchers. First, to ensure continuity and  
6 sustainability and reduce the system's dependency on a particular person or party,  
7 SIMUNDU management and maintenance should be managed by people who have  
8 competency and interest in a good reporting system. Furthermore, a human resources plan  
9 should be developed in preparation for SIMUNDU roll-out in other provinces or at the  
10 national levels; this is necessary to avoid vacancies when DIY province staff are seconded  
11 to other areas for mentoring support. Second, the fact that SIMUNDU emerged from an  
12 actual need for immunization programme implementers and saw these at the front-line of  
13 its development and implementation, positively impacted its feasibility and viability. This  
14 suggests that the approach to scaling up SIMUNDU should be stepwise, considering each  
15 region's specific characteristics and needs. To this effect, a readiness map and a timeline  
16 may be developed to roll out of SIMUNDU in a particular region. Third, further research  
17 is needed to assess the impact of SIMUNDU on immunization coverage. Based on our  
18 conversations with stakeholders, it would be particularly relevant to focus on a low-  
19 performing region and observe the impact over a 2 to the 3-year time window.

### 20 **Study limitations**

21 The empirical results reported herein should be considered in light of limitations. First,  
22 the results of the quantitative study must be considered concerning the limited sample  
23 size, particularly for UPS Health Facilities. However, considering the top-down

1 immunization program and the characteristics of UPS, which will not be significantly  
2 different from each other, the results of this study are still valid and relevant to the  
3 existing. In qualitative research that aims to explore, caution is needed in interpreting the  
4 interview results. These results still a need in-depth studies with different approaches,  
5 such as focus group discussions to confirm the results.

## 6 **Declarations**

### 7 Ethics approval and consent to participate

8 This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan,  
9 Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began,  
10 consent to participate was obtained from research subjects (both survey and key  
11 informant interviews).

### 12 Adherence to national and international regulations

13 Not applicable

### 14 Consent for publication

15 Before data collection begins, an approval that data is taken for publication purposes is  
16 obtained from research subjects (both surveys and key informant interviews).

### 17 Availability of data and materials

18 The datasets generated and or analyzed for this study can be requested from the  
19 corresponding author.

### 20 Competing interests

21 The authors declare that they have no competing interests.

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#### 7 Authors' contributions

8 SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the  
9 data. SS and RR conducted data analysis. SS developed the paper with inputs and  
10 comments from MF on each draft. All authors agree with the manuscript's results and  
11 conclusions.

12

13

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#### 19 Authors' information:

20 The authors alone are responsible for the views expressed in this article. They do not  
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# BMC Health Services Research

## Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up --Manuscript Draft--

<b>Manuscript Number:</b>	BHSR-D-21-00992R4	
<b>Full Title:</b>	Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up	
<b>Article Type:</b>	Research article	
<b>Section/Category:</b>	Health systems and services in low and middle income settings	
<b>Funding Information:</b>	Alliance for Health Policy and Systems Research (2020/1011143-0)	Mrs Sulistyawati Sulistyawati
<b>Abstract:</b>	<p><b>Background:</b> Immunization is critical to saving children from infections. To increase vaccination coverage, valid and real-time data is needed. Accordingly, it is essential to have a good report system that serves as defaulter tracking to prevent children's immunization failure. The Daerah Istimewa Yogyakarta (DIY) Health Office introduced an electronic immunization registry and successfully implemented it for over than five years. It is the only individual-based record system in Indonesia that has been sustainably operated for a long time. Yet, no systematic assessment of this system has been conducted to date. This study examines the Sistem Informasi Imunisasi Terpadu (SIMUNDU) introduction and implementation process to draw lessons that could inform scalability and sustainability across the country.</p> <p><b>Methods:</b> This study used an explanatory sequential mixed-method design, which collected quantitative data from 142 participants and qualitative data from 9 participants. Entry data clerk in a health facility was systematically selected to participate in the survey. While in the key informant interview, the informant was selected based on the survey result. A descriptive and thematic approach was adopted to analyze the quantitative and qualitative data. Results from across the two approaches were integrated for comparison and contrast.</p> <p><b>Results:</b> Findings are presented according to three core themes that emerged from the data: system strengths, potential threats, and opportunities for scale-up. Strengths - i.e. factors contributing to the success of SIMUNDU - include management, system performance, people's behavior, and resources. Potential threats to sustaining the system include individual capacity, technical or system issues, and high workload. Opportunities - i.e promising factors that SIMUNDU can be operated sustainably - such as continuity, expectation and scale up possibility.</p> <p><b>Conclusions:</b> SIMUNDU is a promising innovation for Indonesia, beyond DIY. There is agreement about the potential for scale-up of this IIS to other provinces. Experience of implementing this system in DIY over the past five years has shown that the benefits outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly system.</p>	
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1 **Introduction and implementation of an immunization information**  
2 **system in Indonesia province of Daerah Istimewa Yogyakarta: lessons**  
3 **for scale-up**

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1 **Abstract**

2 **Background:** Immunization is critical to saving children from infections. To increase  
3 vaccination coverage, valid and real-time data is needed. Accordingly, it is essential to  
4 have a good report system that serves as defaulter tracking to prevent children's  
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6 an electronic immunization registry and successfully implemented it for over than five  
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11 and sustainability across the country.

12 **Methods:** This study used an explanatory sequential mixed-method design, which  
13 collected quantitative data from 142 participants and qualitative data from 9 participants.  
14 Entry data clerk in a health facility was systematically selected to participate in the  
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16 survey result. A descriptive and thematic approach was adopted to analyze the  
17 quantitative and qualitative data. Results from across the two approaches were integrated  
18 for comparison and contrast.

19 **Results:** Findings are presented according to three core themes that emerged from the  
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21 up. Strengths -i.e. factors contributing to the success of SIMUNDU - include  
22 management, system performance, people's behavior, and resources. Potential threats to  
23 sustaining the system include individual capacity, technical or system issues, and high

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1 workload. Opportunities – i.e promising factors that SIMUNDU can be operated  
2 sustainably – such as continuity, expectation and scale up possibility.

3 **Conclusions:** SIMUNDU is a promising innovation for Indonesia, beyond DIY. There  
4 is agreement about the potential for scale-up of this IIS to other provinces. Experience of  
5 implementing this system in DIY over the past five years has shown that the benefits  
6 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
7 system.

8  
9 **Keywords:** immunization, electronic immunization registry, immunization information  
10 system, interoperability, implementation research

11 **Background**

12 Neonatal and childhood vaccination is essential to infectious disease prevention and an  
13 absolute human right (1),(2). Vaccination has been proven to reduce the burden of  
14 infectious diseases globally (3). According to the WHO, in 2020, an estimated 23 million  
15 children under one year did not receive their essential vaccinations. Of these, 60% live in  
16 just ten countries, one of which is Indonesia (4). Indonesia is the fourth most populous  
17 country globally. It is composed of thousands of islands organized into 34 provinces.  
18 Various geographical and cultural factors influence population inequalities to access  
19 health services (5). In 2001, the Indonesian government's decentralization policy was  
20 enacted. This was an excellent strategy to foster development by engaging regional  
21 resources (6). However, this strategy was not without consequence. One primary concern  
22 was the Health Information System (HIS) fragmentation.

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1 Indonesia's federal structure results in provinces and districts being relatively independent  
2 of the national Ministry of Health. This means that provincial and district-levels  
3 information systems are locally regulated (7). For instance, *Pemantauan Wilayah*  
4 *Setempat* (PWS) is a management tool used to monitor coverage of specific health  
5 services in an administrative boundary. Depending on the service and region, it can be  
6 paper- or electronic-based. PWS-KIA is the monitoring system specific to maternal and  
7 child health (KIA), including immunization. PWS-KIA data are reported to the District  
8 or City Health Office, go to Province Health Office, and finally reported to the main level.  
9 Generally, the data are in Microsoft Excel formats; it will report via emails or various  
10 information systems, including Komdat, SiTT, SIHA, PISPK, and SIKDA Generik.  
11 PWS-KIA data feeds into District Health Information System 2 (DHIS2). Regional  
12 information systems have varying data quality, which reflects inequities in resources  
13 across regions. This adds to data integration challenges at the national level (7),(8) and  
14 affects strategic policymaking.

15 In Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) Province has the  
16 authority to regulate and use its budget within its four districts plus one city (Sleman,  
17 Gunungkidul, Bantul, Kulonprogo and Yogyakarta). **This province is classified as a small**  
18 **province in terms of area size and the number of regions inside (9). However, this region**  
19 **can be considered a representation of Indonesia when viewed from the geographical,**  
20 **socio-economic and heterogeneous population.** Regarding childhood vaccination, DIY is  
21 among the top ten performing provinces in the country, with 97.7 % of children  
22 completing basic immunization coverage in 2019 (10). Immunization services are  
23 provided by Primary Health Centres or Puskesmas (PHC), as well as private clinics,

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1 hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* or  
2 UPS).

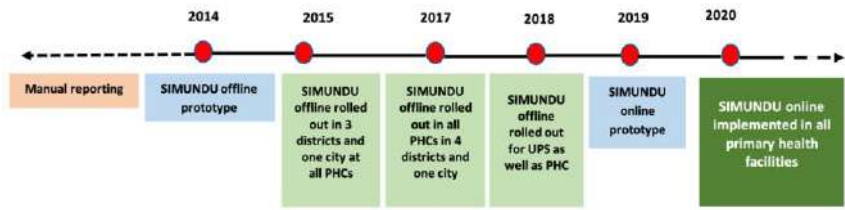
3 An electronic immunization registry is a tool for recording individual children's  
4 immunization histories. In 2014, the DIY Health Office introduced an electronic  
5 immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu/*  
6 *Integrated Immunization Information System*). An electronic registry serves essential  
7 functions at all levels of the health system. At the district and higher levels, it allows for  
8 monitoring vaccination coverage by the vaccine, dose, cohort, and other variables – and  
9 can support microplanning and vaccine management. The service delivery level can  
10 facilitate individual follow-up of vaccination status and enable health workers to identify  
11 children due for vaccination and those who missed their vaccinations (defaulters).

12 SIMUNDU was designed to link with the PWS-KIA for immunization and  
13 interoperability with the DHIS2. While it predominantly contains individual-level  
14 immunization records, SIMUNDU also serves as a source for aggregation and can  
15 synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this  
16 reason, it can be considered an Immunization Information System (IIS). This means that  
17 City and District levels feed into Provincial and National levels (*Personal communication*  
18 *with DIY immunization program officer*).

19 The original prototype was designed by the information and technology (IT) department  
20 of DIY Health Office to be operated offline. In DIY, three out of the four districts and the  
21 city introduced the system in 2015. The final district introduced it in 2017. At this stage,  
22 the point of data entry was the PHC only. By 2018, UPS facilities were also equipped  
23 with SIMUNDU and could enter data into the system. In 2019, the prototype was further

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1 developed to operate online. The online version was rolled out in 2020 (Figure 1). As of  
2 May 2021, 79.4% of all PHC and UPS facilities complied. This average rate masks,  
3 however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce  
4 its use in UPC facilities (Suyani 2020, oral communication, 2020, May 11).



5  
6 **Figure 1.** SIMUNDU’s development and introduction

7 When a child receives a vaccination in a health facility, information on the child and the  
8 vaccination is entered in SIMUNDU as an individual child record. Each record includes  
9 a personal identifier, the child’s socio-demographic characteristics (e.g., name, gender,  
10 date of birth, name of parents, address), the antigen administered, and the date and place  
11 of vaccination. SIMUNDU has been recently updated to allow the recording of  
12 vaccinations administered in schools (e.g., Human papillomavirus (HPV), Diphtheria  
13 Toxoid (DT), Tetanus-Diphtheria (TD), and Measles-Rubella (MR), though in the form  
14 of aggregate data only. Furthermore, SIMUNDU has been developed to record COVID-  
15 19 vaccinations in health facilities and those carried out in masse.

16 Monitoring is conducted monthly to assess data completeness across health facilities,  
17 while an evaluation is conducted yearly. These exercises have allowed the identification  
18 of several challenges related to implementing the system (e.g., workload, staff turnover,  
19 and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic  
20 assessment of the system has been conducted to date. SIMUNDU is the first

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1 immunization information system ever introduced in Indonesia. Other districts and  
2 provinces have shown interest in rolling it out, and the Ministry of Health has  
3 acknowledged the innovation. The work presented here aims to examine SIMUNDU's  
4 introduction and implementation process to draw lessons that could inform scalability  
5 and sustainability across the country.

6 **Methods**

7 From May to October 2020, we examined the experience of introducing and  
8 implementing an immunization information system in the DIY province using an  
9 explanatory sequential mixed-method design, where each step informed the next (11).  
10 First, we reviewed of all relevant documentation available in the DIY Health Office –  
11 e.g., staff notes, meeting notes and monitoring notes – documenting SIMUNDU  
12 development and management processes. We also examined online documents, including  
13 health profiles and regulations on health reporting systems in Indonesia. This served as  
14 the initial data source and provided an overview of who was involved and how in  
15 developing and implementing SIMUNDU. This informed the survey design that we  
16 conducted as a second step. The survey targeted any staff responsible for entering data in  
17 SIMUNDU (i. e. data clerks) across all PHC and selected UPS facilities and any staff  
18 responsible for managing the system at the district and city level (i. e., immunization  
19 coordinators). Sampling and recruitment strategies are outlined in Table 1.



**Table 1. Survey participant**

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
Primary Health Centre (PHC)	121	Data entry clerks	All facilities	Open invitation across all facilities	113
UPS - Central, General, Maternity and Pediatric Hospitals	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
UPS - Clinics	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
UPS - Midwives' Practices	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinators	Total sampling	Open invitation	4*
<b>Total</b>					<b>142</b>

\*When the immunization coordinator had recently changed, the former was also invited.

All immunization coordinators in each district/city and data entry clerks from all primary health facilities (PHC) were invited to participate in this survey. For UPS facilities, we selected two clinics, two midwives' practices, and two hospitals per district/city and invited all of their staff ~~who~~ ~~who~~ involved in SIMUNDU data entry and management.

We developed and pre-tested an online survey in Bahasa Indonesia to inquire about SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, district or city and province offices. The questionnaire consisted of close-ended and Likert scale questions – ranging from 45 to 50 depending on the target type of facility and/or level of the health system – and enquired about respondents' socio-demographic characteristics as well as the process of implementing and managing SIMUNDU. Some questions provided an additional field for clarifying the reason for a particular answer choice.

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1 All participants were invited to the DIY Health Office to complete the survey on their  
2 laptops, with their prior consent. All participants in a room allowed researchers to monitor  
3 any missing or incomplete responses in real time and follow up with individual  
4 participants on-site to fill any gaps. We don't believe this may have introduced any  
5 significant bias as researchers would simply flag any missing responses and invite  
6 respondents to address those. Data were then exported and analyzed in Microsoft Excel.  
7 An exploratory analysis of the survey data informed the topic areas that qualitative  
8 interviews explore further.

9 Similarly, some informants were purposefully selected among survey participants to  
10 follow up on the range of perspectives that had emerged from the survey. Other  
11 informants had been identified at the desk review stage and chosen for their management  
12 functions. Selected informants were invited to the DIY Health Office for the interview,  
13 and COVID-19 prevention protocol was observed. Every informant was informed about  
14 the study and asked to sign the informed consent. All invited informants agreed to  
15 participate. A total of nine 30-minute semi-structured interviews were conducted in  
16 Bahasa Indonesia language and recorded with prior consent from participants. The  
17 interview team consisted of three researchers with the respective task of running the  
18 interview, observing and taking notes. A research assistant transcribed all interviews in  
19 Bahasa Indonesia language.

20 Thematic analysis was conducted using Quirkos qualitative tool following Braun and  
21 Clarke's approaches (12). Researchers familiarized themselves with the data, searching  
22 for initial codes and allowing themes to emerge. The principal investigator led the coding  
23 process, and led the research team in defining and naming the core themes emerging from  
24 the data, organizing and analyzing the data across the themes, and triangulating

1 information from the desk review, the survey, and the interviews. This stage was also  
 2 performed in Bahasa Indonesia. Data were translated to English only at sub-theme and  
 3 core themes.

## 4 Results

### 5 Characteristic participant

#### 6 a. Quantitative study

7 In total, 142 respondents participated in this study spread across five districts/cities in the DIY  
 8 province. Most respondents came from Gunungkidul District, PHC, UPS, and DHO, 24.8%, 24%,  
 9 and 25%, respectively. For all research units, the majority are women. At the UPS and DHO/CHO  
 10 levels, most respondents were aged 41-45 years, i.e., 28.3% and 75%, respectively, while at the UPS  
 11 level, the majority were aged 25-30 years (56.0%). For education level, PHC and UPS are dominated  
 12 by Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, it is  
 13 predominantly undergraduate graduates (75%) (Table 2)

14 **Table 2.** Characteristic respondents in three groups of respondents

Characteristic	PHC (n= 113) n (%)	UPS (n=25) n (%)	DHO/CHO (n= 4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3 (2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25-30	3 (2.7)	14 (56.0)	0 (0.0)
31-35	30 (26.5)	3 (12.0)	0 (0.0)
36-40	19 (16.8)	1 (4.0)	0 (0.0)
41-45	32 (28.3)	0 (0.0)	3 (75.0)
46-50	18 (15.9)	0 (0.0)	1 (25.0)
>50	11 (9.7)	2 (8.0)	0 (0.0)

Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

b. Qualitative study

Nine informants were recruited to provide the required information to explore the quantitative study results more deeply. They serve as managers and staff at DHO/CHO, PHC, and UPS. Among the nine informants, 2 were men, and 7 were women. Three informants graduated with master's, one bachelor's, and five diplomas graduates (Table 3).

**Table 3.** Informants' characteristics for the qualitative study

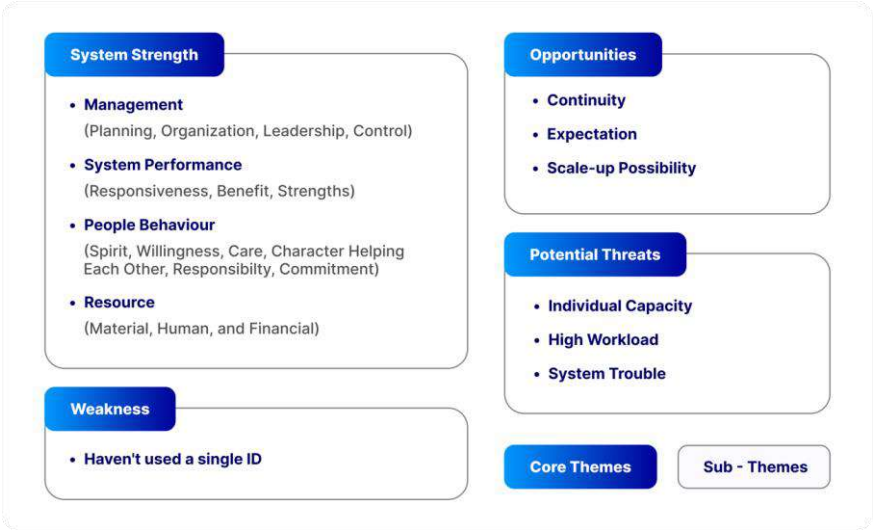
Sex	Age (years)	Education	Position	Subject group	Informant's code
Female	56	Magister	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Magister	The former of the disease prevention and control section at the PHO level	Managerial	M 02
Male	54	Bachelor	Immunization programmer at the PHO level	Managerial	M 03
Female	47	Magister	IT Person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at the UPS level	Staff	S 02
Female	31	Diploma	Data entry at the UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

c. Finding

Findings from the study are organized and presented across the three core themes that emerged from the qualitative analysis, notably system strengths, potential threats, and opportunities for scale-up. However, data from qualitative and quantitative data fed into

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1 the analysis of these core themes to cross-validate the findings (Figure 2. Detailed  
2 findings from the survey are presented in Table Supplement 1.



3  
4 **Figure 2.** Strengths, potential threats, and opportunities for scale-up

5 ***System's Strengths***

6 Factors contributing to the success of SIMUNDU include management, system  
7 performance, people's behavior, and resources.

8 **Management**

9 SIMUNDU arose due to concerns from the DIY Health Office immunization section  
10 around data quality, notably the need to address data inaccuracy, duplicate or missing  
11 data and lack of timely data, and the need for quality data to support follow-up and  
12 appropriate planning. The need for SIMUNDU arose from these challenges and needs.

13 *"To our knowledge, [SIMUNDU development] started with a problem: estimates of the*  
14 *target population varied depending on the data source" (M02)*

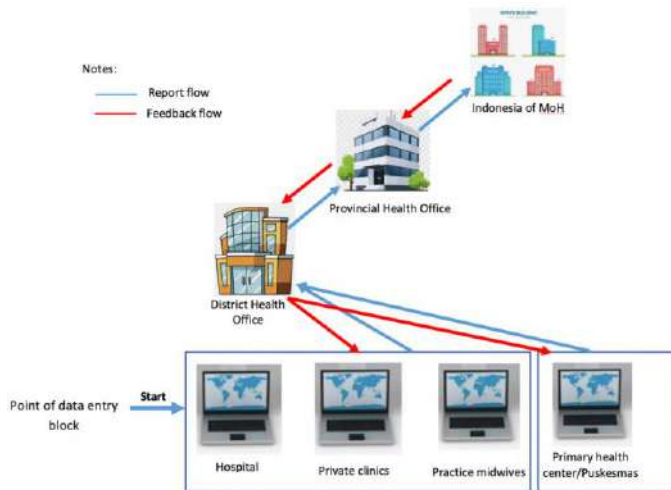
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1 “Yes, I think [SIMUNDU management team] started to tire of managing a large volume  
2 of data with dubious validity. They need to know the situation in each district”. (M04)

3 Effective management of SIMUNDU from development to implementation was  
4 highlighted as an essential determinant of its success across the critical functions of  
5 Planning, Organization, Leadership, and Control.

6 Careful **Planning** was ensured at each stage of SIMUNDU development and  
7 implementation. These stages included developing an initial business plan, providing  
8 training on and socialization to SIMUNDU, and developing a staff replacement plan to  
9 respond to turnover or retirement of staff in charge of operating the system or entering  
10 data. The parties involved in planning included the Head of the Disease Prevention and  
11 Control Department, IT personnel, and from the DIY Health Office immunization  
12 program staff.

13 **Organization-** the organization of SIMUNDU, is carried out at several levels. The top  
14 level is the DIY Health Office, the second level is the district/city health office, and the  
15 third level is health facilities (Figure 2). A third party was also involved in developing  
16 the system interface.



**Figure 2.** Visual organizing framework of SIMUNDU – DIY Province, Indonesia

At the beginning of SIMUNDU development, essential functions included database administrators, interface designers, and server administrators, and their interplay facilitated the system's smooth operation. Training specific to SIMUNDU was integrated with other training, typically immunization-related training. This enabled us to share of resources with other programs, thus ensuring viability. The training was delivered in the district/city health office: 87.6%, 72%, and 75% of survey respondents from PHC, UPS, and DHO/CHO, respectively had participated in in-house training. Training typically consisted of short sessions and included practice on the trainee's device to operate the system in both online and offline mode. Informants indicated that day-to-day operations were carried out autonomously by the staff through flexibly adjusting their work to protect the time to enter the data. This seemed to work effectively.

**Leadership** - the success of SIMUNDU implementation is arguably related to strong leadership. Informants noted that managers played a crucial role in bridging the needs of

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1 the immunization program with the system design, closely monitoring the initial  
2 implementation process, and creating an enabling environment.

3 *“I try to combine supporting and managing and monitoring the people involved.*

4 *Currently, I monitor whether [SIMUNDU] can run optimally as our users are health  
5 facilities. I also monitor program development and the system's output.” (M01)*

6 *“[SIMUNDU] was born from program managers, primary health centers, Districts, and  
7 DIY Health Offices wanting to build systems together. We – DIY Health Office - give  
8 them motivation in every meeting.” (M03)*

9 *“I see that [management] is very good at networking. Staff data entry in the field  
10 always said that these people are very kind.” (M02)*

11 The role of IT workers in developing SIMUNDU was also significant. They helped  
12 develop the system and facilitated correct data entry operators whenever technical issues  
13 arose. IT workers also helped resolve inconsistencies in data records. Acknowledgment  
14 of staff efforts was also important to maintain motivation and buy-in.

15 *“In the early days of SIMUNDU’s development, the system was challenging to operate,  
16 as it wasn’t as stable as it is now. I praise the enthusiasm and dedication of the users.”  
17 (M01)*

18 The **control** function - consisting of **quality** assurance management - was critical to avoid  
19 data duplication or missing entries and ultimately ensure data quality. This process was  
20 not regulated by specific Standard Operating Procedures but was addressed during  
21 training and monitored monthly. In addition, the DIY Health Office provided negative  
22 incentives to health facilities that were not submitting complete records and provided  
23 regular feedback from monitoring and evaluation exercises.

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1 Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO,  
2 respectively, reported their work had been subject to monitoring. More than half of the  
3 respondents in PHC and UPS facilities had been observed by supervisors while  
4 performing data entry at least once over the past year. At the PHC level, 48.3% of survey  
5 respondents had been subject to monitoring from the district/city office’s team, and 45.7%  
6 received monitoring from DIY Health Office’s staff. Conversely, 40% of respondents  
7 from UPS facilities were monitored by PHC’s staff. Almost all survey respondents  
8 reported receiving feedback from the monitoring, mainly from the District/City and DIY  
9 Health Offices. Forty percent of respondents from UPS facilities reported receiving  
10 feedback from PHC. Immunization coordinators from the District/City Health Offices  
11 received feedback from the DIY Health Offices.

12 *“In a [evaluation] meeting, DIY Health Office or District Health Office showed the*  
13 *progress of our data entry – correct or not, proper or not.” (M02)*

14 It is worth noting that DIY Province is quite a small geographic area. Because it consists  
15 of only five districts and one city, this province is relatively easy to monitor across all  
16 phases, from planning through monitoring and evaluation.

17 **System performance**

18 While SIMUNDU predominantly contains individual-level immunization records, it also  
19 serves as a source for aggregation and can synergize with other information systems.  
20 Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports  
21 per the Ministry of Health’s requirements. These reports are sent to the upper levels  
22 automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is

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1 operated offline. This functionality has had an essential role in ensuring the acceptability  
2 and adoption of the system.

3 Informants noted how transitioning from paper-based tools to an electronic system made  
4 data entry easier and reduced errors. SIMUNDU also facilitated the implementation of  
5 protocols for data storage and security. It enabled follow-up and defaulter tracking.  
6 Finally, integration with the DHIS2 meant reduced workload for the staff.

7 *“We can track children who may have received vaccinations in different locations  
8 faster. For example, when the first dose of a vaccine is given in Bantul and the second  
9 one in Yogyakarta, the record can be linked within SIMUNDU” (M01).*

10 *“SIMUNDU makes detecting what data and vaccinations are missing easier since we  
11 enter data from the children’s birth through the end of the immunization schedule. So,  
12 we will know where they miss any vaccine.” (S03)*

13 *“The benefit of using SIMUNDU is first: we know the situation of immunizations more  
14 accurately....so our vaccine forecasting is more accurate .... and our budget, staff,  
15 facilities can be more effective and efficient in providing services.” (S05)*

16 *“Colleagues from the mother and child health (KIA) program enter the data via the KIA  
17 “Sembada.” So, this data will appear automatically in SIMUNDU because the two  
18 system are connected.” (S01)*

19 SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the  
20 responsible staff to maintain data entry irrespective of connectivity. 82.3%, 96%, and  
21 100% of survey respondents from PHC, UPS, and DHO, respectively reported operating  
22 SIMUNDU online.

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1 **People’s behavior**

2 The interview showed that staff commitment was critical for the successful  
3 implementation of SIMUNDU, as indicated by their willingness to work overtime and  
4 bring home the data to enter into the system.

5 *“I take it [the data] home too, for example, after immunization sessions– in my clinic,  
6 immunization runs four times per month, every week. So, when the session is finished,  
7 we can take the data home, [and] do the entry at home while relaxing.” (S03)*

8 The interviews confirmed this dedication, which spoke to a societal culture of helping  
9 others and responsibility and commitment to the team. This contributed to shaping an  
10 environment where people approach SIMUNDU as a shared responsibility and a  
11 collective endeavor. Informants also noted the high motivation of dedicated staff.

12 *“That’s all; we cannot judge by money [people’s kindness, culture, and behavior];  
13 explaining how good people are in Yogyakarta is essential. I was in another place  
14 before, and could not find people’s kindness like in Yogyakarta - different characters.”  
15 (M02)*

16 *“The second thing is that we need human resources concerned and love for data;  
17 otherwise, even though we have a good system, it will amount to nothing without good  
18 human resources. But good implementation will come more easily when people are  
19 concerned about data.” (M04)*

20 **Resource: material, human and financial**

21 Infrastructure and equipment emerged as critical factors in introducing and sustaining  
22 SIMUNDU implementation. Some desktops were explicitly allocated to the

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1 immunization program, and some had to be shared with other staff. Other data entry  
2 officers reported using their laptop or smartphone (36.3% of survey respondents from  
3 PHC). In UPS facilities, 40.7% reported using office desktops; in the DHO, more than  
4 half of the respondents stated they used an office-supplied laptop. The majority of  
5 respondents – regardless of the type of facility - said their current device was sufficient  
6 to perform their work on SIMUNDU. Regarding connectivity, 64.6% of PHC survey  
7 respondents and 67.7% of UPS’s reported operating SIMUNDU online, relying on the  
8 office’s internet connection.

9 Management of financial resources was also crucial. According to the key informants, no  
10 special funds were allocated to SIMUNDU in the initial stages. Resources were leveraged  
11 through sharing activities – e.g., monitoring visits or transportation - with other programs,  
12 thus allowing cost efficiencies. Integration with other programs proved critical to  
13 ensuring sustainability.

14 *“SIMUNDU's budget comes from the state budget called as Anggaran Pendapatan dan*  
15 *Belanja Negara (APBN). Every year the APBN allocates funding envelope for*  
16 *immunization to DIY and other provinces, where the budget is apportioned across the*  
17 *program [not explicitly written budget for SIMUNDU].” (M02)*

18 Human resources are critical to the operation of SIMUNDU. According to interview,  
19 SIMUNDU data entry clerks must have patience, work carefully and not rush, be  
20 interested in data, be responsible, and have basic computer skills in word processing and  
21 spreadsheet software tools such as Microsoft Word and Excel, respectively. As shown by  
22 the survey, the large majority of SIMUNDU-operating staff was educated: at least 80%  
23 of data entry clerks in either PHC or UPS facilities have secondary education (>80%),

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1 while at the managerial level (DHO), 75% of respondents have a Bachelor’s degree (see  
2 Table 2). However, 19.4% and 9.1% of respondents from PHC and UPS facilities, have  
3 low computer literacy.

4 Various data entry clerks looked for strategies to resolve the obstacles they encountered  
5 when entering data to SIMUNDU. Based on the interviews, some clerks furthered their  
6 computer skills by taking private computer classes. Others learned from colleagues at  
7 their offices, or reached out for help to the district person in charge. To deal with the  
8 accumulation of data needing to be entered in SIMUNDU, staff would sometimes work  
9 at home after office hours, as their busy schedule at work did not allow time for data  
10 entry.

11 *“If we found obstacles, we asked people in charge in PHC – asking for a solution or*  
12 *sharing by WhatsApp – or sometimes I asked the IT person in the DIY Health Office.”*  
13 (S03)

14 **Potential threats**

15 As of today, SIMUNDU can be said to be a successful experience. However, some  
16 obstacles were encountered and addressed during implementation. Potential system  
17 sustaining include individual capacity, technical or system issues, and high workload.

18 Staff computer literacy was identified as one of the main sustainability challenges.  
19 Internet connectivity was another obstacle, as not a good network equally supported all  
20 health facilities. The survey shows that 64.6% and 67.7% of PHC and UPS staff used  
21 office internet, while others had to rely on their home internet.

22 Further, incomplete and inconsistent records – such as differing child’s date of birth or  
23 name spelling across relevant entries - make it challenging to consistently record

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1 immunization information. These challenges have arisen during implementation and were  
2 promptly addressed. Yet, they had an impact on staff who was already juggling busy  
3 schedule in the office, causing delays in data entry. As shown by the survey, almost all  
4 respondents stated having other responsibilities besides operating SIMUNDU – notably  
5 97.3%, 88%, and 100% of participants from PHC, UPS and district and city offices,  
6 respectively.

**Weakness**

8 The informant said that SIMUNDU assisted in their daily work, but they also reported  
9 that sometimes they needed more time to find the children's names on the next visit. It is  
10 because SIMUNDU data entry did not use a single national ID that could be valid  
11 anywhere. As a result, when a name input error occurs, the officer will need time to check  
12 with the name of the child's parents or the manual register.

13 *"Sometimes, there was an incorrect name during the data entry; for example, Dita was*  
14 *written as Dieta. So, it is difficult for us to find them. If that happens, we must look back*  
15 *at the register or medical record data. "* (S04)

16 *"I experienced difficulty entering data on SIMUNDU when a new patient came from*  
17 *another health facility to us. It was challenging to find their record on*  
18 *SIMUNDU"* (S05)

**Commented [SS1]:** new information about weakness

**Opportunities**

20 Informants appreciated SIMUNDU as an excellent system to manage immunization data.  
21 SIMUNDU has become necessary for program managers and policymakers; it allows  
22 them to monitor coverage and can help inform planning and programming. Currently,  
23 SIMUNDU is stable, thus is easier to manage than when it was in the development phase.

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1 It is also viable and no longer requires heavy reliance on the core workforce that started  
2 the system. The hopes expressed by data entry clerks in the interviews are that SIMUNDU  
3 is easier to operate and system errors are less frequent. Informants also stressed the need  
4 for refresher training to ensure knowledge and practice of the system is not lost.

5 *“In my opinion, SIMUNDU is the best program in DIY, a collaboration between*  
6 *program managers and IT. It will continue to be implemented because it is a necessity.*

7 *It has been stably used for more than five years, meaning this is needed.” (M01)*

8 *“If I have the tool, in this case, SIMUNDU, when it is stable, whoever will be able to*  
9 *run it, I am sure that anyone can operate it. It means that it doesn't matter if we have*  
10 *people shifting (jobs).” (M01)*

11 *“In the future, if SIMUNDU is still used, other reports are not necessary. Now we have*  
12 *two different reports: SIMUNDU and stock card of vaccine – each stand-alone and*  
13 *need a separate report.” (S05)*

14 Based on the key informants’ interviews, SIMUNDU is likely to be developed further /  
15 or expanded to other provinces. The DIY Health Office is open to supporting other  
16 provinces interested in introducing the system, for instance, through the lending staff for  
17 training and orientation. However, informants advised that a successful introduction  
18 requires a strong commitment from staff and management.

19 **Discussion**

20 Robust health information systems (HIS) are essential components of robust health  
21 systems (13). At the most basic level, immunization registries are systems that collect and  
22 report individual-level vaccine administration record data, thus facilitating individual

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1 follow-up of vaccination status. Registries also allow for the monitoring of vaccination  
2 coverage and enable analysis of AEFIs and surveillance data to inform the design of  
3 coverage interventions and outbreak investigations. When an electronic registry has  
4 interoperability with other electronic systems – such as in the case with SIMUNDU – it  
5 is considered an Immunization Information System (IIS) (14). This paper presents lessons  
6 learned from DIY’s experience implementing an IIS.

7 DIY is the only province in Indonesia – out of thirty-four - that uses an IIS. This work  
8 has shed light on the strengths and underlying barriers of implementing an IIS in this  
9 context. The objective of this study was to draw lessons that inform sustainable scale-up  
10 in other provinces and possibly at the national level. This study highlighted individual  
11 capacity, technical or system issues, and high workload as the major barriers to  
12 sustainability. Conversely, management, system performance, people’s behavior, and  
13 available resources emerged as the main determinants of SIMUNDU’s successful  
14 implementation - notably in improving acceptability, implementation costs, and adoption  
15 of this innovation (15).

16 Despite several obstacles encountered during the implementation of SIMUNDU, this  
17 study showed that this innovation was well accepted by key stakeholders. On the one  
18 hand, data entry clerks noted that the system is relatively user-friendly and allows to  
19 organize the data better and enhance its quality. On the other hand, managers noted the  
20 benefits this innovation brought about, namely in the potential for cohort data to support  
21 planning and monitoring and ultimately improve immunization coverage.

22 Effective management - across planning, organization, leadership, and control functions  
23 – is a crucial reason why SIMUNDU has been viable for over 5 years. Managers use



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1 their control to encourage the beliefs and actions of the staff with a dedicated and robust  
2 managerial process (16). SIMUNDU was born from the need for credible data to assist in  
3 carrying out DIY Health Office duties at the managerial and operational levels. At the  
4 managerial level, the disease prevention and control department and the IT department  
5 collaborated in designing a system that intended users readily accepted. Immunization  
6 officers and IT programmers played a central role from the early stages of development  
7 through implementation with effective coordination and communication. They were  
8 helped in this task with the full support of their respective superiors.

9 SIMUNDU is cost-effective in several ways. During the introductory period of its  
10 implementation, immunization programmers, IT officers, and other staff assisted in  
11 introducing SIMUNDU in all districts in the province. This was done by integrating some  
12 of the activities across programs, thus building efficiency in terms of time and costs for  
13 both managers and staff. Sharing resources across programs was critical in the first years  
14 of building sustainability. Additionally, SIMUNDU maintenance does not require high  
15 costs because the DIY Health Office has developed the system and thus possesses in-  
16 house technical skills. The IT department has the capacity to monitor and improve  
17 processes and tailor them to user needs without much additional cost.

18 A good program without good leadership could fail in its implementation, and even if it  
19 was initially successful, it might not be sustainable (17). In the context of SIMUNDU,  
20 leadership and effective management support facilitated the program's adoption. The  
21 uptake of the new system was good and all health facilities providing immunization  
22 services have successfully transitioned to SIMUNDU. The strong network of the  
23 prominent persons in charge of SIMUNDU also facilitated the adoption. Good  
24 communication, care, and attention to staff concern positively affected staff performance.

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1 They felt that they were well-supported and treated kindly, and this helped them carry out  
2 their work joyfully. According to several informants, the DIY immunization program  
3 manager’s leadership played an essential role in this effect.

4 The monitoring and evaluation mechanisms of SIMUNDU were also important.  
5 Preferred monitoring and evaluation activities include monthly reports and staff  
6 discussions during site monitoring visits. The immunization program manager suggested  
7 this approach to maintain data quality and ensure the system sustainability. These chosen  
8 mechanisms allow program managers to assess the actual practice in the field and the  
9 challenges faced to inform decisions about the follow-up actions to be taken. These  
10 processes supported the ongoing development of and learning from, SIMUNDU as a tool  
11 for data collection, analysis, and visualization, as well as the benefits for managers to  
12 carry out monitoring and evaluation. The same sentiment was reflected in previous  
13 research undertaken in the India (18).

14 Human resources are a key determinant of the successful implementation of any HIS (19).  
15 People's behavior affects how the system works, develops, and survives (20),(21). In the  
16 case of SIMUNDU, implementation was facilitated by a culture of care, established  
17 networks, and a positive attitude towards data of both the program manager and IT team.  
18 From the staff's point of view, the local culture of helping each other and doing their job  
19 correctly and responsibly translated into staff carrying out their duties with enthusiasm  
20 and high commitment. Although facilities, funding and human resources were limited,  
21 the individuals involved were highly motivated and supportive.

22 Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its  
23 sustainability in the long term. These obstacles can be divided into human variables and

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1 technical variables. From the human variables side, unequal capacity distribution at the  
2 operational level can result in differing levels of data quality across facilities and districts.  
3 Staff workload is another challenge need addressing, as their willingness to work  
4 overtime is not a sustainable strategy. Technical problems were another obstacle during  
5 the introduction of SIMUNDU, but qualified technicians/developers could solve these  
6 issues. During our research, we recognized the weakness of SIMUNDU that it had not  
7 used the person number as a unique (single) code (ID) in data entry. This impacts on the  
8 challenging on finding a person when the previous entry was inaccurate. The in absence  
9 SIMUNDU single ID also affect the SIMUNDU's inability to synchronize with other  
10 health programs that use a person's number as a unique code. However, this weakness  
11 can be seen as room for improvement for SIMUNDU shortly. Another thing that needs  
12 to be considered for other regions that will implement SIMUNDU that SIMUNDU is that  
13 implemented in the DIY province which consists of 5 districts/cities with relatively easy  
14 regional accessibility. For areas with more difficult access, the commitment of the  
15 leadership and subordinates is the key to successful implementation.

16 **Conclusion and recommendation**

17 SIMUNDU is a promising innovation for the entire country, beyond DIY. There is  
18 agreement about the potential for scale-up of this IIS to other provinces. Experience of  
19 implementing this system in DIY over the past five years has shown that the benefits  
20 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
21 system. Regular training to dedicated staff for strengthen their capacity as the system  
22 evolves and is updated, and a plan for anticipating and responding to staff turnover have  
23 proven critical strategies towards sustainability. SIMUNDU's success also rests on

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1 remarkable leadership, both in creating and enabling a supportive environment and  
2 pursuing integration with other programs to share limited resources.

3 **Recommendation**

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4 This study's recommendations address three different stakeholders' groups: the DIY  
5 Health Office, the national government, and researchers. First, to ensure continuity and  
6 sustainability and reduce the system's dependency on a particular person or party,  
7 SIMUNDU management and maintenance should be managed by people who have  
8 competency and interest in a good reporting system. Furthermore, a human resources plan  
9 should be developed in preparation for SIMUNDU roll-out in other provinces or at the  
10 national levels; this is necessary to avoid vacancies when DIY province staff are seconded  
11 to other areas for mentoring support. Second, the fact that SIMUNDU emerged from an  
12 actual need for immunization programme implementers and saw these at the front-line of  
13 its development and implementation, positively impacted its feasibility and viability. This  
14 suggests that the approach to scaling up SIMUNDU should be stepwise, considering each  
15 region's specific characteristics and needs. To this effect, a readiness map and a timeline  
16 may be developed to roll out of SIMUNDU in a particular region. Third, further research  
17 is needed to assess the impact of SIMUNDU on immunization coverage. Based on our  
18 conversations with stakeholders, it would be particularly relevant to focus on a low-  
19 performing region and observe the impact over a 2 to the 3-year time window.

20 **Study limitations**

21 The empirical results reported herein should be considered in light of limitations. First,  
22 the results of the quantitative study must be considered concerning the limited sample  
23 size, particularly for UPS Health Facilities. However, considering the top-down

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1 immunization program and the characteristics of UPS, which will not be significantly  
2 different from each other, the results of this study are still valid and relevant to the  
3 existing. In qualitative research that aims to explore, caution is needed in interpreting the  
4 interview results. These results still a need in-depth studies with different approaches,  
5 such as focus group discussions to confirm the results.

6 **Declarations**

7 Ethics approval and consent to participate

8 This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan,  
9 Yogyakarta, Indonesia (ethical approval code: 012005021). Before data collection began,  
10 consent to participate was obtained from research subjects (both survey and key informant  
11 interviews).

12 Adherence to national and international regulations

13 Not applicable

14 Consent for publication

15 Before data collection begins, an approval that data is taken for publication purposes is  
16 obtained from research subjects (both surveys and key informant interviews).

17 Availability of data and materials

18 The datasets generated and or analyzed for this study can be requested from the  
19 corresponding author.

20 Competing interests

21 The authors declare that they have no competing interests.

22 Funding

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7 Authors' contributions

8 SS, TAW, RR, ASDN and MF designed the study. SS, TWS, SKW, SAM collected the  
9 data. SS and RR conducted data analysis. SS developed the paper with inputs and  
10 comments from MF on each draft. All authors agree with the manuscript's results and  
11 conclusions.

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19 Authors' information:

20 The authors alone are responsible for the views expressed in this article. They do not  
21 necessarily represent the views, decisions, or policies of the institutions affiliated with  
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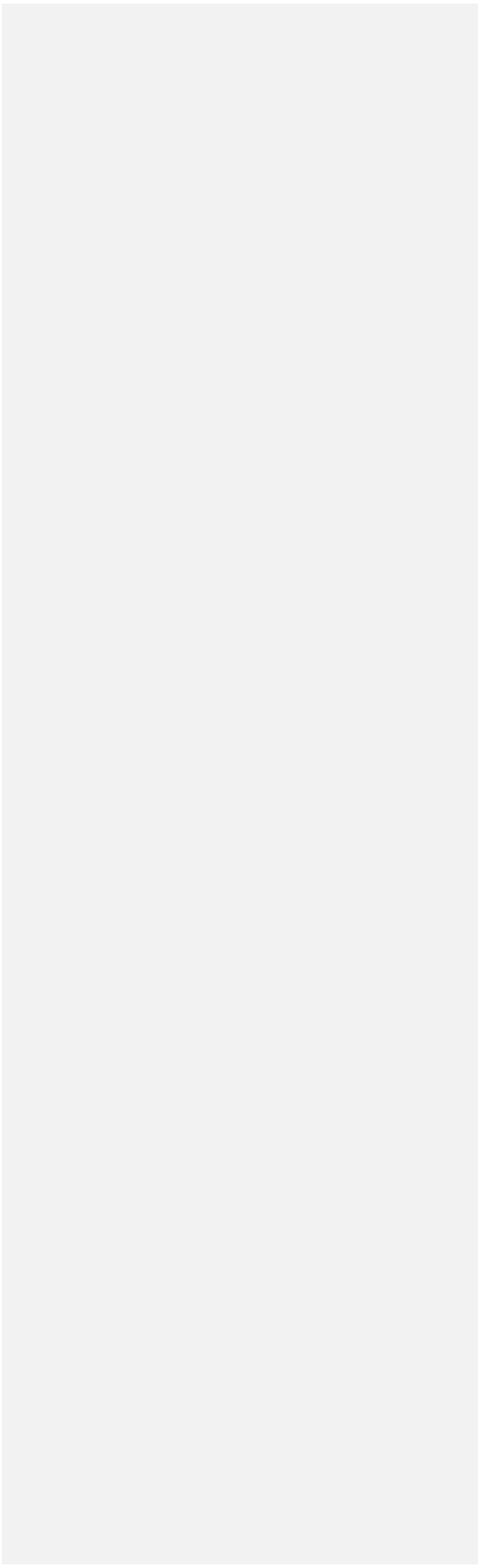
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BHSR-D-21-00992R4

Introduction and implementation of an immunization information system in Indonesia province of Daerah Istimewa Yogyakarta: lessons for scale-up  
Sulistyawati Sulistyawati; Trisno Agung Wibowo; Rokhmayanti Rokhmayanti; Andri Setyo Dwi Nugroho; Tri Wahyuni Sukei; Siti Kurnia Widi Hastuti; Surahma Asti Mulasari; Marta Feletto  
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# 1 Introduction and implementation of an immunization information 2 system in the Indonesian province of Daerah Istimewa Yogyakarta: 3 lessons for scaling-up 4

## 5 Abstract

6 **Background:** Immunization is critical to saving children from infections. To increase  
7 vaccination coverage, valid and real-time data are needed. Accordingly, it is essential to  
8 have a good report system that serves as defaulter tracking to prevent children's  
9 immunization failure. The Daerah Istimewa Yogyakarta (DIY) Health Office introduced  
10 an electronic immunization registry and successfully implemented it for more than five  
11 years. It is the only individual-based record system in Indonesia that has been sustainably  
12 operated for a long time. Yet, no systematic assessment of this system has been conducted  
13 to date. This study examines the Sistem Informasi Imunisasi Terpadu (SIMUNDU)  
14 introduction and implementation process with a view to extracting lessons that could  
15 inform scalability and sustainability across the country.

16 **Methods:** This study used an explanatory sequential mixed-method design, which  
17 collected quantitative data from 142 participants and qualitative data from nine  
18 participants. The data entry clerk at a health facility was systematically selected to  
19 participate in the survey, while in the key informant interview, the informant was selected  
20 based on the survey result. A descriptive and thematic approach was adopted to analyze  
21 the quantitative and qualitative data. Results from across the two approaches were  
22 integrated for comparison and contrast.

23 **Results:** Findings are presented according to three core themes that emerged from the  
24 data: system strengths, potential threats, weakness and opportunities for scaling-up.  
25 Strengths, i.e., factors contributing to the success of SIMUNDU, include management,

1 system performance, people’s behavior, and resources. Potential threats to sustaining the  
2 system include individual capacity, technical or system issues, and high workload.  
3 Opportunities – i.e., a promising factor that influences the SIMUNDU ability to operate  
4 sustainably – such as continuity, expectation, and the possibility of scaling up.

5 **Conclusions:** SIMUNDU is a promising innovation for Indonesia, beyond DIY. There is  
6 agreement about the potential for scaling up this IIS to other provinces. The experience  
7 of implementing this system in DIY over the past five years has shown that the benefits  
8 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
9 system.

10

11 **Keywords:** immunization, electronic immunization registry, immunization information  
12 system, interoperability, implementation research

### 13 **Background**

14 Neonatal and childhood vaccination is essential for infectious disease prevention and an  
15 absolute human right (1),(2). Vaccination has been proven to reduce the burden of  
16 infectious diseases globally (3). According to the WHO, in 2020, an estimated 23 million  
17 children under the age of one year did not receive their essential vaccinations. Of these,  
18 60% live in just ten countries, one of which is Indonesia (4). Indonesia is the fourth most  
19 populous country globally. It is composed of thousands of islands organized into 34  
20 provinces. Various geographical and cultural factors influence population inequalities in  
21 accessing health services (5). In 2001, the Indonesian government's decentralization  
22 policy was enacted. This was an excellent strategy for fostering development by engaging  
23 regional resources (6). However, this strategy was not without consequence. One primary  
24 concern was the health information system (HIS) fragmentation.

1 Indonesia's federal structure results in provinces and districts being relatively independent  
2 of the national Ministry of Health. This means that provincial- and district-level  
3 information systems are locally regulated (7). For instance, *Pemantauan Wilayah*  
4 *Setempat* (PWS) is a management tool used to monitor the coverage of specific health  
5 services within an administrative boundary. Depending on the service and region, it can  
6 be paper- or electronic-based. PWS-KIA is the monitoring system specific to maternal  
7 and child health (KIA), including immunization. PWS-KIA data are reported to the  
8 District or City Health Office, go to the Province Health Office, and are finally reported  
9 to the main level. Generally, the data are in Microsoft Excel formats; they will be reported  
10 via emails or various information systems, including Komdat Kesmas, SITT, SIHA,  
11 PISPK, and SIKDA Generik. PWS-KIA data feed into District Health Information  
12 System 2 (DHIS2). Regional information systems have varying data quality, which  
13 reflects inequities in resources across regions. This adds to data integration challenges at  
14 the national level (7),(8) and affects strategic policymaking.

15 In Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) province has the  
16 authority to regulate and use its budget within its four districts plus one city (Sleman,  
17 Gunungkidul, Bantul, Kulonprogo, and Yogyakarta). This province is classified as a  
18 small province in terms of area size and the number of regions inside (9). However, this  
19 region can be considered a representation of Indonesia when viewed from the  
20 geographical, socioeconomic, and heterogeneous population perspective. With regard to  
21 childhood vaccination, DIY is among the top ten performing provinces in the country,  
22 with 97.7% of children completing basic immunization coverage in 2019 (10).  
23 Immunization services are provided by primary health centers or Puskesmas (PHC), as

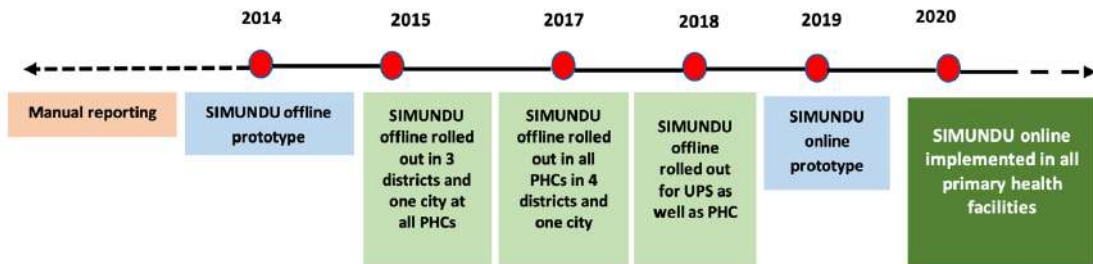
1 well as private clinics, hospitals, and midwives' practices (typically referred to as *Unit*  
2 *Pelayanan Swasta* or UPS).

3 An electronic immunization registry is a tool for recording individual children's  
4 immunization histories. In 2014, the DIY Health Office introduced an electronic  
5 immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu/*  
6 *Integrated Immunization Information System*). An electronic registry provides essential  
7 functions at all levels of the health system. At the district and higher levels, it allows for  
8 monitoring vaccination coverage by vaccine, dose, cohort, and other variables – and can  
9 support microplanning and vaccine management. The service delivery level can facilitate  
10 individual follow-up of vaccination status and enable health workers to identify children  
11 due for vaccination and those who have missed their vaccinations (defaulters).

12 SIMUNDU was designed to link with PWS-KIA for immunization and interoperability  
13 with the DHIS2. While it predominantly contains individual-level immunization records,  
14 SIMUNDU also serves as a source for aggregation and can synergize with the  
15 *Pemantauan Wilayah Setempat* (PWS) reporting system. For this reason, it can be  
16 considered an immunization information system (IIS). This means that city and district  
17 levels feed into provincial and national levels (*Personal communication with DIY*  
18 *immunization program officer*).

19 The original prototype was designed by the information and technology (IT) department  
20 of the DIY Health Office to be operated offline. In DIY, three out of the four districts and  
21 the city introduced the system in 2015. The final district introduced it in 2017. At this  
22 stage, the point of data entry was the PHC only. By 2018, UPS facilities were also  
23 equipped with SIMUNDU and could enter data into the system. In 2019, the prototype

1 was further developed to operate online. The online version was rolled out in 2020 (Figure  
 2 1). As of May 2021, 79.4% of all PHC and UPS facilities complied. This average rate  
 3 masks, however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to  
 4 enforce its use in UPC facilities (Suyani 2020, oral communication, 2020, May 11).



5  
 6 **Figure 1.** SIMUNDU’s development and introduction

7 When a child receives a vaccination in a health facility, information on the child and the  
 8 vaccination is entered in SIMUNDU as an individual child record. Each record includes  
 9 a personal identifier, the child’s sociodemographic characteristics (e.g., name, gender,  
 10 date of birth, name of parents, address), the antigen administered, and the date and place  
 11 of vaccination. SIMUNDU has been recently updated to allow the recording of  
 12 vaccinations administered in schools (e.g., human papillomavirus (HPV), diphtheria  
 13 toxoid (DT), tetanus-diphtheria (TD), and measles-rubella (MR)), albeit in the form of  
 14 aggregate data only. Furthermore, SIMUNDU has been developed to record COVID-19  
 15 vaccinations in health facilities and those carried out en masse.

16 Monitoring is conducted monthly to assess data completeness across health facilities,  
 17 while an evaluation is conducted yearly. These exercises have allowed the identification  
 18 of several challenges related to implementing the system (e.g., workload, staff turnover,  
 19 and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic  
 20 assessment of the system has been conducted to date. SIMUNDU is the first

1 immunization information system ever introduced in Indonesia. Other districts and  
2 provinces have shown interest in rolling it out, and the Ministry of Health has  
3 acknowledged the innovation. The work presented here aims to examine SIMUNDU’s  
4 introduction and implementation process with a view to extracting lessons that could  
5 inform scalability and sustainability across the country.

## 6 **Methods**

7 From May to October 2020, we examined the experience of introducing and  
8 implementing an immunization information system in DIY province using an  
9 explanatory sequential mixed-method design, where each step informed the next (11).  
10 First, we reviewed all relevant documentation available in the DIY Health Office – e.g.,  
11 staff notes, meeting notes, and monitoring notes – documenting SIMUNDU development  
12 and management processes. We also examined online documents, including health  
13 profiles and regulations on health-reporting systems in Indonesia. This served as the  
14 initial data source and provided an overview of who was involved and how in developing  
15 and implementing SIMUNDU. This informed the survey design that we conducted as a  
16 second step. The survey targeted any staff responsible for entering data in SIMUNDU  
17 (i.e., data clerks) across all PHC and selected UPS facilities and any staff responsible for  
18 managing the system at the district and city level (i.e., immunization coordinators).  
19 Sampling and recruitment strategies are outlined in Table 1.

20

21

22

23



1

**Table 1.** Survey participants

Level of the data entry and reporting system	Total number of facilities/offices	Study population	Sampling strategy	Recruitment	Sample size
Primary Health Center (PHC)	121	Data entry clerks	All facilities	Open invitation across all facilities	113
UPS – Central, General, Maternity, and Pediatric Hospitals	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	8
UPS – Clinics	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	7
UPS – Midwives' Practices	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5=10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinators	Total sampling	Open invitation	4*
<b>Total</b>					<b>142</b>

2 \*When the immunization coordinator recently changed, the former was also invited.

3

4 All immunization coordinators in each district/city and data entry clerks from all primary  
5 health facilities (PHCs) were invited to participate in this survey. For UPS facilities, we  
6 selected two clinics, two midwives' practices, and two hospitals per district/city and  
7 invited all of their staff who were involved in SIMUNDU data entry and management.

8 We developed and pretested an online survey in Bahasa Indonesia to inquire about  
9 SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, and  
10 district or city and province offices. The questionnaire consisted of closed-ended and  
11 Likert scale questions – ranging from 45 to 50 depending on the target type of facility  
12 and/or level of the health system – and enquired about respondents' sociodemographic  
13 characteristics as well as the process of implementing and managing SIMUNDU. Some

1 questions provided an additional field for clarifying the reason for a particular answer  
2 choice.

3 All participants were invited to the DIY Health Office to complete the survey on their  
4 laptops, with their prior consent. All participants in a room allowed researchers to monitor  
5 any missing or incomplete responses in real time and follow up with individual  
6 participants on-site to fill any gaps. We don't believe this may have introduced any  
7 significant bias as researchers would simply flag any missing responses and invite  
8 respondents to address those. Data were then exported and analyzed in Microsoft Excel.

9 The topic areas for the qualitative interview were informed by an exploratory analysis of  
10 the survey data.

11 Similarly, some informants were purposefully selected among survey participants to  
12 follow up on the range of perspectives that had emerged from the survey. Other  
13 informants had been identified at the desk review stage and chosen for their management  
14 functions. Selected informants were invited to the DIY Health Office for the interview,  
15 and COVID-19 prevention protocols were observed. Every informant was informed about  
16 the study and asked to sign the informed consent. All invited informants agreed to  
17 participate. A total of nine 30-minute semi-structured interviews were conducted in the  
18 Bahasa Indonesia language and recorded with prior consent from participants. The  
19 interview team consisted of three researchers with the respective tasks of running the  
20 interview, observing, and taking notes. A research assistant transcribed all interviews into  
21 Bahasa Indonesia.

22 Thematic analysis was conducted using the Quirkos qualitative tool following Braun and  
23 Clarke's approaches (12). Researchers familiarized themselves with the data, searching

1 for initial codes and allowing themes to emerge. The principal investigator led the coding  
 2 process, and led the research team too in defining and naming the core themes emerging  
 3 from the data, organizing and analyzing the data across the themes, and triangulating  
 4 information from the desk review, the survey, and the interviews. This stage was also  
 5 performed in Bahasa Indonesia. Data were translated into English only at subtheme and  
 6 core themes levels’.

## 7 **Results**

### 8 **Participant characteristics**

#### 9 a. Quantitative study

10 In total, 142 respondents participated in this study spread across five districts/cities in DIY province.  
 11 Among them, Gunungkidul has a higher proportion of respondents than the other district, with  
 12 24.8%, 24%, and 25% for PHC, UPS, and DHO, respectively. For all research units, the majority  
 13 were women. At the UPS and DHO/CHO levels, most respondents were aged 41–45 years, i.e.,  
 14 28.3% and 75%, respectively, while at the UPS level, the majority were aged 25–30 years (56.0%).  
 15 In terms of education level, PHC and UPS are dominated by Diploma 3 graduates, namely 86.7%  
 16 and 80%, respectively, while in DHO/CHO, there are predominantly undergraduate graduates  
 17 (75%) (Table 2)

18 **Table 2.** Characteristic respondents in three groups of respondents

Characteristic	PHC (n=113) n (%)	UPS (n=25) n (%)	DHO/CHO (n=4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3 (2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)

Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25–30	3 (2.7)	14 (56.0)	0 (0.0)
31–35	30 (26.5)	3 (12.0)	0 (0.0)
36–40	19 (16.8)	1 (4.0)	0 (0.0)
41–45	32 (28.3)	0 (0.0)	3 (75.0)
46–50	18 (15.9)	0 (0.0)	1 (25.0)
>50	11 (9.7)	2 (8.0)	0 (0.0)
Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

1

2 b. Qualitative study

3 Nine informants were recruited to provide the required information to explore the  
 4 quantitative study results more deeply. They serve as managers and staff at  
 5 DHO/CHO, PHC, and UPS. Among the nine informants, two were men and seven  
 6 were women. Three informants graduated with a master's, one with a bachelor's, and  
 7 there were five graduates with diplomas (Table 3).

8

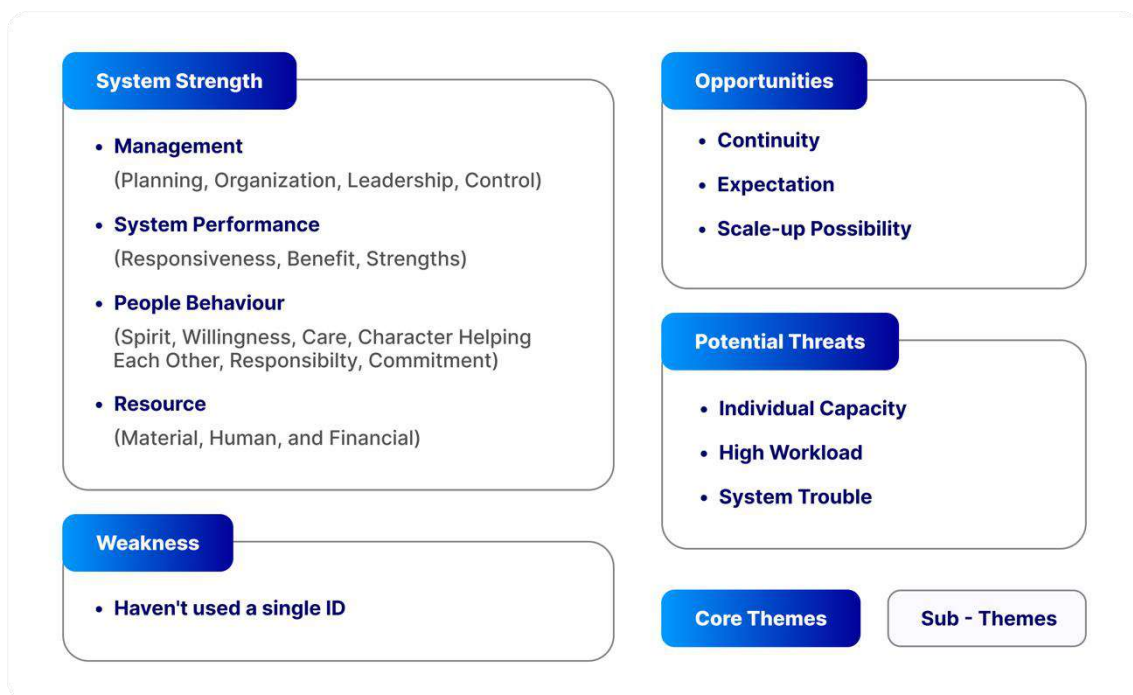
**Table 3.** Informants' characteristics for the qualitative study

Sex	Age (years)	Education	Position	Subject group	Informant's code
Female	56	Master's	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Master's	The former head of the disease prevention and control section at the PHO level	Managerial	M 02
Male	54	Bachelor's	Immunization programmer at the PHO level	Managerial	M 03
Female	47	Master's	IT person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at the UPS level	Staff	S 02
Female	31	Diploma	Data entry at the UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

9

10 c. Findings

1 Findings from the study are organized and presented across the three core themes that  
 2 emerged from the qualitative analysis, notably system strengths, potential threats, and  
 3 opportunities for scale-up. However, data from qualitative and quantitative data fed into  
 4 the analysis of these core themes to cross-validate the findings (Figure 2. Detailed  
 5 findings from the survey are presented in Table Supplement 1.



6  
 7 **Figure 2.** Strengths, potential threats, and opportunities for scale-up

## 8 *System's Strengths*

9 Factors contributing to the success of SIMUNDU include management, system  
 10 performance, people's behavior, and resources.

### 11 **Management**

12 SIMUNDU arose due to concerns from the DIY Health Office immunization section  
 13 around data quality, notably the need to address data inaccuracy, duplicate or missing

1 data and a lack of timely data, and the need for quality data to support follow-up and  
2 appropriate planning. The need for SIMUNDU arose from these challenges and needs.

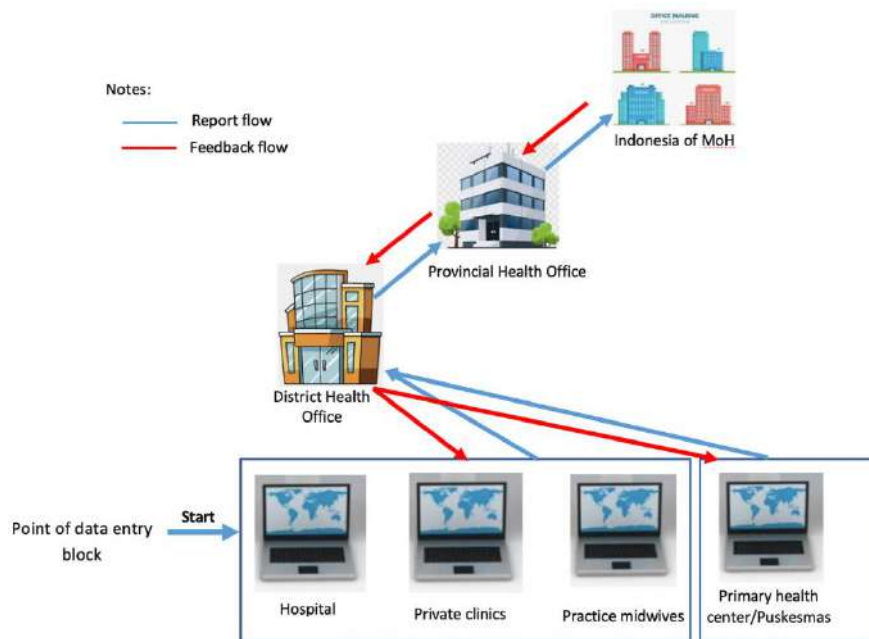
3 *“To our knowledge, [SIMUNDU development] started with a problem: estimates of the*  
4 *target population varied depending on the data source.” (M02)*

5 *“Yes, I think [SIMUNDU management team] started to tire of managing a large volume*  
6 *of data with dubious validity. They need to know the situation in each district.” (M04)*

7 Effective management of SIMUNDU from development to implementation was  
8 highlighted as an essential determinant of its success across the critical functions of  
9 planning, organization, leadership, and control.

10 Careful **planning** was ensured at each stage of the development and implementation of  
11 SIMUNDU. These stages included developing an initial business plan, providing training  
12 on and socialization to SIMUNDU, and developing a staff replacement plan to respond  
13 to turnover or retirement of staff in charge of operating the system or entering data. The  
14 parties involved in planning included the Head of the Disease Prevention and Control  
15 Department, IT personnel, and, from the DIY Health Office, immunization program staff.

16 **Organization** – the organization of SIMUNDU is carried out at several levels. The top  
17 level is the DIY Health Office, the second level is the district/city health office, and the  
18 third level is health facilities (Figure 2). A third party was also involved in developing  
19 the system interface.



**Figure 3.** Visual organizing framework of SIMUNDU – DIY province, Indonesia

At the beginning of the development of SIMUNDU, essential functions included database administrators, interface designers, and server administrators, and their interplay facilitated the system's smooth operation. Training specific to SIMUNDU was integrated with other training, typically immunization-related training. This enabled us to share resources with other programs, thus ensuring viability. The training was delivered in the district/city health office: 87.6%, 72%, and 75% of survey respondents from PHC, UPS, and DHO/CHO, respectively, participated in in-house training. Training typically consisted of short sessions and included practice on the trainee's device in operating the system in both online and offline mode. Informants indicated that day-to-day operations were carried out autonomously by the staff through flexibly adjusting their work to protect the time to enter the data. This seemed to work effectively.

**Leadership** – the success of SIMUNDU implementation is arguably related to strong leadership. Informants noted that managers played a crucial role in bridging the needs of

1 the immunization program with the system design, closely monitoring the initial  
2 implementation process, and creating an enabling environment.

3 *“I try to combine supporting and managing and monitoring the people involved.  
4 Currently, I monitor whether [SIMUNDU] can run optimally as our users are health  
5 facilities. I also monitor program development and the system's output.” (M01)*

6 *“[SIMUNDU] was born from program managers, primary health centers, districts, and  
7 DIY health offices wanting to build systems together. We – DIY Health Office – give  
8 them motivation in every meeting.” (M03)*

9 *“I see that [management] is very good at networking. Staff data entries in the field  
10 always indicated that these people are very kind.” (M02)*

11 The role of IT workers in developing SIMUNDU was also significant. They helped  
12 develop the system and facilitated correct data entry operators whenever technical issues  
13 arose. IT workers also helped resolve inconsistencies in data records. Acknowledgment  
14 of staff efforts was also important to maintain motivation and buy-in.

15 *“In the early days of SIMUNDU’s development, the system was challenging to operate,  
16 as it wasn’t as stable as it is now. I praise the enthusiasm and dedication of the users.”  
17 (M01)*

18 The **control** function – consisting of **quality** assurance management – was critical to  
19 avoid data duplication or missing entries and ultimately ensure data quality. This process  
20 was not regulated by specific standard operating procedures but was addressed during  
21 training and monitored monthly. In addition, the DIY Health Office provided negative  
22 incentives to health facilities that were not submitting complete records and provided  
23 regular feedback from monitoring and evaluation exercises.



1 Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO,  
2 respectively, reported that their work had been subject to monitoring. More than half of  
3 the respondents in PHC and UPS facilities had been observed by supervisors while  
4 performing data entry at least once over the past year. At the PHC level, 48.3% of survey  
5 respondents had been subject to monitoring from the district/city office’s team, and 45.7%  
6 received monitoring from DIY Health Office staff. Conversely, 40% of respondents from  
7 UPS facilities were monitored by PHC staff. Almost all survey respondents reported  
8 receiving feedback from the monitoring, mainly from the district/city and DIY health  
9 offices. Forty percent of respondents from UPS facilities reported receiving feedback  
10 from PHC. Immunization coordinators from the district/city health offices received  
11 feedback from the DIY health offices.

12 *“In a [evaluation] meeting, the DIY Health Office or District Health Office showed the*  
13 *progress of our data entry – correct or not, proper or not.” (M02)*

14 It is worth noting that DIY province is quite a small geographic area. Because it consists  
15 of only five districts and one city, this province is relatively easy to monitor across all  
16 phases, from planning through monitoring and evaluation.

## 17 **System performance**

18 While SIMUNDU predominantly contains individual-level immunization records, it also  
19 serves as a source for aggregation and can synergize with other information systems.  
20 Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports  
21 as per the Ministry of Health’s requirements. These reports are sent to the upper levels  
22 automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is

1 operated offline. This functionality has had an essential role in ensuring the acceptability  
2 and adoption of the system.

3 Informants noted how transitioning from paper-based tools to an electronic system made  
4 data entry easier and reduced errors. SIMUNDU also facilitated the implementation of  
5 protocols for data storage and security. It enabled follow-up and defaulter tracking.  
6 Finally, integration with the DHIS2 meant reduced workload for the staff.

7 *“We can track children who may have received vaccinations in different locations*  
8 *faster. For example, when the first dose of a vaccine is given in Bantul and the second*  
9 *one in Yogyakarta, the record can be linked within SIMUNDU.” (M01)*

10 *“SIMUNDU makes detecting what data and vaccinations are missing easier since we*  
11 *enter data from the children’s birth through the end of the immunization schedule. So,*  
12 *we will know where they miss any vaccine.” (S03)*

13 *“The benefit of using SIMUNDU is first: we know the situation of immunizations more*  
14 *accurately....so our vaccine forecasting is more accurate .... and our budget, staff,*  
15 *facilities can be more effective and efficient in providing services.” (S05)*

16 *“Colleagues from the mother and child health (KIA) program enter the data via the KIA*  
17 *"Sembada." So, these data will appear automatically in SIMUNDU because the two*  
18 *systems are connected.” (S01)*

19 SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the  
20 responsible staff to maintain data entry irrespective of connectivity; 82.3%, 96%, and  
21 100% of survey respondents from PHC, UPS, and DHO, respectively, reported operating  
22 SIMUNDU online.

## 1 **People's behavior**

2 The interview showed that staff commitment was critical for the successful  
3 implementation of SIMUNDU, as indicated by their willingness to work overtime and  
4 bring home the data to enter into the system.

5 *"I take it [the data] home too, for example, after immunization sessions – in my clinic,*  
6 *immunization runs four times per month, every week. So, when the session is finished,*  
7 *we can take the data home, [and] do the entry at home while relaxing."* (S03)

8 The interviews confirmed this dedication, which spoke to a societal culture of helping  
9 others and responsibility and commitment to the team. This contributed to shaping an  
10 environment where people approach SIMUNDU as a shared responsibility and a  
11 collective endeavor. Informants also noted the high motivation of dedicated staff.

12 *"That's all; we cannot judge by money [people's kindness, culture, and behavior];*  
13 *explaining how good people are in Yogyakarta is essential. I was in another place*  
14 *before, and could not find people's kindness like in Yogyakarta – different characters."*

15 (M02)

16 *"The second thing is that we need human resources that are concerned about, and have*  
17 *a love for, data; otherwise, even if we have a good system, it will amount to nothing*  
18 *without good human resources. But good implementation will come more easily when*  
19 *people are concerned about data."* (M04)

## 20 **Resources: material, human, and financial**

21 Infrastructure and equipment emerged as critical factors in introducing and sustaining  
22 SIMUNDU implementation. Some desktops were explicitly allocated to the

1 immunization program, and some had to be shared with other staff. Other data entry  
2 officers reported using their laptop or smartphone (36.3% of survey respondents from  
3 PHC). In UPS facilities, 40.7% reported using office desktops; in the DHO, more than  
4 half of the respondents said they used an office-supplied laptop. The majority of  
5 respondents – regardless of the type of facility – said their current device was sufficient  
6 to perform their work on SIMUNDU. In terms of connectivity, 64.6% of PHC survey  
7 respondents and 67.7% of UPS’s reported operating SIMUNDU online, relying on the  
8 office’s Internet connection.

9 Management of financial resources was also crucial. According to the key informants, no  
10 special funds were allocated to SIMUNDU in the initial stages. Resources were leveraged  
11 through sharing activities – e.g., monitoring visits or transportation – with other  
12 programs, thus allowing cost efficiencies. Integration with other programs proved critical  
13 to ensuring sustainability.

14 *“SIMUNDU's budget comes from the state budget known as Anggaran Pendapatan dan*  
15 *Belanja Negara (APBN). Every year the APBN allocates funding envelopes for*  
16 *immunization to DIY and other provinces, where the budget is apportioned across the*  
17 *program [not an explicitly written budget for SIMUNDU].” (M02)*

18 Human resources are critical to the operation of SIMUNDU. According to the interviews,  
19 SIMUNDU data entry clerks must have patience, work carefully and not rush, be  
20 interested in data, be responsible, and have basic computer skills in word processing and  
21 spreadsheet software tools such as Microsoft Word and Excel, respectively. As shown by  
22 the survey, the large majority of SIMUNDU-operating staff were educated: At least 80%  
23 of data entry clerks in both PHC and UPS facilities have secondary education (> 80%),

1 while at the managerial level (DHO), 75% of respondents have a bachelor’s degree (see  
2 Table 2). However, 19.4% and 9.1% of respondents from PHC and UPS facilities have  
3 low computer literacy.

4 Various data entry clerks looked for strategies to resolve the obstacles they encountered  
5 when entering data into SIMUNDU. Based on the interviews, some clerks furthered their  
6 computer skills by taking private computer classes. Others learned from colleagues in  
7 their offices, or reached out for help to the district person in charge. To deal with the  
8 accumulation of data needing to be entered in SIMUNDU, staff would sometimes work  
9 at home after office hours, as their busy schedule at work did not allow time for data  
10 entry.

11 *“If we found obstacles, we asked people in charge in PHC – asking for a solution or*  
12 *sharing by WhatsApp – or sometimes I asked the IT person in the DIY Health Office.”*

13 *(S03)*

#### 14 ***Potential threats***

15 As of today, SIMUNDU can be said to be a successful experience. However, some  
16 obstacles were encountered and addressed during implementation. Potential system  
17 sustaining includes individual capacity, technical or system issues, and high workload.  
18 Staff computer literacy was identified as one of the main sustainability challenges.  
19 Internet connectivity was another obstacle, as a good network did not support all health  
20 facilities. The survey shows that 64.6% and 67.7% of PHC and UPS staff, respectively,  
21 used the office Internet, while others had to rely on their home Internet.

22 Further incomplete and inconsistent records – such as a different child's date of birth or  
23 name spelling across relevant entries – make it challenging to consistently record

1 immunization information. These challenges have arisen during implementation and were  
2 promptly addressed. Yet, they had an impact on staff who were already juggling busy  
3 schedules in the office, causing delays in data entry. As shown by the survey, almost all  
4 respondents said they had other responsibilities besides operating SIMUNDU – notably  
5 97.3%, 88%, and 100% of participants from PHC, UPS and district and city offices,  
6 respectively.

### 7 **Weakness**

8 The informant said that SIMUNDU assisted in their daily work, but they also reported  
9 that sometimes they needed more time to find the children's names on the next visit. This  
10 is because SIMUNDU data entry did not use a single national ID that could be valid  
11 anywhere. As a result, when a name input error occurs, the officer will need time to check  
12 the name with the child's parents or the manual register.

13 *“Sometimes, there was an incorrect name during the data entry; for example, Dita was*  
14 *written as Dieta. So, it is difficult for us to find them. If that happens, we must look back*  
15 *at the register or medical record data.” (S04)*

16 *“I experienced difficulty entering data in SIMUNDU when a new patient came from*  
17 *another health facility to us. It was challenging to find their record on*  
18 *SIMUNDU.” (S05)*

### 19 **Opportunities**

20 Informants appreciated SIMUNDU as an excellent system to manage immunization data.  
21 SIMUNDU has become necessary for program managers and policymakers; it allows  
22 them to monitor coverage and can help inform planning and programming. Currently,  
23 SIMUNDU is stable, thus it is easier to manage than when it was in the development

1 phase. It is also viable and no longer requires heavy reliance on the core workforce that  
2 started the system. The hopes expressed by data entry clerks in the interviews are that  
3 SIMUNDU is easier to operate and system errors are less frequent. Informants also  
4 stressed the need for refresher training to ensure that knowledge and practice of the  
5 system is not lost.

6 *“In my opinion, SIMUNDU is the best program in DIY, a collaboration between*  
7 *program managers and IT. It will continue to be implemented because it is a necessity.*

8 *It has been stably used for more than five years, meaning this is needed.” (M01)*

9 *“If I have the tool, in this case SIMUNDU, when it is stable, whoever will be able to run*  
10 *it, I am sure that anyone can operate it. It means that it doesn't matter if we have people*  
11 *shifting [jobs].” (M01)*

12 *“In the future, if SIMUNDU is still used, other reports are not necessary. Now we have*  
13 *two different reports: SIMUNDU and stock card of vaccine – each stands alone and*  
14 *needs a separate report.” (S05)*

15 Based on the key informants’ interviews, SIMUNDU is likely to be developed further or  
16 expanded to other provinces. The DIY Health Office is open to supporting other provinces  
17 interested in introducing the system – for instance, through the lending staff for training  
18 and orientation. However, informants advised that a successful introduction requires a  
19 strong commitment from staff and management.

## 20 **Discussion**

21 Robust health information systems (HIS) are essential components of robust health  
22 systems (13). At the most basic level, immunization registries are systems that collect and

1 report individual-level vaccine administration record data, thus facilitating individual  
2 follow-up of vaccination status. Registries also allow for the monitoring of vaccination  
3 coverage and enable analysis of AEFIs and surveillance data to inform the design of  
4 coverage interventions and outbreak investigations. When an electronic registry has  
5 interoperability with other electronic systems – such as in the case of SIMUNDU – it is  
6 considered an immunization information system (IIS) (14). This paper presents lessons  
7 learned from DIY’s experience of implementing an IIS.

8 DIY is the only province in Indonesia – out of 34 – that uses an IIS. This work has shed  
9 light on the strengths of, and underlying barriers to, implementing an IIS in this context.  
10 The objective of this study was to draw lessons that inform sustainable scale-up in other  
11 provinces and possibly at the national level. This study highlighted individual capacity,  
12 technical or system issues, and high workload as the major barriers to sustainability.  
13 Conversely, management, system performance, people’s behavior, and available  
14 resources emerged as the main determinants of SIMUNDU’s successful implementation  
15 – notably in improving acceptability, implementation costs, and adoption of this  
16 innovation (15).

17 Despite several obstacles encountered during the implementation of SIMUNDU, this  
18 study showed that this innovation was well accepted by key stakeholders. On the one  
19 hand, data entry clerks noted that the system is relatively user-friendly and makes it  
20 possible to organize the data better and enhance its quality. On the other hand, managers  
21 noted the benefits this innovation brought about, namely in the potential for cohort data  
22 to support planning and monitoring and ultimately improve immunization coverage.



1 Effective management – across planning, organization, leadership, and control functions  
2 – is a crucial reason why SIMUNDU has been viable for over five years. Managers use  
3 their control to encourage the beliefs and actions of the staff with a dedicated and robust  
4 managerial process (16). SIMUNDU was born from the need for credible data to assist in  
5 carrying out DIY Health Office duties at the managerial and operational levels. At the  
6 managerial level, the disease prevention and control department and the IT department  
7 collaborated in designing a system that intended users readily accepted. Immunization  
8 officers and IT programmers played a central role from the early stages of development  
9 through implementation with effective coordination and communication. They were  
10 helped in this task, with the full support of their respective superiors.

11 SIMUNDU is cost-effective in several ways. During the introductory period of its  
12 implementation, immunization programmers, IT officers, and other staff assisted in  
13 introducing SIMUNDU in all districts in the province. This was done by integrating some  
14 of the activities across programs, thus building efficiency in terms of time and costs for  
15 both managers and staff. Sharing resources across programs was critical in the first years  
16 of building sustainability. Additionally, maintaining SIMUNDU does not incur high costs  
17 because the DIY Health Office has developed the system and thus possesses in-house  
18 technical skills. The IT department has the capacity to monitor and improve processes  
19 and tailor them to user needs without much additional cost.

20 A good program without good leadership could fail in its implementation, and even if it  
21 was initially successful, it might not be sustainable (17). In the context of SIMUNDU,  
22 leadership and effective management support facilitated the program's adoption. The  
23 uptake of the new system was good and all health facilities providing immunization  
24 services have successfully transitioned to SIMUNDU. The strong network of the

1 prominent persons in charge of SIMUNDU also facilitated the adoption. Good  
2 communication, care, and attention to staff concern positively affected staff performance.  
3 They felt that they were well supported and treated kindly, and this helped them carry out  
4 their work joyfully. According to several informants, the DIY immunization program  
5 manager's leadership played an essential role in this effect.

6 The monitoring and evaluation mechanisms of SIMUNDU were also important.  
7 Preferred monitoring and evaluation activities include monthly reports and staff  
8 discussions during site monitoring visits. The immunization program manager suggested  
9 this approach to maintain data quality and ensure the system's sustainability. These  
10 chosen mechanisms allow program managers to assess the actual practice in the field and  
11 the challenges faced to inform decisions about the follow-up actions to be taken. These  
12 processes supported the ongoing development of, and learning from, SIMUNDU as a tool  
13 for data collection, analysis, and visualization, as well as the benefits for managers in  
14 carrying out monitoring and evaluation. The same sentiment was reflected in previous  
15 research undertaken in India (18).

16 Human resources are a key determinant of the successful implementation of any HIS (19).  
17 People's behavior affects how the system works, develops, and survives (20),(21). In the  
18 case of SIMUNDU, implementation was facilitated by a culture of care, established  
19 networks, and a positive attitude towards data on the part of both the program manager  
20 and the IT team. From the staff's point of view, the local culture of helping each other and  
21 doing their job correctly and responsibly translated into staff carrying out their duties with  
22 enthusiasm and great commitment. Although facilities, funding, and human resources  
23 were limited, the individuals involved were highly motivated and supportive.

1 Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its  
2 sustainability in the long term. These obstacles can be divided into human variables and  
3 technical variables. In terms of human variables, unequal capacity distribution at the  
4 operational level can result in differing levels of data quality across facilities and districts.  
5 Staff workload is another challenge that needs addressing, as their willingness to work  
6 overtime is not a sustainable strategy. Technical problems were another obstacle during  
7 the introduction of SIMUNDU, but qualified technicians/developers could solve these  
8 issues. During our research, we recognized the weakness of SIMUNDU that it had not  
9 used the person number as a unique (single) code (ID) in data entry. This impacts on the  
10 challenge of finding a person when the previous entry was inaccurate. The in absence  
11 SIMUNDU single ID also affects SIMUNDU's inability to synchronize with other health  
12 programs that use a person's number as a unique code. However, this weakness can be  
13 seen as room for improvement for SIMUNDU shortly. Another thing that needs to be  
14 considered for other regions that will implement SIMUNDU that SIMUNDU is that  
15 implemented in DIY province, which consists of five districts/cities with relatively easy  
16 regional accessibility. For areas with more difficult access, the commitment of the  
17 leadership and subordinates is the key to successful implementation.

## 18 **Conclusion**

19 SIMUNDU is a promising innovation for the entire country, beyond DIY. There is  
20 agreement about the potential for scale-up of this IIS to other provinces. Experience of  
21 implementing this system in DIY over the past five years has shown that the benefits  
22 outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly  
23 system. Regular training for dedicated staff to strengthen their capacity as the system  
24 evolves and is updated, and a plan for anticipating and responding to staff turnover, have

1 proven critical strategies towards sustainability. SIMUNDU’s success also rests on  
2 remarkable leadership, both in creating and enabling a supportive environment and  
3 pursuing integration with other programs to share limited resources.

#### 4 **Recommendations**

5 This study’s recommendations address three different stakeholder groups: the DIY Health  
6 Office, the national government, and researchers. First, to ensure continuity and  
7 sustainability and reduce the system's dependency on a particular person or party,  
8 SIMUNDU management and maintenance should be managed by people who have  
9 competency and interest in a good reporting system. Furthermore, a human resources plan  
10 should be developed in preparation for SIMUNDU rollout in other provinces or at the  
11 national level; this is necessary to avoid vacancies when DIY province staff are seconded  
12 to other areas for mentoring support. Second, the fact that SIMUNDU emerged from an  
13 actual need for immunization program implementers and saw these at the front line of its  
14 development and implementation positively impacted its feasibility and viability. This  
15 suggests that the approach to scaling up SIMUNDU should be stepwise, taking into  
16 consideration each region’s specific characteristics and needs. To this effect, a readiness  
17 map and a timeline may be developed to roll out SIMUNDU in a particular region. Third,  
18 further research is needed to assess the impact of SIMUNDU on immunization coverage.  
19 Based on our conversations with stakeholders, it would be particularly relevant to focus  
20 on a low-performing region and observe the impact over a two- to three-year time  
21 window.

## 1 **Study limitations**

2 The empirical results reported herein should be considered in light of limitations. First,  
3 the results of the quantitative study must be considered in view of the limited sample size,  
4 particularly for UPS health facilities. However, given the top-down immunization  
5 program and the characteristics of UPS, which will not be significantly different from  
6 each other, the results of this study are still valid and relevant to the existing. In qualitative  
7 research that aims to explore, caution is needed in interpreting the interview results. There  
8 is still a need for in-depth studies with different approaches, such as focus group  
9 discussions, to confirm the results.

10

## 11 **Abbreviations**

12	AEFI	: Adverse Events Following Immunization
13	APBN	: Anggaran Pendapatan dan Belanja Negara (State Budget)
14	CHO	: City Health Office
15	COVID-19	: Coronavirus Disease 2019
16	DHIS2	: District Health Information System 2
17	DHO	: District Health Office
18	DIY	: Daerah Istimewa Yogyakarta (Special Region of Yogyakarta)
19	DT	: Diphtheria Toxoid
20	HIS	: Health Information System
21	HPV	: Human papillomavirus
22	ID	: Identity
23	IIS	: Immunization Information System
24	IT	: Information Technology

- 1 KIA : Kesehatan Ibu dan Anak (Maternal and Child Health)
- 2 KOMDAT KESMAS : Komunikasi Data Kesehatan Masyarakat (Public Health Data  
3 Communication)
- 4 MR : Measles-Rubella
- 5 PHC : Primary Health Centers
- 6 PHO : Provincial Health Office
- 7 PISPK : Program Indonesia Sehat dengan Pendekatan Keluarga (Healthy  
8 Indonesia Program with Family Approach)
- 9 PWS : Pemantauan Wilayah Setempat (Local Area Monitoring)
- 10 SIHA : HIV AIDS Information System
- 11 SIKDA : Regional Health Information System
- 12 SIMUNDU : Integrated Immunization Information System
- 13 SITT : Integrated Tuberculosis Information System
- 14 TD : Tetanus-Diphtheria
- 15 UPS : Unit Pelayanan Swasta (Private Service Unit)

16 **Declarations**

17 Ethics approval and consent to participate

18 This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan,  
19 Yogyakarta, Indonesia (ethical approval code: 012005021). Written informed consent  
20 was obtained from the participants before data collection started.

21 Adherence to national and international regulations

22 Not applicable

23 Consent for publication

24 Not applicable

1 Availability of data and materials

2 The data sets generated and/or analyzed for this study can be requested from the  
3 corresponding author.

4 Competing interests

5 The authors declare that they have no competing interests.

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12 Alliance donors, please visit: <https://ahpsr.who.int/about-us/funders>.

13 Authors' contributions

14 SS, TAW, RR, ASDN, and MF designed the study. SS, TWS, SKW, and SAM collected  
15 the data. SS and RR conducted data analysis. SS developed the paper with inputs and  
16 comments from MF on each draft. All authors agree with the manuscript's results and  
17 conclusions.

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1 Authors' note:

2 The authors alone are responsible for the views expressed in this article. They do not  
3 necessarily represent the views, decisions, or policies of the institutions affiliated with  
4 them.



**Accepted**

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2 messages

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Introduction and implementation of an immunization information system in the Indonesia province of Daerah Istimewa Yogyakarta: lessons for scaling-up

Sulistyawati Sulistyawati; Trisno Agung Wibowo; Rokhmayanti Rokhmayanti; Andri Setyo Dwi Nugroho; Tri Wahyuni Sukei; Siti Kurnia Widi Hastuti; Surahma Asti Mulasari; Marta Feletto

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Thank you

Best regards,

**Sulistyawati, MPH., Ph.D.**

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# Introduction and implementation of an immunization information system in the Indonesian province of Daerah Istimewa Yogyakarta: lessons for scaling-up

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## Abstract

### Background

Immunization **AQ1** is critical to saving children from infections. To increase vaccination coverage, valid and real-time data are needed. Accordingly, it is essential to have a good report system that serves as defaulter tracking to prevent children's immunization failure. The Daerah Istimewa Yogyakarta (DIY) Health Office introduced an electronic immunization registry and successfully implemented it for more than five years. It is the only individual-based record system in Indonesia that has been sustainably operated for a long time. Yet, no systematic assessment of this system has been conducted to date. This study examines the Sistem Informasi Imunisasi Terpadu (SIMUNDU) introduction and implementation process with a view to extracting lessons that could inform scalability and sustainability across the country.

### Methods

This study **AQ2** used an explanatory sequential mixed-method design, which collected quantitative data from 142 participants and qualitative data from nine participants. The data entry clerk at a health facility was systematically selected to participate in the survey, while in the key informant interview, the informant was selected based on the survey result. A descriptive and thematic approach was adopted to analyze the quantitative and qualitative data. Results from across the two approaches were integrated for comparison and contrast.

### Results

Findings are presented according to three core themes that emerged from the data: system strengths, potential threats, weakness and opportunities for scaling-up. Strengths, i.e., factors contributing to the success of SIMUNDU, include management, system performance, people's behavior, and resources. Potential threats to sustaining the system include individual capacity, technical or system issues, and high workload. Opportunities – i.e., a promising factor that influences the SIMUNDU ability to operate sustainably – such as continuity, expectation, and the possibility of scaling up.

### Conclusions

SIMUNDU is a promising innovation for Indonesia, beyond DIY. There is agreement about the potential for scaling up this IIS to other provinces. The experience of implementing this system in DIY over the past five years has shown that the benefits outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly system.

## Keywords

Immunization  
Electronic immunization registry  
Immunization information system  
Interoperability  
Implementation research

## Abbreviations

AEFI Adverse Events Following Immunization  
APBN Anggaran Pendapatan dan Belanja Negara (State Budget)  
CHO City Health Office  
COVID-19 Coronavirus Disease 2019  
DHIS2 District Health Information System 2  
DHO District Health Office  
DIY Daerah Istimewa Yogyakarta (Special Region of Yogyakarta)  
DT Diphtheria Toxoid  
HIS Health Information System  
HPV Human papillomavirus  
ID Identity  
IIS Immunization Information System  
IT Information Technology  
KIA Kesehatan Ibu dan Anak (Maternal and Child Health)  
KOMDAT KESMAS Komunikasi Data Kesehatan Masyarakat (Public Health Data Communication)  
MR Measles-Rubella  
PHC Primary Health Centers  
PHO Provincial Health Office  
PISPK Program Indonesia Sehat dengan Pendekatan Keluarga (Healthy Indonesia Program with Family Approach)  
PWS Pemantauan Wilayah Setempat (Local Area Monitoring)  
SIHA HIV AIDS Information System

SIKDA Regional Health Information System  
 SIMUNDU Integrated Immunization Information System  
 SITT Integrated Tuberculosis Information System  
 TD Tetanus-Diphtheria  
 UPS Unit Pelayanan Swasta (Private Service Unit)

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12913-022-08910-6>.

### Background

Neonatal **AQ3** and childhood vaccination is essential for infectious disease prevention and an absolute human right [1,2]. Vaccination has been proven to reduce the burden of infectious diseases globally [3]. According to the WHO, in 2020, an estimated 23 million children under the age of one year did not receive their essential vaccinations. Of these, 60% live in just ten countries, one of which is Indonesia [4]. Indonesia is the fourth most populous country globally. It is composed of thousands of islands organized into 34 provinces. Various geographical and cultural factors influence population inequalities in accessing health services [5]. In 2001, the Indonesian government's decentralization policy was enacted. This was an excellent strategy for fostering development by engaging regional resources [6]. However, this strategy was not without consequence. One primary concern was the health information system (HIS) fragmentation.

Indonesia's federal structure results in provinces and districts being relatively independent of the national Ministry of Health. This means that provincial- and district-level information systems are locally regulated [7]. For instance, *Pemantauan Wilayah Setempat* (PWS) is a management tool used to monitor the coverage of specific health services within an administrative boundary. Depending on the service and region, it can be paper- or electronic-based. PWS-KIA is the monitoring system specific to maternal and child health (KIA), including immunization. PWS-KIA data are reported to the District or City Health Office, go to the Province Health Office, and are finally reported to the main level. Generally, the data are in Microsoft Excel formats; they will be reported via emails or various information systems, including Komdat Kesmas, SITT, SIHA, PISPK, and SIKDA Generik. PWS-KIA data feed into District Health Information System 2 (DHIS2). Regional information systems have varying data quality, which reflects inequities in resources across regions. This adds to data integration challenges at the national level [7,8] and affects strategic policymaking.

In Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) province has the authority to regulate and use its budget within its four districts plus one city (Sleman, Gunungkidul, Bantul, Kulonprogo, and Yogyakarta). This province is classified as a small province in terms of area size and the number of regions inside [9]. However, this region can be considered a representation of Indonesia when viewed from the geographical, socioeconomic, and heterogeneous population perspective. With regard to childhood vaccination, DIY is among the top ten performing provinces in the country, with 97.7% of children completing basic immunization coverage in 2019 [10]. Immunization services are provided by primary health centers or Puskesmas (PHC), as well as private clinics, hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* or UPS).

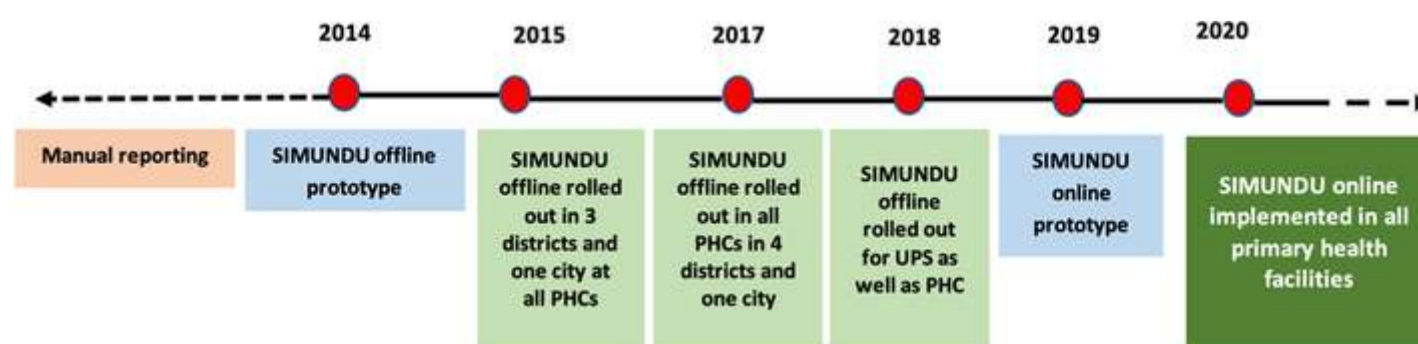
An electronic immunization registry is a tool for recording individual children's immunization histories. In 2014, the DIY Health Office introduced an electronic immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu*/ Integrated Immunization Information System). An electronic registry provides essential functions at all levels of the health system. At the district and higher levels, it allows for monitoring vaccination coverage by vaccine, dose, cohort, and other variables – and can support microplanning and vaccine management. The service delivery level can facilitate individual follow-up of vaccination status and enable health workers to identify children due for vaccination and those who have missed their vaccinations (defaulters).

SIMUNDU was designed to link with PWS-KIA for immunization and interoperability with the DHIS2. While it predominantly contains individual-level immunization records, SIMUNDU also serves as a source for aggregation and can synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this reason, it can be considered an immunization information system (IIS). This means that city and district levels feed into provincial and national levels (*Personal communication with DIY immunization program officer*).

The original prototype was designed by the information and technology (IT) department of the DIY Health Office to be operated offline. In DIY, three out of the four districts and the city introduced the system in 2015. The final district introduced it in 2017. At this stage, the point of data entry was the PHC only. By 2018, UPS facilities were also equipped with SIMUNDU and could enter data into the system. In 2019, the prototype was further developed to operate online. The online version was rolled out in 2020 (Fig. 1). As of May 2021, 79.4% of all PHC and UPS facilities complied. This average rate masks, however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce its use in UPC facilities (Suyani 2020, oral communication, **AQ4** 2020, May 11).

**Fig. 1**

SIMUNDU's development and introduction



When a child receives a vaccination in a health facility, information on the child and the vaccination is entered in SIMUNDU as an individual child record. Each record includes a personal identifier, the child's sociodemographic characteristics (e.g., name, gender, date of birth, name of parents, address), the antigen administered, and the date and place of vaccination. SIMUNDU has been recently updated to allow the recording of vaccinations administered in schools (e.g., human papillomavirus (HPV), diphtheria toxoid (DT), tetanus-diphtheria (TD), and measles-rubella (MR)), albeit in the form of aggregate data only. Furthermore, SIMUNDU has been developed to record COVID-19 vaccinations in health facilities and those carried out en masse.

Monitoring is conducted monthly to assess data completeness across health facilities, while an evaluation is conducted yearly. These exercises have allowed the identification of several challenges related to implementing the system (e.g., workload, staff turnover, and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic assessment of the system has been conducted to date. SIMUNDU is the first immunization information system ever introduced in Indonesia. Other districts and provinces have shown interest in rolling it out, and the Ministry of Health has acknowledged the innovation. The work presented here aims to examine SIMUNDU's introduction and implementation process with a view to extracting lessons that could inform scalability and sustainability across the country.

## Methods

From May to October 2020, we examined the experience of introducing and implementing an immunization information system in DIY province using an explanatory sequential mixed-method design, where each step informed the next [11]. First, we reviewed all relevant documentation available in the DIY Health Office – e.g., staff notes, meeting notes, and monitoring notes – documenting SIMUNDU development and management processes. We also examined online documents, including health profiles and regulations on health-reporting systems in Indonesia. This served as the initial data source and provided an overview of who was involved and how in developing and implementing SIMUNDU. This informed the survey design that we conducted as a second step. The survey targeted any staff responsible for entering data in SIMUNDU (i.e., data clerks) across all PHC and selected UPS facilities and any staff responsible for managing the system at the district and city level (i.e., immunization coordinators). Sampling and recruitment AQ5 strategies are outlined in Table 1.

**Table 1**

Survey participants

Level of the data entry and reporting system	Total number of facilities/ offices	Study population	Sampling strategy	Recruitment	Sample size
Primary Health Center (PHC)	121	Data entry clerks	All facilities	Open invitation across all facilities	113
UPS – Central, General, Maternity, and Pediatric Hospitals	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5 = 10)	Open invitation across selected facilities	8
UPS – Clinics	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5 = 10)	Open invitation across selected facilities	7
UPS – Midwives' Practices	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5 = 10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinators	Total sampling	Open invitation	4*
Total					142

\*When the immunization coordinator recently changed, the former was also invited

All immunization coordinators in each district/city and data entry clerks from all primary health facilities (PHCs) were invited to participate in this survey. For UPS facilities, we selected two clinics, two midwives' practices, and two hospitals per district/city and invited all of their staff who were involved in SIMUNDU data entry and management.

We developed and pretested an online survey in Bahasa Indonesia to inquire about SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, and district or city and province offices. The questionnaire consisted of closed-ended and Likert scale questions – ranging from 45 to 50 depending on the target type of facility and/or level of the health system – and enquired about respondents' sociodemographic characteristics as well as the process of implementing and managing SIMUNDU. Some questions provided an additional field for clarifying the reason for a particular answer choice.

All participants were invited to the DIY Health Office to complete the survey on their laptops, with their prior consent. All participants in a room allowed researchers to monitor any missing or incomplete responses in real time and follow up with individual participants on-site to fill any gaps. We don't believe this may have introduced any significant bias as researchers would simply flag any missing responses and invite respondents to address those. Data were then exported and analyzed in Microsoft Excel. The topic areas for the qualitative interview were informed by an exploratory analysis of the survey data.

Similarly, some informants were purposefully selected among survey participants to follow up on the range of perspectives that had emerged from the survey. Other informants had been identified at the desk review stage and chosen for their management functions. Selected informants were invited to the DIY Health Office for the interview, and COVID-19 prevention protocols were observed. Every informant was informed about the study and asked to sign the informed consent. All invited informants agreed to participate. A total of nine 30-min semi-structured interviews were conducted in the Bahasa Indonesia language and recorded with prior consent from participants. The interview team consisted of three researchers with the respective tasks of running the interview, observing, and taking notes. A research assistant transcribed all interviews into Bahasa Indonesia.



Thematic analysis was conducted using the Quirkos qualitative tool following Braun and Clarke's approaches [12]. Researchers familiarized themselves with the data, searching for initial codes and allowing themes to emerge. The principal investigator led the coding process, and led the research team too in defining and naming the core themes emerging from the data, organizing and analyzing the data across the themes, and triangulating information from the desk review, the survey, and the interviews. This stage was also performed in Bahasa Indonesia. Data were translated into English only at subtheme and core themes levels'.

## Results

### Participant characteristics

#### Quantitative study

In total, 142 respondents participated in this study spread across five districts/cities in DIY province. Among them, Gunungkidul has a higher proportion of respondents than the other district, with 24.8%, 24%, and 25% for PHC, UPS, and DHO, respectively. For all research units, the majority were women. At the UPS and DHO/CHO levels, most respondents were aged 41–45 years, i.e., 28.3% and 75%, respectively, while at the PHC level, the majority were aged 25–30 years (56.0%). In terms of education level, PHC and UPS are dominated by Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, there are predominantly undergraduate graduates (75%) (Table 2).

**Table 2**

Characteristic **respondents** participants in three groups of respondents

Characteristic	PHC ( <i>n</i> = 113) <i>n</i> (%)	UPS ( <i>n</i> = 25) <i>n</i> (%)	DHO/CHO ( <i>n</i> = 4) <i>n</i> (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3333(2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25–30	3 (2.7)	14 (56.0)	0 (0.0)
31–35	30 (26.5)	3 (12.0)	0 (0.0)
36–40	19 (16.8)	1 (4.0)	0 (0.0)
41–45	32 (28.3)	0 (0.0)	3 (75.0)
46–50	18 (15.9)	0 (0.0)	1 (25.0)
> 50	11 (9.7)	2 (8.0)	0 (0.0)
Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

#### Qualitative study

Nine informants were recruited to provide the required information to explore the quantitative study results more deeply. They serve as managers and staff at DHO/CHO, PHC, and UPS. Among the nine informants, two were men and seven were women. Three informants graduated with a master's, one with a bachelor's, and there were five graduates with diplomas (Table 3).

**Table 3**

Informants' characteristics for the qualitative study

Sex	Age (years)	Education	Position	Subject group	Informant's code
Female	56	Master's	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Master's	The former head of the disease prevention and control section at the PHO level	Managerial	M 02

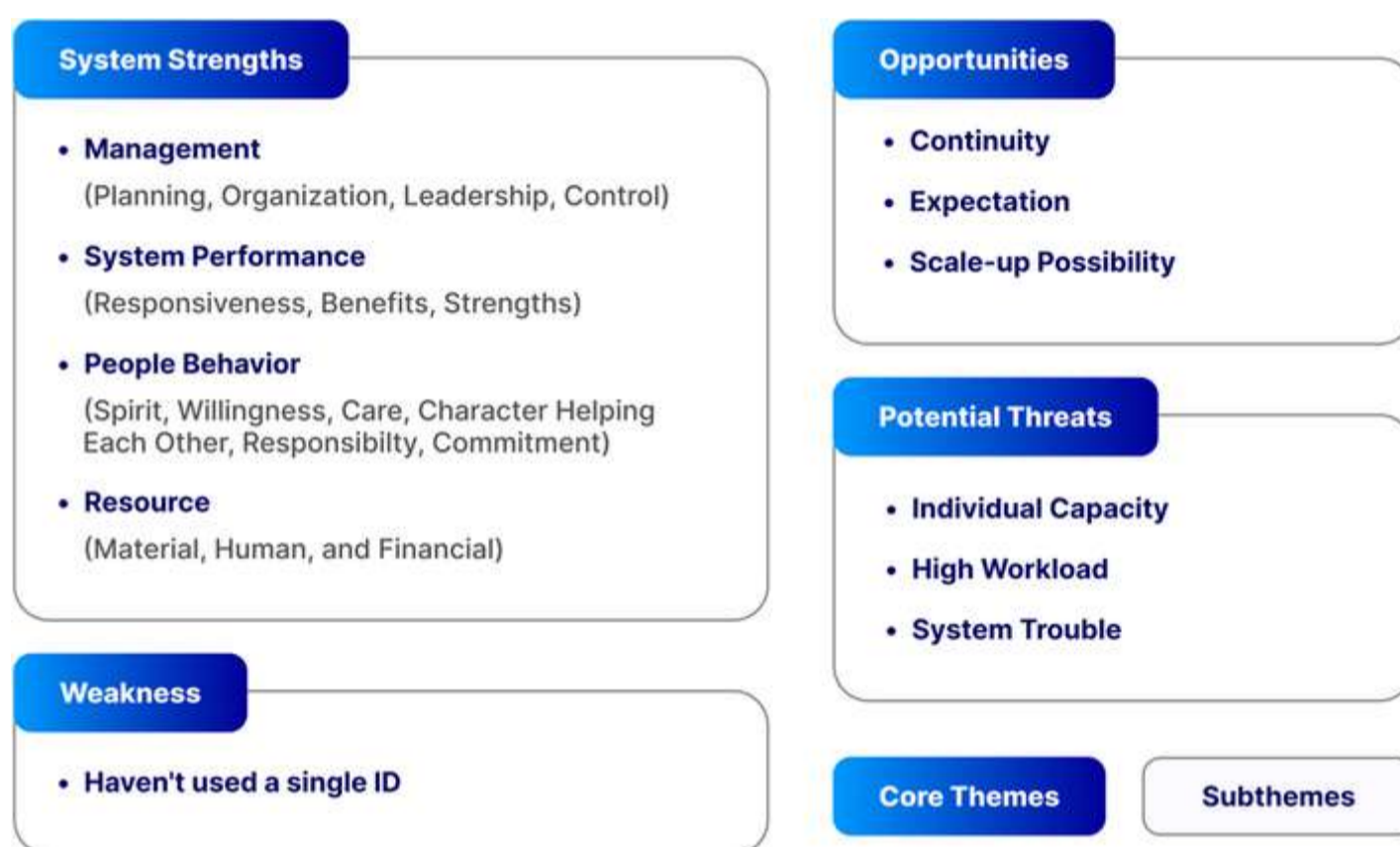
Sex	Age (years)	Education	Position	Subject group	Informant's code
Male	54	Bachelor's	Immunization programmer (coordinator) at the PHO level	Managerial	M 03
Female	47	Master's	IT person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at the UPS level	Staff	S 02
Female	31	Diploma	Data entry at the UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

## Findings

Findings from the study are organized and presented across the three core themes that emerged from the qualitative analysis, notably system strengths, potential threats, and opportunities for scale-up. However, data from qualitative and quantitative data fed into the analysis of these core themes to cross-validate the findings (Fig. 2). Detailed findings from the survey are presented in Table Supplement 1.

**Fig. 2**

Strengths, potential threats, and opportunities for scaling-up



## System's strengths

Factors contributing to the success of SIMUNDU include management, system performance, people's behavior, and resources.

## Management

SIMUNDU arose due to concerns from the DIY Health Office immunization section around data quality, notably the need to address data inaccuracy, duplicate or missing data and a lack of timely data, and the need for quality data to support follow-up and appropriate planning. The need for SIMUNDU arose from these challenges and needs.

“To our knowledge, [SIMUNDU development] started with a problem: estimates of the target population varied depending on the data source.” (M02)

“Yes, I think [SIMUNDU management team] started to tire of managing a large volume of data with dubious validity. They need to know the situation in each district.” (M04)

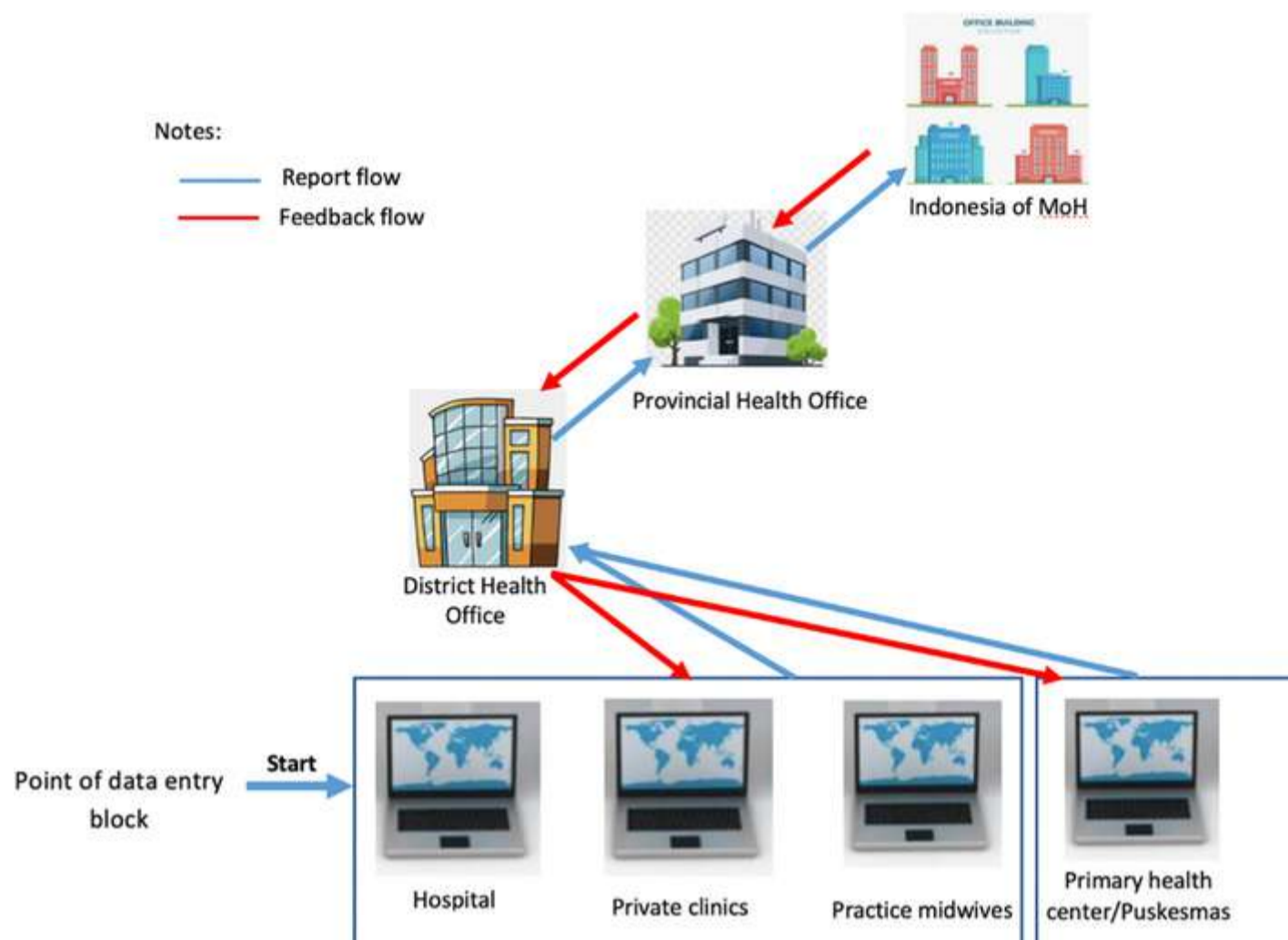
Effective management of SIMUNDU from development to implementation was highlighted as an essential determinant of its success across the critical functions of planning, organization, leadership, and control.

Careful planning was ensured at each stage of the development and implementation of SIMUNDU. These stages included developing an initial business plan, providing training on and socialization to SIMUNDU, and developing a staff replacement plan to respond to turnover or retirement of staff in charge of operating the system or entering data. The parties involved in planning included the Head of the Disease Prevention and Control Department, IT personnel, and, from the DIY Health Office, immunization program staff.

Organization – the organization of SIMUNDU is carried out at several levels. The top level is the DIY Health Office, the second level is the district/city health office, and the third level is health facilities (Fig. 3). A third party was also involved in developing the system interface.

**Fig. 3**

## Visual organizing framework of SIMUNDU – DIY province, Indonesia



At the beginning of the development of SIMUNDU, essential functions included database administrators, interface designers, and server administrators, and their interplay facilitated the system's smooth operation. Training specific to SIMUNDU was integrated with other training, typically immunization-related. This enabled us to share resources with other programs, thus ensuring viability. The training was delivered in the district/city health office: 87.6%, 72%, and 75% of survey respondents from PHC, UPS, and DHO/CHO, respectively, participated in in-house training. Training typically consisted of short sessions and included practice on the trainee's device in operating the system in both online and offline mode. Informants indicated that day-to-day operations were carried out autonomously by the staff through flexibly adjusting their work to protect the time to enter the data. This seemed to work effectively.

Leadership – the success of SIMUNDU implementation is arguably related to strong leadership. Informants noted that managers played a crucial role in bridging the needs of the immunization program with the system design, closely monitoring the initial implementation process, and creating an enabling environment.

“I try to combine supporting and managing and monitoring the people involved. Currently, I monitor whether [SIMUNDU] can run optimally as our users are health facilities. I also monitor program development and the system's output.” (M01).

“[SIMUNDU] was born from program managers, primary health centers, districts, and DIY health offices wanting to build systems together. We – DIY Health Office – give them motivation in every meeting.” (M03).

“I see that [management] is very good at networking. Staff data entries in the field always indicated that these people are very kind.” (M02)

The role of IT workers in developing SIMUNDU was also significant. They helped develop the system and facilitated correct entries by entry clerk whenever technical issues arose. IT workers also helped resolve inconsistencies in data records. Acknowledgment of staff efforts was also important to maintain motivation and buy-in.

“In the early days of SIMUNDU's development, the system was challenging to operate, as it wasn't as stable as it is now. I praise the enthusiasm and dedication of the users.” (M01)

The control function – consisting of quality assurance management – was critical to avoid data duplication or missing entries and ultimately ensure data quality. This process was not regulated by specific standard operating procedures but was addressed during training and monitored monthly. In addition, the DIY Health Office provided negative incentives to health facilities that were not submitting complete records and provided regular feedback from monitoring and evaluation exercises.

Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO, respectively, reported that their work had been subject to monitoring. More than half of the respondents in PHC and UPS facilities had been observed by supervisors while performing data entry at least once over the past year. At the PHC level, 48.3% of survey respondents had been subject to monitoring from the district/city office's team, and 45.7% received monitoring from DIY Health Office staff. Conversely, 40% of respondents from UPS facilities were monitored by PHC staff. Almost all survey respondents reported receiving feedback from the monitoring, mainly from the district/city and DIY health offices. Forty percent of respondents from UPS facilities reported receiving feedback from PHC. Immunization coordinators from the district/city health offices received feedback from the DIY health offices.

“In a [evaluation] meeting, the DIY Health Office or District Health Office showed the progress of our data entry – correct or not, proper or not.” (M02)

It is worth noting that DIY province is quite a small geographic area. Because it consists of only five districts and one city, this province is relatively easy to monitor across all phases, from planning through monitoring and evaluation.

## System performance

While SIMUNDU predominantly contains individual-level immunization records, it also serves as a source for aggregation and can synergize with other information systems. Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports as per the Ministry of Health’s requirements. These reports are sent to the upper levels automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is operated offline. This functionality has had an essential role in ensuring the acceptability and adoption of the system.

Informants noted how transitioning from paper-based tools to an electronic system made data entry easier and reduced errors. SIMUNDU also facilitated the implementation of protocols for data storage and security. It enabled follow-up and defaulter tracking. Finally, integration with the DHIS2 meant reduced workload for the staff.

“We can track children who may have received vaccinations in different locations faster. For example, when the first dose of a vaccine is given in Bantul and the second one in Yogyakarta, the record can be linked within SIMUNDU.” (M01).

“SIMUNDU makes detecting what data and vaccinations are missing easier since we enter data from the children’s birth through the end of the immunization schedule. So, we will know where they miss any vaccine.” (S03).

“The benefit of using SIMUNDU is first: we know the situation of immunizations more accurately....so our vaccine forecasting is more accurate .... and our budget, staff, facilities can be more effective and efficient in providing services.” (S05).

“Colleagues from the mother and child health (KIA) program enter the data via the KIA "Sembada." So, these data will appear automatically in SIMUNDU because the two systems are connected.” (S01).

SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the responsible staff to maintain data entry irrespective of connectivity; 82.3%, 96%, and 100% of survey respondents from PHC, UPS, and DHO, respectively, reported operating SIMUNDU online.

## People’s behavior

The interview showed that staff commitment was critical for the successful implementation of SIMUNDU, as indicated by their willingness to work overtime and bring home the data to enter into the system.

“I take it [the data] home too, for example, after immunization sessions – in my clinic, immunization runs four times per month, every week. So, when the session is finished, we can take the data home, [and] do the entry at home while relaxing.” (S03).

The interviews confirmed this dedication, which spoke to a societal culture of helping others and responsibility and commitment to the team. This contributed to shaping an environment where people approach SIMUNDU as a shared responsibility and a collective endeavor. Informants also noted the high motivation of dedicated staff.

“That's all; we cannot judge by money [people’s kindness, culture, and behavior]; explaining how good people are in Yogyakarta is essential. I was in another place before, and could not find people's kindness like in Yogyakarta – different characters.” (M02).

“The second thing is that we need human resources that are concerned about, and have a love for, data; otherwise, even if we have a good system, it will amount to nothing without good human resources. But good implementation will come more easily when people are concerned about data.” (M04).

## Resources: material, human, and financial

Infrastructure and equipment emerged as critical factors in introducing and sustaining SIMUNDU implementation. Some desktops were explicitly allocated to the immunization program, and some had to be shared with other staff. Other data entry officers reported using their laptop or smartphone (36.3% of survey respondents from PHC). In UPS facilities, 40.7% reported using office desktops; in the DHO, more than half of the respondents said they used an office-supplied laptop. The majority of respondents – regardless of the type of facility – said their current device was sufficient to perform their work on SIMUNDU. In terms of connectivity, 64.6% of PHC survey respondents and 67.7% of UPS’s reported operating SIMUNDU online, relying on the office’s Internet connection.

Management of financial resources was also crucial. According to the key informants, no special funds were allocated to SIMUNDU in the initial stages. Resources were leveraged through sharing activities – e.g., monitoring visits or transportation – with other programs, thus allowing cost efficiencies. Integration with other programs proved critical to ensuring sustainability.

“SIMUNDU's budget comes from the state budget known as Anggaran Pendapatan dan Belanja Negara (APBN). Every year the APBN allocates funding envelopes for immunization to DIY and other provinces, where the budget is

apportioned across the program [not an explicitly written budget for SIMUNDU].” (M02).

Human resources are critical to the operation of SIMUNDU. According to the interviews, SIMUNDU data entry clerks must have patience, work carefully and not rush, be interested in data, be responsible, and have basic computer skills in word processing and spreadsheet software tools such as Microsoft Word and Excel, respectively. As shown by the survey, the large majority of SIMUNDU-operating staff were educated: At least 80% of data entry clerks in both PHC and UPS facilities have secondary education (> 80%), while at the managerial level (DHO), 75% of respondents have a bachelor’s degree (see Table 2). However, 19.4% and 9.1% of respondents from PHC and UPS facilities have low computer literacy.

Various data entry clerks looked for strategies to resolve the obstacles they encountered when entering data into SIMUNDU. Based on the interviews, some clerks furthered their computer skills by taking private computer classes. Others learned from colleagues in their offices, or reached out for help to the district person in charge. To deal with the accumulation of data needing to be entered in SIMUNDU, staff would sometimes work at home after office hours, as their busy schedule at work did not allow time for data entry.

“If we found obstacles, we asked people in charge in PHC – asking for a solution or sharing by WhatsApp – or sometimes I asked the IT person in the DIY Health Office.” (S03)

## Potential threats

As of today, SIMUNDU can be said to be a successful experience. However, some obstacles were encountered and addressed during implementation. Potential system sustaining includes individual capacity, technical or system issues, and high workload. Staff computer literacy was identified as one of the main sustainability challenges. Internet connectivity was another obstacle, as a good network did not support all health facilities. The survey shows that 64.6% and 67.7% of PHC and UPS staff, respectively, used the office Internet, while others had to rely on their home Internet.

Further incomplete and inconsistent records – such as a different child’s date of birth or name spelling across relevant entries – make it challenging to consistently record immunization information. These challenges have arisen during implementation and were promptly addressed. Yet, they had an impact on staff who were already juggling busy schedules in the office, causing delays in data entry. As shown by the survey, almost all respondents said they had other responsibilities besides operating SIMUNDU – notably 97.3%, 88%, and 100% of participants from PHC, UPS and district and city offices, respectively.

## Weakness

Some informants said that SIMUNDU assisted in their daily work, but they also reported that sometimes they needed more time to find the children’s names on the next visit. This is because SIMUNDU data entry did not use a single national ID that could be valid anywhere. As a result, when a name input error occurs, the officer will need time to check the name with the child’s parents or the manual register.

“Sometimes, there was an incorrect name during the data entry; for example, Dita was written as Dieta. So, it is difficult for us to find them. If that happens, we must look back at the register or medical record data.” (S04).

“I experienced difficulty entering data in SIMUNDU when a new patient came from another health facility to us. It was challenging to find their record on SIMUNDU.” (S05).

## Opportunities

Informants appreciated SIMUNDU as an excellent system to manage immunization data. SIMUNDU has become necessary for program managers and policymakers; it allows them to monitor coverage and can help inform planning and programming. Currently, SIMUNDU is stable, thus it is easier to manage than when it was in the development phase. It is also viable and no longer requires heavy reliance on the core workforce that started the system. The hopes expressed by data entry clerks in the interviews are that SIMUNDU is easier to operate and system errors are less frequent. Informants also stressed the need for refresher training to ensure that knowledge and practice of the system is not lost.

“In my opinion, SIMUNDU is the best program in DIY, a collaboration between program managers and IT. It will continue to be implemented because it is a necessity. It has been stably used for more than five years, meaning this is needed.” (M01).

“If I have the tool, in this case SIMUNDU, when it is stable, whoever will be able to run it, I am sure that anyone can operate it. It means that it doesn’t matter if we have people shifting [jobs].” (M01).

“In the future, if SIMUNDU is still used, other reports are not necessary. Now we have two different reports: SIMUNDU and stock card of vaccine – each stands alone and needs a separate report.” (S05).

Based on the key informants’ interviews, SIMUNDU is likely to be developed further or expanded to other provinces. The DIY Health Office is open to supporting other provinces interested in introducing the system – for instance, through the lending staff for training and orientation. However, informants advised that a successful introduction requires a strong commitment from staff and management.

## Discussion

Robust health information systems (HIS) are essential components of robust health systems [13]. At the most basic level, immunization registries are systems that collect and report individual-level vaccine administration record data, thus facilitating individual follow-up of vaccination status. Registries also allow for the monitoring of vaccination coverage and enable analysis of AEFIs and surveillance data to

inform the design of coverage interventions and outbreak investigations. When an electronic registry has interoperability with other electronic systems – such as in the case of SIMUNDU – it is considered an immunization information system (IIS) [14]. This paper presents lessons learned from DIY's experience of implementing an IIS.

DIY is the only province in Indonesia – out of 34 – that uses an IIS. This work has shed light on the strengths of, and underlying barriers to, implementing an IIS in this context. The objective of this study was to draw lessons that inform sustainable scaling-up in other provinces and possibly at the national level. This study highlighted individual capacity, technical or system issues, and high workload as the major barriers to sustainability. Conversely, management, system performance, people's behavior, and available resources emerged as the main determinants of SIMUNDU's successful implementation – notably in improving acceptability, implementation costs, and adoption of this innovation [15].

Despite several obstacles encountered during the implementation of SIMUNDU, this study showed that this innovation was well accepted by key stakeholders. On the one hand, data entry clerks noted that the system is relatively user-friendly and makes it possible to organize the data better and enhance its quality. On the other hand, managers noted the benefits this innovation brought about, namely in the potential for cohort data to support planning and monitoring and ultimately improve immunization coverage.

Effective management – across planning, organization, leadership, and control functions – is a crucial reason why SIMUNDU has been viable for over five years. Managers use their control to encourage the beliefs and actions of the staff with a dedicated and robust managerial process [16]. SIMUNDU was born from the need for credible data to assist in carrying out DIY Health Office duties at the managerial and operational levels. At the managerial level, the disease prevention and control department and the IT department collaborated in designing a system that intended users readily accepted. Immunization officers and IT programmers played a central role from the early stages of development through implementation with effective coordination and communication. They were helped in this task, with the full support of their respective superiors.

SIMUNDU is cost-effective in several ways. During the introductory period of its implementation, immunization programmers, IT officers, and other staff assisted in introducing SIMUNDU in all districts in the province. This was done by integrating some of the activities across programs, thus building efficiency in terms of time and costs for both managers and staff. Sharing resources across programs was critical in the first years of building sustainability. Additionally, maintaining SIMUNDU does not incur high costs because the DIY Health Office has developed the system and thus possesses in-house technical skills. The IT department has the capacity to monitor and improve processes and tailor them to user needs without much additional cost.

A good program without good leadership could fail in its implementation, and even if it was initially successful, it might not be sustainable [17]. In the context of SIMUNDU, leadership and effective management support facilitated the program's adoption. The uptake of the new system was good and all health facilities providing immunization services have successfully transitioned to SIMUNDU. The strong network of the prominent persons in charge of SIMUNDU also facilitated the adoption. Good communication, care, and attention to staff concern positively affected staff performance. They felt that they were well supported and treated kindly, and this helped them carry out their work joyfully. According to several informants, the DIY immunization program manager's leadership played an essential role in this effect.

The monitoring and evaluation mechanisms of SIMUNDU were also important. Preferred monitoring and evaluation activities include monthly reports and staff discussions during site monitoring visits. The immunization program manager suggested this approach to maintain data quality and ensure the system's sustainability. These chosen mechanisms allow program managers to assess the actual practice in the field and the challenges faced to inform decisions about the follow-up actions to be taken. These processes supported the ongoing development of, and learning from, SIMUNDU as a tool for data collection, analysis, and visualization, as well as the benefits for managers in carrying out monitoring and evaluation. The same sentiment was reflected in previous research undertaken in India [18].

Human resources are a key determinant of the successful implementation of any HIS [19]. People's behavior affects how the system works, develops, and survives [20,21]. In the case of SIMUNDU, implementation was facilitated by a culture of care, established networks, and a positive attitude towards data on the part of both the program manager and the IT team. From the staff's point of view, the local culture of helping each other and doing their job correctly and responsibly translated into staff carrying out their duties with enthusiasm and great commitment. Although facilities, funding, and human resources were limited, the individuals involved were highly motivated and supportive.

Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its sustainability in the long term. These obstacles can be divided into human variables and technical variables. In terms of human variables, unequal capacity distribution at the operational level can result in differing levels of data quality across facilities and districts. Staff workload is another challenge that needs addressing, as their willingness to work overtime is not a sustainable strategy. Technical problems were another obstacle during the introduction of SIMUNDU, but qualified technicians/developers were able to solve these issues. During our research, we recognized the weakness of SIMUNDU that it had not used the person number as a unique (single) code (ID) in data entry. This impacts on the challenge of finding a person when the previous entry was inaccurate. The in absence SIMUNDU single ID also affects SIMUNDU's inability to synchronize with other health programs that use a person's number as a unique code. However, this weakness can be seen as room for improvement for SIMUNDU shortly. Another thing that needs to be considered for other regions that want to implement SIMUNDU, so far SIMUNDU is implemented in DIY province, which consists of five districts/cities with relatively easy regional accessibility. For areas with more difficult access, the commitment of the leadership and subordinates is the key to successful implementation.

## Conclusion

SIMUNDU is a promising innovation for the entire country, beyond DIY. There is agreement about the potential for scaling-up of this IIS to other provinces. Experience of implementing this system in DIY over the past five years has shown that the benefits outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly system. Regular training for dedicated staff to strengthen their capacity as the system evolves and is updated, and a plan for anticipating and responding to staff turnover, have proven critical strategies

towards sustainability. SIMUNDU's success also rests on remarkable leadership, both in creating and enabling a supportive environment and pursuing integration with other programs to share limited resources.

## Recommendations

This study's recommendations address three different stakeholder groups: the DIY Health Office, the national government, and researchers. First, to ensure continuity and sustainability and reduce the system's dependency on a particular person or party, SIMUNDU management and maintenance should be managed by people who have competency and interest in a good reporting system. Furthermore, a human resources plan should be developed in preparation for SIMUNDU rollout in other provinces or at the national level; this is necessary to avoid vacancies when DIY province staff are seconded to other areas for mentoring support. Second, the fact that SIMUNDU emerged from an actual need for immunization program implementers and saw these at the front line of its development and implementation positively impacted its feasibility and viability. This suggests that the approach to scaling up SIMUNDU should be stepwise, taking into consideration each region's specific characteristics and needs. To this effect, a readiness map and a timeline may be developed to roll out SIMUNDU in a particular region. Third, further research is needed to assess the impact of SIMUNDU on immunization coverage. Based on our conversations with stakeholders, it would be particularly relevant to focus on a low-performing region and observe the impact over a two- to three-year time window.

## Study limitations

The empirical results reported herein should be considered in light of limitations. First, the results of the quantitative study must be considered in view of the limited sample size, particularly for UPS health facilities. However, given the top-down immunization program and the characteristics of UPS, which will not be significantly different from each other, the results of this study are still valid and relevant to the existing condition. In qualitative research that aims to explore, caution is needed in interpreting the interview results. There is still a need for in-depth studies with different approaches, such as focus group discussions, to confirm the results.

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**Authors' note** The authors alone are **AQ6** responsible for the views expressed in this article. They do not necessarily represent the views, decisions, or policies of the institutions affiliated with them.

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### Authors' contributions

SS, TAW, RR, ASDN, and MF designed the study. SS, TWS, SKW, and SAM collected the data. SS and RR conducted data analysis. SS developed the paper with inputs and comments from MF on each draft. All authors agree with the manuscript's results and conclusions.

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### Availability of data and materials

The data sets generated and/or analyzed for this study can be requested from the corresponding author.

## Declarations

**Ethics approval and consent to participate** This study was approved by the Ethical **AQ7** Review Board of Universitas Ahmad Dahlan, Yogyakarta, Indonesia (ethical approval code: 012005021). Written informed consent was obtained from the participants before data collection started.

**Consent for publication** Not applicable.

**Competing interests** The authors declare that they have no competing interests.

## Supplementary Information

**Additional file 1.**

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RESEARCH ARTICLE

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# Introduction and implementation of an immunization information system in the Indonesian province of Daerah Istimewa Yogyakarta: lessons for scaling-up

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## Abstract

**Background** Immunization is critical to saving children from infections. To increase vaccination coverage, valid and real-time data are needed. Accordingly, it is essential to have a good report system that serves as default tracking to prevent children's immunization failure. The Daerah Istimewa Yogyakarta (DIY) Health Office introduced an electronic immunization registry and successfully implemented it for more than five years. It is the only individual-based record system in Indonesia that has been sustainably operated for a long time. Yet, no systematic assessment of this system has been conducted to date. This study examines the Sistem Informasi Imunisasi Terpadu (SIMUNDU) introduction and implementation process with a view to extracting lessons that could inform scalability and sustainability across the country.

**Methods** This study used an explanatory sequential mixed-method design, which collected quantitative data from 142 participants and qualitative data from nine participants. The data entry clerk at a health facility was systematically selected to participate in the survey, while in the key informant interview, the informant was selected based on the survey result. A descriptive and thematic approach was adopted to analyze the quantitative and qualitative data. Results from across the two approaches were integrated for comparison and contrast.

**Results** Findings are presented according to three core themes that emerged from the data: system strengths, potential threats, weakness and opportunities for scaling-up. Strengths, i.e., factors contributing to the success of SIMUNDU, include management, system performance, people's behavior, and resources. Potential threats to sustaining the system include individual capacity, technical or system issues, and high workload. Opportunities – i.e., a promising factor that influences the SIMUNDU ability to operate sustainably – such as continuity, expectation, and the possibility of scaling up.

**Conclusions** SIMUNDU is a promising innovation for Indonesia, beyond DIY. There is agreement about the potential for scaling up this IIS to other provinces. The experience of implementing this system in DIY over the past five years has shown that the benefits outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly system.

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**Keywords** Immunization, Electronic immunization registry, Immunization information system, Interoperability, Implementation research

## Background

Neonatal and childhood vaccination is essential for infectious disease prevention and an absolute human right [1, 2]. Vaccination has been proven to reduce the burden of infectious diseases globally [3]. According to the WHO, in 2020, an estimated 23 million children under the age of one year did not receive their essential vaccinations. Of these, 60% live in just ten countries, one of which is Indonesia [4]. Indonesia is the fourth most populous country globally. It is composed of thousands of islands organized into 34 provinces. Various geographical and cultural factors influence population inequalities in accessing health services [5]. In 2001, the Indonesian government's decentralization policy was enacted. This was an excellent strategy for fostering development by engaging regional resources [6]. However, this strategy was not without consequence. One primary concern was the health information system (HIS) fragmentation.

Indonesia's federal structure results in provinces and districts being relatively independent of the national Ministry of Health. This means that provincial- and district-level information systems are locally regulated [7]. For instance, *Pemantauan Wilayah Setempat* (PWS) is a management tool used to monitor the coverage of specific health services within an administrative boundary. Depending on the service and region, it can be paper- or electronic-based. PWS-KIA is the monitoring system specific to maternal and child health (KIA), including immunization. PWS-KIA data are reported to the District or City Health Office, go to the Province Health Office, and are finally reported to the main level. Generally, the data are in Microsoft Excel formats; they will be reported via emails or various information systems, including Komdat Kesmas, SITT, SIHA, PISPK, and SIKDA Generik. PWS-KIA data feed into District Health Information System 2 (DHIS2). Regional information systems have varying data quality, which reflects inequities in resources across regions. This adds to data integration challenges at the national level [7, 8] and affects strategic policymaking.

In Indonesia's federal system, Daerah Istimewa Yogyakarta (DIY) province has the authority to regulate and use its budget within its four districts plus one city (Sleman, Gunungkidul, Bantul, Kulonprogo, and Yogyakarta). This province is classified as a small province in terms of area size and the number of regions inside [9]. However, this region can be considered a representation of Indonesia when viewed from the geographical, socioeconomic,

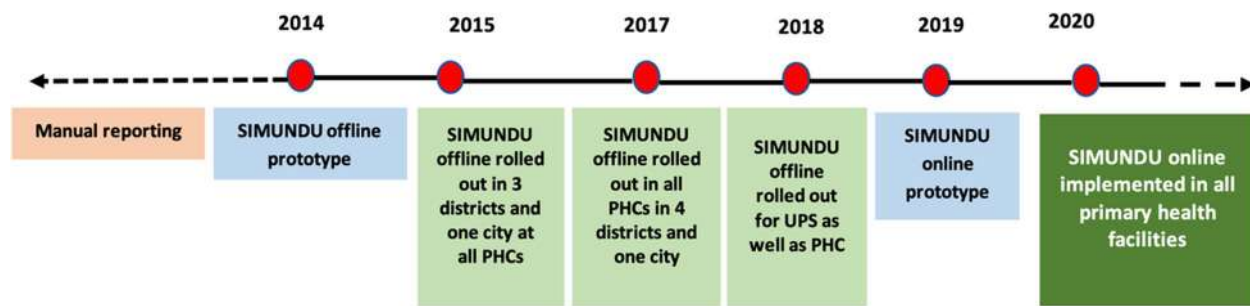
and heterogeneous population perspective. With regard to childhood vaccination, DIY is among the top ten performing provinces in the country, with 97.7% of children completing basic immunization coverage in 2019 [10]. Immunization services are provided by primary health centers or Puskesmas (PHC), as well as private clinics, hospitals, and midwives' practices (typically referred to as *Unit Pelayanan Swasta* or UPS).

An electronic immunization registry is a tool for recording individual children's immunization histories. In 2014, the DIY Health Office introduced an electronic immunization registry named SIMUNDU (*Sistem Informasi Imunisasi Terpadu*/ Integrated Immunization Information System). An electronic registry provides essential functions at all levels of the health system. At the district and higher levels, it allows for monitoring vaccination coverage by vaccine, dose, cohort, and other variables – and can support microplanning and vaccine management. The service delivery level can facilitate individual follow-up of vaccination status and enable health workers to identify children due for vaccination and those who have missed their vaccinations (defaulters).

SIMUNDU was designed to link with PWS-KIA for immunization and interoperability with the DHIS2. While it predominantly contains individual-level immunization records, SIMUNDU also serves as a source for aggregation and can synergize with the *Pemantauan Wilayah Setempat* (PWS) reporting system. For this reason, it can be considered an immunization information system (IIS). This means that city and district levels feed into provincial and national levels (*Personal communication with DIY immunization program officer*).

The original prototype was designed by the information and technology (IT) department of the DIY Health Office to be operated offline. In DIY, three out of the four districts and the city introduced the system in 2015. The final district introduced it in 2017. At this stage, the point of data entry was the PHC only. By 2018, UPS facilities were also equipped with SIMUNDU and could enter data into the system. In 2019, the prototype was further developed to operate online. The online version was rolled out in 2020 (Fig. 1). As of May 2021, 79.4% of all PHC and UPS facilities complied. This average rate masks, however, the fact that while all PHCs adopt SIMUNDU, it is more challenging to enforce its use in UPC facilities (Suyani 2020, oral communication, 2020, May 11).

When a child receives a vaccination in a health facility, information on the child and the vaccination is entered



**Fig. 1** SIMUNDU's development and introduction

in SIMUNDU as an individual child record. Each record includes a personal identifier, the child's sociodemographic characteristics (e.g., name, gender, date of birth, name of parents, address), the antigen administered, and the date and place of vaccination. SIMUNDU has been recently updated to allow the recording of vaccinations administered in schools (e.g., human papillomavirus (HPV), diphtheria toxoid (DT), tetanus-diphtheria (TD), and measles-rubella (MR)), albeit in the form of aggregate data only. Furthermore, SIMUNDU has been developed to record COVID-19 vaccinations in health facilities and those carried out en masse.

Monitoring is conducted monthly to assess data completeness across health facilities, while an evaluation is conducted yearly. These exercises have allowed the identification of several challenges related to implementing the system (e.g., workload, staff turnover, and rotation) and data quality (e.g., accuracy and timeliness). However, no systematic assessment of the system has been conducted to date. SIMUNDU is the first immunization information system ever introduced in Indonesia. Other districts and provinces have shown interest in rolling it out, and the Ministry of Health has acknowledged the innovation. The work presented here aims to examine SIMUNDU's introduction and implementation process with a view to extracting lessons that could inform scalability and sustainability across the country.

## Methods

From May to October 2020, we examined the experience of introducing and implementing an immunization information system in DIY province using an explanatory sequential mixed-method design, where each step informed the next [11]. First, we reviewed all relevant documentation available in the DIY Health Office – e.g., staff notes, meeting notes, and monitoring notes – documenting SIMUNDU development and management processes. We also examined online documents, including health profiles and regulations on

health-reporting systems in Indonesia. This served as the initial data source and provided an overview of who was involved and how in developing and implementing SIMUNDU. This informed the survey design that we conducted as a second step. The survey targeted any staff responsible for entering data in SIMUNDU (i.e., data clerks) across all PHC and selected UPS facilities and any staff responsible for managing the system at the district and city level (i.e., immunization coordinators). Sampling and recruitment strategies are outlined in Table 1.

All immunization coordinators in each district/city and data entry clerks from all primary health facilities (PHCs) were invited to participate in this survey. For UPS facilities, we selected two clinics, two midwives' practices, and two hospitals per district/city and invited all of their staff who were involved in SIMUNDU data entry and management.

We developed and pretested an online survey in Bahasa Indonesia to inquire about SIMUNDU implementation, processes, and outcomes across PHC, UPS clinics, and district or city and province offices. The questionnaire consisted of closed-ended and Likert scale questions – ranging from 45 to 50 depending on the target type of facility and/or level of the health system – and enquired about respondents' sociodemographic characteristics as well as the process of implementing and managing SIMUNDU. Some questions provided an additional field for clarifying the reason for a particular answer choice.

All participants were invited to the DIY Health Office to complete the survey on their laptops, with their prior consent. All participants in a room allowed researchers to monitor any missing or incomplete responses in real time and follow up with individual participants on-site to fill any gaps. We don't believe this may have introduced any significant bias as researchers would simply flag any missing responses and invite respondents to address those. Data were then exported and analyzed in Microsoft Excel. The topic areas for the qualitative

**Table 1** Survey participants

Level of the data entry and reporting system	Total number of facilities/ offices	Study population	Sampling strategy	Recruitment	Sample size
Primary Health Center (PHC)	121	Data entry clerks	All facilities	Open invitation across all facilities	113
UPS – Central, General, Maternity, and Pediatric Hospitals	65	Data entry clerks	Randomly selected 2 facilities per district/city (2*5 = 10)	Open invitation across selected facilities	8
UPS – Clinics	73	Data entry clerks	Randomly selected 2 facilities per district/city (2*5 = 10)	Open invitation across selected facilities	7
UPS – Midwives' Practices	271	Data entry clerks	Randomly selected 2 facilities per district/city (2*5 = 10)	Open invitation across selected facilities	10
District/City Health Office	5	Immunization coordinators	Total sampling	Open invitation	4*
Total					<b>142</b>

\* When the immunization coordinator recently changed, the former was also invited

interview were informed by an exploratory analysis of the survey data.

Similarly, some informants were purposefully selected among survey participants to follow up on the range of perspectives that had emerged from the survey. Other informants had been identified at the desk review stage and chosen for their management functions. Selected informants were invited to the DIY Health Office for the interview, and COVID-19 prevention protocols were observed. Every informant was informed about the study and asked to sign the informed consent. All invited informants agreed to participate. A total of nine 30-min semi-structured interviews were conducted in the Bahasa Indonesia language and recorded with prior consent from participants. The interview team consisted of three researchers with the respective tasks of running the interview, observing, and taking notes. A research assistant transcribed all interviews into Bahasa Indonesia.

Thematic analysis was conducted using the Quirkos qualitative tool following Braun and Clarke's approaches [12]. Researchers familiarized themselves with the data, searching for initial codes and allowing themes to emerge. The principal investigator led the coding process, and led the research team too in defining and naming the core themes emerging from the data, organizing and analyzing the data across the themes, and triangulating information from the desk review, the survey, and the interviews. This stage was also performed in Bahasa Indonesia. Data were translated into English only at subtheme and core themes levels.

## Results

### Participant characteristics

#### Quantitative study

In total, 142 respondents participated in this study spread across five districts/cities in DIY province. Among them, Gunungkidul has a higher proportion of respondents

than the other district, with 24.8%, 24%, and 25% for PHC, UPS, and DHO, respectively. For all research units, the majority were women. At the UPS and DHO/CHO levels, most respondents were aged 41–45 years, i.e., 28.3% and 75%, respectively, while at the UPS level, the majority were aged 25–30 years (56.0%). In terms of education level, PHC and UPS are dominated by Diploma 3 graduates, namely 86.7% and 80%, respectively, while in DHO/CHO, there are predominantly undergraduate graduates (75%) (Table 2).

#### Qualitative study

Nine informants were recruited to provide the required information to explore the quantitative study results more deeply. They serve as managers and staff at DHO/CHO, PHC, and UPS. Among the nine informants, two were men and seven were women. Three informants graduated with a master's, one with a bachelor's, and there were five graduates with diplomas (Table 3).

#### Findings

Findings from the study are organized and presented across the three core themes that emerged from the qualitative analysis, notably system strengths, potential threats, and opportunities for scale-up. However, data from qualitative and quantitative data fed into the analysis of these core themes to cross-validate the findings (Fig. 2). Detailed findings from the survey are presented in Table Supplement 1.

#### System's strengths

Factors contributing to the success of SIMUNDU include management, system performance, people's behavior, and resources.



**Table 2** Characteristic participants in three groups of respondents

Characteristic	PHC (n = 113) n (%)	UPS (n = 25) n (%)	DHO/CHO (n = 4) n (%)
District/City			
Bantul	23 (20.4)	5 (20.0)	1 (25.0)
Gunungkidul	28 (24.8)	6 (24.0)	1 (25.0)
Yogyakarta	17 (15.0)	4 (16.0)	0 (0.0)
Kulonprogo	21 (18.6)	4 (16.0)	1 (25.0)
Sleman	24 (21.2)	6 (24.0)	1 (25.0)
Sex			
Male	3333(2.7)	0 (0.0)	2 (50.0)
Female	110 (97.3)	25 (100)	2 (50.0)
Age			
< 25	0 (0.0)	5 (20.0)	0 (0.0)
25–30	3 (2.7)	14 (56.0)	0 (0.0)
31–35	30 (26.5)	3 (12.0)	0 (0.0)
36–40	19 (16.8)	1 (4.0)	0 (0.0)
41–45	32 (28.3)	0 (0.0)	3 (75.0)
46–50	18 (15.9)	0 (0.0)	1 (25.0)
> 50	11 (9.7)	2 (8.0)	0 (0.0)
Education			
Master	0 (0.0)	1 (4.0)	1 (25.0)
Bachelor	5 (4.4)	1 (4.0)	3 (75.0)
Diploma 4	9 (8.0)	2 (8.0)	0 (0.0)
Diploma 3	98 (86.7)	20 (80.0)	0 (0.0)
Senior high school	1 (0.9)	1 (4.0)	0 (0.0)

**Management**

SIMUNDU arose due to concerns from the DIY Health Office immunization section around data quality, notably the need to address data inaccuracy, duplicate or missing data and a lack of timely data, and the need for quality data to support follow-up and appropriate planning.

The need for SIMUNDU arose from these challenges and needs.

*“To our knowledge, [SIMUNDU development] started with a problem: estimates of the target population varied depending on the data source.” (M02)*  
*“Yes, I think [SIMUNDU management team] started to tire of managing a large volume of data with dubious validity. They need to know the situation in each district.” (M04)*

Effective management of SIMUNDU from development to implementation was highlighted as an essential determinant of its success across the critical functions of planning, organization, leadership, and control.

Careful planning was ensured at each stage of the development and implementation of SIMUNDU. These stages included developing an initial business plan, providing training on and socialization to SIMUNDU, and developing a staff replacement plan to respond to turnover or retirement of staff in charge of operating the system or entering data. The parties involved in planning included the Head of the Disease Prevention and Control Department, IT personnel, and, from the DIY Health Office, immunization program staff.

Organization – the organization of SIMUNDU is carried out at several levels. The top level is the DIY Health Office, the second level is the district/city health office, and the third level is health facilities (Fig. 3). A third party was also involved in developing the system interface.

At the beginning of the development of SIMUNDU, essential functions included database administrators, interface designers, and server administrators, and their interplay facilitated the system’s smooth operation. Training specific to SIMUNDU was integrated with other training, typically immunization-related. This enabled us to share resources with other programs, thus ensuring viability. The training was delivered in the district/city

**Table 3** Informants’ characteristics for the qualitative study

Sex	Age (years)	Education	Position	Subject group	Informant’s code
Female	56	Master’s	Head of disease prevention and control department at PHO level	Managerial	M 01
Male	57	Master’s	The former head of the disease prevention and control section at the PHO level	Managerial	M 02
Male	54	Bachelor’s	Immunization programmer (coordinator) at the PHO level	Managerial	M 03
Female	47	Master’s	IT person	Managerial	M 04
Female	34	Diploma	Data entry at the PHC level	Staff	S 01
Female	25	Diploma	Data entry at the UPS level	Staff	S 02
Female	31	Diploma	Data entry at the UPS level	Staff	S 03
Female	42	Diploma	Data entry at the PHC level	Staff	S 04
Female	24	Diploma	Data entry at the PHC level	Staff	S 05

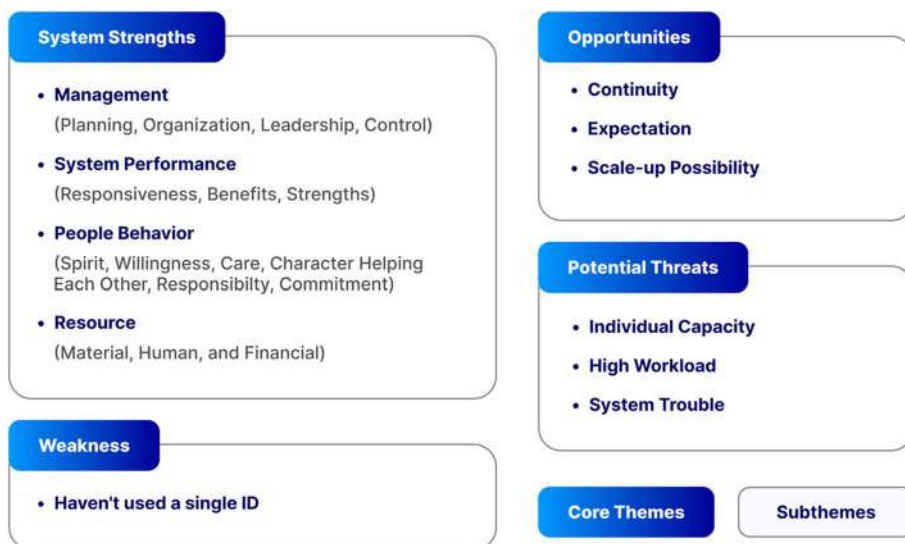


Fig. 2 Strengths, potential threats, and opportunities for scaling-up

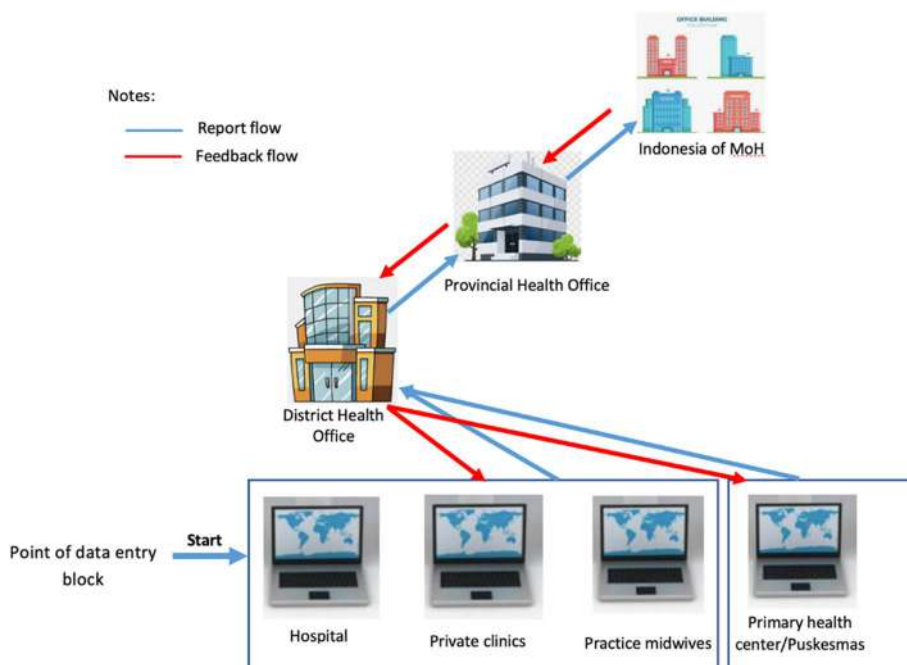


Fig. 3 Visual organizing framework of SIMUNDU – DIY province, Indonesia

health office: 87.6%, 72%, and 75% of survey respondents from PHC, UPS, and DHO/CHO, respectively, participated in in-house training. Training typically consisted of short sessions and included practice on the trainee’s device in operating the system in both online and offline mode. Informants indicated that day-to-day operations

were carried out autonomously by the staff through flexibly adjusting their work to protect the time to enter the data. This seemed to work effectively.

Leadership – the success of SIMUNDU implementation is arguably related to strong leadership. Informants noted that managers played a crucial role in bridging the needs

of the immunization program with the system design, closely monitoring the initial implementation process, and creating an enabling environment.

*"I try to combine supporting and managing and monitoring the people involved. Currently, I monitor whether [SIMUNDU] can run optimally as our users are health facilities. I also monitor program development and the system's output." (M01).*

*"[SIMUNDU] was born from program managers, primary health centers, districts, and DIY health offices wanting to build systems together. We – DIY Health Office – give them motivation in every meeting." (M03).*  
*"I see that [management] is very good at networking. Staff data entries in the field always indicated that these people are very kind." (M02)*

The role of IT workers in developing SIMUNDU was also significant. They helped develop the system and facilitated correct entries by entry clerk whenever technical issues arose. IT workers also helped resolve inconsistencies in data records. Acknowledgment of staff efforts was also important to maintain motivation and buy-in.

*"In the early days of SIMUNDU's development, the system was challenging to operate, as it wasn't as stable as it is now. I praise the enthusiasm and dedication of the users." (M01)*

The control function – consisting of quality assurance management – was critical to avoid data duplication or missing entries and ultimately ensure data quality. This process was not regulated by specific standard operating procedures but was addressed during training and monitored monthly. In addition, the DIY Health Office provided negative incentives to health facilities that were not submitting complete records and provided regular feedback from monitoring and evaluation exercises.

Specifically, 94.2%, 100%, and 100% of survey respondents in PHC, UPS, and DHO, respectively, reported that their work had been subject to monitoring. More than half of the respondents in PHC and UPS facilities had been observed by supervisors while performing data entry at least once over the past year. At the PHC level, 48.3% of survey respondents had been subject to monitoring from the district/city office's team, and 45.7% received monitoring from DIY Health Office staff. Conversely, 40% of respondents from UPS facilities were monitored by PHC staff. Almost all survey respondents reported receiving feedback from the monitoring, mainly from the district/city and DIY health offices. Forty percent of respondents from UPS facilities reported receiving feedback from PHC. Immunization coordinators from the district/city health offices received feedback from the DIY health offices.

*"In a [evaluation] meeting, the DIY Health Office or District Health Office showed the progress of our data entry – correct or not, proper or not." (M02)*

It is worth noting that DIY province is quite a small geographic area. Because it consists of only five districts and one city, this province is relatively easy to monitor across all phases, from planning through monitoring and evaluation.

### System performance

While SIMUNDU predominantly contains individual-level immunization records, it also serves as a source for aggregation and can synergize with other information systems. Notably, SIMUNDU can link to the DHIS2 and generate immunization-specific reports as per the Ministry of Health's requirements. These reports are sent to the upper levels automatically if SIMUNDU is operated online or submitted via email if SIMUNDU is operated offline. This functionality has had an essential role in ensuring the acceptability and adoption of the system.

Informants noted how transitioning from paper-based tools to an electronic system made data entry easier and reduced errors. SIMUNDU also facilitated the implementation of protocols for data storage and security. It enabled follow-up and defaulter tracking. Finally, integration with the DHIS2 meant reduced workload for the staff.

*"We can track children who may have received vaccinations in different locations faster. For example, when the first dose of a vaccine is given in Bantul and the second one in Yogyakarta, the record can be linked within SIMUNDU." (M01).*

*"SIMUNDU makes detecting what data and vaccinations are missing easier since we enter data from the children's birth through the end of the immunization schedule. So, we will know where they miss any vaccine." (S03).*

*"The benefit of using SIMUNDU is first: we know the situation of immunizations more accurately....so our vaccine forecasting is more accurate .... and our budget, staff, facilities can be more effective and efficient in providing services." (S05).*

*"Colleagues from the mother and child health (KIA) program enter the data via the KIA "Sembada." So, these data will appear automatically in SIMUNDU because the two systems are connected." (S01).*

SIMUNDU is user-friendly and can be flexibly operated offline or online, allowing the responsible staff to maintain data entry irrespective of connectivity; 82.3%, 96%, and 100% of survey respondents from PHC, UPS, and DHO, respectively, reported operating SIMUNDU online.

### People's behavior

The interview showed that staff commitment was critical for the successful implementation of SIMUNDU, as indicated by their willingness to work overtime and bring home the data to enter into the system.

*"I take it [the data] home too, for example, after immunization sessions – in my clinic, immunization runs four times per month, every week. So, when the session is finished, we can take the data home, [and] do the entry at home while relaxing." (S03).*

The interviews confirmed this dedication, which spoke to a societal culture of helping others and responsibility and commitment to the team. This contributed to shaping an environment where people approach SIMUNDU as a shared responsibility and a collective endeavor. Informants also noted the high motivation of dedicated staff.

*"That's all; we cannot judge by money [people's kindness, culture, and behavior]; explaining how good people are in Yogyakarta is essential. I was in another place before, and could not find people's kindness like in Yogyakarta – different characters." (M02).*

*"The second thing is that we need human resources that are concerned about, and have a love for, data; otherwise, even if we have a good system, it will amount to nothing without good human resources. But good implementation will come more easily when people are concerned about data." (M04).*

### Resources: material, human, and financial

Infrastructure and equipment emerged as critical factors in introducing and sustaining SIMUNDU implementation. Some desktops were explicitly allocated to the immunization program, and some had to be shared with other staff. Other data entry officers reported using their laptop or smartphone (36.3% of survey respondents from PHC). In UPS facilities, 40.7% reported using office desktops; in the DHO, more than half of the respondents said they used an office-supplied laptop. The majority of respondents – regardless of the type of facility – said their current device was sufficient to perform their work on SIMUNDU. In terms of connectivity, 64.6% of PHC survey respondents and 67.7% of UPS's reported operating SIMUNDU online, relying on the office's Internet connection.

Management of financial resources was also crucial. According to the key informants, no special funds were allocated to SIMUNDU in the initial stages. Resources

were leveraged through sharing activities – e.g., monitoring visits or transportation – with other programs, thus allowing cost efficiencies. Integration with other programs proved critical to ensuring sustainability.

*"SIMUNDU's budget comes from the state budget known as Anggaran Pendapatan dan Belanja Negara (APBN). Every year the APBN allocates funding envelopes for immunization to DIY and other provinces, where the budget is apportioned across the program [not an explicitly written budget for SIMUNDU]." (M02).*

Human resources are critical to the operation of SIMUNDU. According to the interviews, SIMUNDU data entry clerks must have patience, work carefully and not rush, be interested in data, be responsible, and have basic computer skills in word processing and spreadsheet software tools such as Microsoft Word and Excel, respectively. As shown by the survey, the large majority of SIMUNDU-operating staff were educated: At least 80% of data entry clerks in both PHC and UPS facilities have secondary education (>80%), while at the managerial level (DHO), 75% of respondents have a bachelor's degree (see Table 2). However, 19.4% and 9.1% of respondents from PHC and UPS facilities have low computer literacy.

Various data entry clerks looked for strategies to resolve the obstacles they encountered when entering data into SIMUNDU. Based on the interviews, some clerks furthered their computer skills by taking private computer classes. Others learned from colleagues in their offices, or reached out for help to the district person in charge. To deal with the accumulation of data needing to be entered in SIMUNDU, staff would sometimes work at home after office hours, as their busy schedule at work did not allow time for data entry.

*"If we found obstacles, we asked people in charge in PHC – asking for a solution or sharing by WhatsApp – or sometimes I asked the IT person in the DIY Health Office." (S03)*

### Potential threats

As of today, SIMUNDU can be said to be a successful experience. However, some obstacles were encountered and addressed during implementation. Potential system sustaining includes individual capacity, technical or system issues, and high workload. Staff computer literacy was identified as one of the main sustainability challenges. Internet connectivity was another obstacle, as a good network did not support all health facilities. The survey shows that 64.6% and 67.7% of PHC and UPS staff,

respectively, used the office Internet, while others had to rely on their home Internet.

Further incomplete and inconsistent records – such as a different child's date of birth or name spelling across relevant entries – make it challenging to consistently record immunization information. These challenges have arisen during implementation and were promptly addressed. Yet, they had an impact on staff who were already juggling busy schedules in the office, causing delays in data entry. As shown by the survey, almost all respondents said they had other responsibilities besides operating SIMUNDU – notably 97.3%, 88%, and 100% of participants from PHC, UPS and district and city offices, respectively.

### Weakness

Some informants said that SIMUNDU assisted in their daily work, but they also reported that sometimes they needed more time to find the children's names on the next visit. This is because SIMUNDU data entry did not use a single national ID that could be valid anywhere. As a result, when a name input error occurs, the officer will need time to check the name with the child's parents or the manual register.

*"Sometimes, there was an incorrect name during the data entry; for example, Dita was written as Dieta. So, it is difficult for us to find them. If that happens, we must look back at the register or medical record data." (S04).*

*"I experienced difficulty entering data in SIMUNDU when a new patient came from another health facility to us. It was challenging to find their record on SIMUNDU." (S05).*

### Opportunities

Informants appreciated SIMUNDU as an excellent system to manage immunization data. SIMUNDU has become necessary for program managers and policy-makers; it allows them to monitor coverage and can help inform planning and programming. Currently, SIMUNDU is stable, thus it is easier to manage than when it was in the development phase. It is also viable and no longer requires heavy reliance on the core workforce that started the system. The hopes expressed by data entry clerks in the interviews are that SIMUNDU is easier to operate and system errors are less frequent. Informants also stressed the need for refresher training to ensure that knowledge and practice of the system is not lost.

*"In my opinion, SIMUNDU is the best program in DIY, a collaboration between program managers*

*and IT. It will continue to be implemented because it is a necessity. It has been stably used for more than five years, meaning this is needed." (M01).*

*"If I have the tool, in this case SIMUNDU, when it is stable, whoever will be able to run it, I am sure that anyone can operate it. It means that it doesn't matter if we have people shifting [jobs]." (M01).*

*"In the future, if SIMUNDU is still used, other reports are not necessary. Now we have two different reports: SIMUNDU and stock card of vaccine – each stands alone and needs a separate report." (S05).*

Based on the key informants' interviews, SIMUNDU is likely to be developed further or expanded to other provinces. The DIY Health Office is open to supporting other provinces interested in introducing the system – for instance, through the lending staff for training and orientation. However, informants advised that a successful introduction requires a strong commitment from staff and management.

### Discussion

Robust health information systems (HIS) are essential components of robust health systems [13]. At the most basic level, immunization registries are systems that collect and report individual-level vaccine administration record data, thus facilitating individual follow-up of vaccination status. Registries also allow for the monitoring of vaccination coverage and enable analysis of AEFIs and surveillance data to inform the design of coverage interventions and outbreak investigations. When an electronic registry has interoperability with other electronic systems – such as in the case of SIMUNDU – it is considered an immunization information system (IIS) [14]. This paper presents lessons learned from DIY's experience of implementing an IIS.

DIY is the only province in Indonesia – out of 34 – that uses an IIS. This work has shed light on the strengths of, and underlying barriers to, implementing an IIS in this context. The objective of this study was to draw lessons that inform sustainable scaling-up in other provinces and possibly at the national level. This study highlighted individual capacity, technical or system issues, and high workload as the major barriers to sustainability. Conversely, management, system performance, people's behavior, and available resources emerged as the main determinants of SIMUNDU's successful implementation – notably in improving acceptability, implementation costs, and adoption of this innovation [15].

Despite several obstacles encountered during the implementation of SIMUNDU, this study showed that this innovation was well accepted by key stakeholders. On the one hand, data entry clerks noted that the

system is relatively user-friendly and makes it possible to organize the data better and enhance its quality. On the other hand, managers noted the benefits this innovation brought about, namely in the potential for cohort data to support planning and monitoring and ultimately improve immunization coverage.

Effective management – across planning, organization, leadership, and control functions – is a crucial reason why SIMUNDU has been viable for over five years. Managers use their control to encourage the beliefs and actions of the staff with a dedicated and robust managerial process [16]. SIMUNDU was born from the need for credible data to assist in carrying out DIY Health Office duties at the managerial and operational levels. At the managerial level, the disease prevention and control department and the IT department collaborated in designing a system that intended users readily accepted. Immunization officers and IT programmers played a central role from the early stages of development through implementation with effective coordination and communication. They were helped in this task, with the full support of their respective superiors.

SIMUNDU is cost-effective in several ways. During the introductory period of its implementation, immunization programmers, IT officers, and other staff assisted in introducing SIMUNDU in all districts in the province. This was done by integrating some of the activities across programs, thus building efficiency in terms of time and costs for both managers and staff. Sharing resources across programs was critical in the first years of building sustainability. Additionally, maintaining SIMUNDU does not incur high costs because the DIY Health Office has developed the system and thus possesses in-house technical skills. The IT department has the capacity to monitor and improve processes and tailor them to user needs without much additional cost.

A good program without good leadership could fail in its implementation, and even if it was initially successful, it might not be sustainable [17]. In the context of SIMUNDU, leadership and effective management support facilitated the program's adoption. The uptake of the new system was good and all health facilities providing immunization services have successfully transitioned to SIMUNDU. The strong network of the prominent persons in charge of SIMUNDU also facilitated the adoption. Good communication, care, and attention to staff concern positively affected staff performance. They felt that they were well supported and treated kindly, and this helped them carry out their work joyfully. According to several informants, the DIY immunization program manager's leadership played an essential role in this effect.

The monitoring and evaluation mechanisms of SIMUNDU were also important. Preferred monitoring

and evaluation activities include monthly reports and staff discussions during site monitoring visits. The immunization program manager suggested this approach to maintain data quality and ensure the system's sustainability. These chosen mechanisms allow program managers to assess the actual practice in the field and the challenges faced to inform decisions about the follow-up actions to be taken. These processes supported the ongoing development of, and learning from, SIMUNDU as a tool for data collection, analysis, and visualization, as well as the benefits for managers in carrying out monitoring and evaluation. The same sentiment was reflected in previous research undertaken in India [18].

Human resources are a key determinant of the successful implementation of any HIS [19]. People's behavior affects how the system works, develops, and survives [20, 21]. In the case of SIMUNDU, implementation was facilitated by a culture of care, established networks, and a positive attitude towards data on the part of both the program manager and the IT team. From the staff's point of view, the local culture of helping each other and doing their job correctly and responsibly translated into staff carrying out their duties with enthusiasm and great commitment. Although facilities, funding, and human resources were limited, the individuals involved were highly motivated and supportive.

Despite the many strengths of SIMUNDU, some obstacles may potentially challenge its sustainability in the long term. These obstacles can be divided into human variables and technical variables. In terms of human variables, unequal capacity distribution at the operational level can result in differing levels of data quality across facilities and districts. Staff workload is another challenge that needs addressing, as their willingness to work overtime is not a sustainable strategy. Technical problems were another obstacle during the introduction of SIMUNDU, but qualified technicians/developers were able to solve these issues. During our research, we recognized the weakness of SIMUNDU that it had not used the person number as a unique (single) code (ID) in data entry. This impacts on the challenge of finding a person when the previous entry was inaccurate. The in absence SIMUNDU single ID also affects SIMUNDU's inability to synchronize with other health programs that use a person's number as a unique code. However, this weakness can be seen as room for improvement for SIMUNDU shortly. Another thing that needs to be considered for other regions that want to implement SIMUNDU, so far SIMUNDU is implemented in DIY province, which consists of five districts/cities with relatively easy regional accessibility. For areas with more difficult access, the commitment of the leadership and subordinates is the key to successful implementation.

## Conclusion

SIMUNDU is a promising innovation for the entire country, beyond DIY. There is agreement about the potential for scaling-up of this IIS to other provinces. Experience of implementing this system in DIY over the past five years has shown that the benefits outweigh the challenges, and SIMUNDU has grown into a robust yet user-friendly system. Regular training for dedicated staff to strengthen their capacity as the system evolves and is updated, and a plan for anticipating and responding to staff turnover, have proven critical strategies towards sustainability. SIMUNDU's success also rests on remarkable leadership, both in creating and enabling a supportive environment and pursuing integration with other programs to share limited resources.

## Recommendations

This study's recommendations address three different stakeholder groups: the DIY Health Office, the national government, and researchers. First, to ensure continuity and sustainability and reduce the system's dependency on a particular person or party, SIMUNDU management and maintenance should be managed by people who have competency and interest in a good reporting system. Furthermore, a human resources plan should be developed in preparation for SIMUNDU rollout in other provinces or at the national level; this is necessary to avoid vacancies when DIY province staff are seconded to other areas for mentoring support. Second, the fact that SIMUNDU emerged from an actual need for immunization program implementers and saw these at the front line of its development and implementation positively impacted its feasibility and viability. This suggests that the approach to scaling up SIMUNDU should be stepwise, taking into consideration each region's specific characteristics and needs. To this effect, a readiness map and a timeline may be developed to roll out SIMUNDU in a particular region. Third, further research is needed to assess the impact of SIMUNDU on immunization coverage. Based on our conversations with stakeholders, it would be particularly relevant to focus on a low-performing region and observe the impact over a two- to three-year time window.

## Study limitations

The empirical results reported herein should be considered in light of limitations. First, the results of the quantitative study must be considered in view of the limited sample size, particularly for UPS health facilities. However, given the top-down immunization program and the characteristics of UPS, which will not be significantly

different from each other, the results of this study are still valid and relevant to the existing condition. In qualitative research that aims to explore, caution is needed in interpreting the interview results. There is still a need for in-depth studies with different approaches, such as focus group discussions, to confirm the results.

## Abbreviations

AEFI	Adverse Events Following Immunization
APBN	Anggaran Pendapatan dan Belanja Negara (State Budget)
CHO	City Health Office
COVID-19	Coronavirus Disease 2019
DHIS2	District Health Information System 2
DHO	District Health Office
DIY	Daerah Istimewa Yogyakarta (Special Region of Yogyakarta)
DT	Diphtheria Toxoid
HIS	Health Information System
HPV	Human papillomavirus
ID	Identity
IIS	Immunization Information System
IT	Information Technology
KIA	Kesehatan Ibu dan Anak (Maternal and Child Health)
KOMDAT KESMAS	Komunikasi Data Kesehatan Masyarakat (Public Health Data Communication)
MR	Measles-Rubella
PHC	Primary Health Centers
PHO	Provincial Health Office
PISPK	Program Indonesia Sehat dengan Pendekatan Keluarga (Healthy Indonesia Program with Family Approach)
PWS	Pemantauan Wilayah Setempat (Local Area Monitoring)
SIHA	HIV AIDS Information System
SIKDA	Regional Health Information System
SIMUNDU	Integrated Immunization Information System
SITT	Integrated Tuberculosis Information System
TD	Tetanus-Diphtheria
UPS	Unit Pelayanan Swasta (Private Service Unit)

## Supplementary Information

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Additional file 1.

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## Authors' note

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Not applicable.

## Authors' contributions

SS, TAW, RR, ASDN, and MF designed the study. SS, TWS, SKW, and SAM collected the data. SS and RR conducted data analysis. SS developed the paper with inputs and comments from MF on each draft. All authors agree with the manuscript's results and conclusions.

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### Availability of data and materials

The data sets generated and/or analyzed for this study can be requested from the corresponding author.

### Declarations

#### Ethics approval and consent to participate

This study was approved by the Ethical Review Board of Universitas Ahmad Dahlan, Yogyakarta, Indonesia (ethical approval code: 012005021). Written informed consent was obtained from the participants before data collection started.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

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