Measles Cluster Detection Using Ordinal Scan Statistic Model

By SULISTYAWATI

WORD COUNT 3601

TIME SUBMITTED 05-DEC-2020 12:02AM

PAPER ID 66469473

DOI: 10.5455/msm.2018.30.282-286
Received: November 03 2018; Accepted: December 21, 2018

© 2018 Sulistyawati Sulistyawati, Siti Sumiana

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ORIGINAL PAPER Mater Sociomed. 2018 Dec; 30(4): 282-286

Measles Cluster Detection Using Ordinal Scan Statistic Model

Sulistyawati Sulistyawati[1], Siti Sumiana[1]

[1]Department of Public Health, Universitas Ahmad Dahlan, Janturan, Umbulharjo, Yogyakarta, Indonesia

Corresponding author: Sulistyawati Sulistyawati, B.Sc., M.P.H. Faculty of Public Health, Ahmad Dahlan University. UAD 3rd Campus, Janturan, Umbulharjo, Yogyakarta 55166, Indonesia, Email: sulistyawatisuyanto@gmail.com, ORCHID ID: https://orcid.org/0000-0002-7299-0360. Phone: +628170402693.

ABSTRACT

Introduction: Measles a very contagious disease which responsible for the thousand's mortality in the world, including Indonesia. Even though vaccination has been claimed victorious to reduce the transmission, but it does not mean that the world is free from Measles. GIS is offering a powerful method to support the decision maker in generating the Measles program. **Aim:** This research aimed to investigate Measles clustering in Bantul, Yogyakarta, Indonesia by considering population density and income level. This study was essential to support decision maker to develop a proper intervention for preventing Measles. **Material and methods:** Quantitative approach was used in this study. Secondary data that consisted of measles cases, population density and income level were collected from the district health office and related government office in Bantul District. Ordinal Scan Statistic Model by using SaTScan v9.6 was applied to detect the cluster and to test the association between the cases and the variables. **Results:** This research revealed that population density and income level are the two predictors of Measles hotspot cluster. People who live in the very high-income level district will have 4.8 higher possibility to be exposed with Measles. People who live in the district with medium and high population density predicted to have 4.5 fewer risks to be infected with Measles. **Conclusion:** There is a correlation between income level and Measles cases. Geographic Information System (GIS) can contribute to a decision support system for disease prevention such as on Measles.

Keywords: measles, cluster analysis, spatial analysis.

1. INTRODUCTION

Measles is caused by a virus, it draws attention to public health due to the extraordinarily contagious disease. Measles is responsible for 89.780 people died across the world in 2016, most of which are children under five year (1). While in Indonesia, in the same year, was reported 6.890 Measles cases which 5 died due to the Measles (2). Before that period, Indonesia government stated has been successful to reduce the number of Measles cases about 76,6% from 55.348 in 2006 to 12.943 in 2014 (3). However, in 2016, remain reported 115 outbreaks in several areas in Indonesia (2) including in Yogyakarta province in 2014-2015 (3).

Measles is easy transmits to not immune people. Accordingly, vaccination is the best strategy to protect people from the Measles transmission. World Health Organization (WHO) stated in their report that Measles vaccination has a significant impact on the Measles incidence and mortality globally (4). Nonetheless, it does not mean that every region is safe from Measles. In the USA who declared Measles was eliminated in 2.000, but after 14 years, Measles was returned with 514 reported cases even though the vaccination program had been run (5). Therefore, research to support the routine programme that is vaccination is needed to help the policy maker in make priorities program. Thus as the proposed by research in Australia who said improving the immunization access and management are essential in measles program (6).

This research was conducted under the framework that GIS can play a role on decision support system in disease prevention. As stated by a review that GIS is a potential tool on medical or public health which is work effectively together other disciplines (7). The leading GIS research was done by John Snow when he mapped the cholera disease in London(8). By this research, a map is well known as disease surveillance tool. And nowadays, coincides with the development of science and technology, the map is produced through vary Geographic Information System (GIS) software. SaTScan as one of GIS software is commonly used to seek the disease pattern and to look for the association within the environmental variable. For this research, SaTScan was employed to detect cluster among Measles cases to see the association between population density and income level. We used ordinal model due to the data characteristic and preventing the data dichotomization (9)such methods for studies involving current status data are scarce. Here, we propose a method for calculating power and sample size for studies using current status data. This method is based on a Weibull survival model for a two-group comparison. The Weibull model allows the investigator to specify a group difference in terms of a hazards ratio or a failure time ratio. We consider exponential, Weibull and uniformly distributed censoring distributions. We base our power calculations on a parametric approach with the Wald test because it is easy for medical investigators to conceptualize and specify the required input variables. As expected, studies with current status data have substantially less power than studies with the usual right-censored failure time data. Our simulation results demonstrate the merits of these proposed power calculations.(9). This research is vital by arguing the direction for priorities of a particular area in Measles prevention.

Some previous research has proofed the uses of GIS study in disease prevention. For instance, an investigation in Indonesia that found exciting finding by elaborated Malaria incidence and lithology, landform, complex slopes and land cover maps (10). Correspondingly, a study on Leptospirosis which successfully identified Spatio-temporal cluster in Bantul, Indonesia (11). While in Measles, some studies have researched some topics, such as GIS application for real-time mapping and cluster detection (12)there was a large measles outbreak in Dublin. Nationally 285 cases were notified to the end of December 2011, and 250 (88% and the using of GIS to understand the local pattern associated with some variables to support the vaccination program (13).

2. AIMS

This paper describes the using of SaTScan as one of GIS tool to detect Measles cluster in Bantul, Yogyakarta, Indonesia during 2015 by considering the population density and income level, which will provide essential evidence to policy maker as consideration on the vaccination policy.

3. MATERIAL AND METHODS

Study Design and Participant

This study was performed by using spatial analysis in 49 participants who have been diagnosed as positive Measles during 2015. Individual positive Measles cases, population density and the level of income per district were collected from Bantul Health Office, Yogyakarta Indonesia and related Bantul agency.

Ethical consideration

This research was approved by the Department of Public Health, Universitas Ahmad Dahlan. A research permit was requested from Bantul District Health Office.

Variables

This present research involving three variables, i.e. the individual positive Measles case, population density and the level of income per district. First, Geographical position (latitude, longitude) for each Measles case, it was recorded by using Geographical Positioning System (GPS). Second variable was population density which was classified as low (500-1.249 people/km^2), medium (1.250-2.449 people /km^2), high (2.500-3.999 people /km^2) and very high (4.000-5.999 people /km^2).The classification is referring to the Indonesia Statistical Bureau by adjusting to this research context (14). The last variable was level of income which was classified using the quartile as follows: low income (IDR <3.807.446/ month), medium (IDR 3.807.446-4.234.339/month), high (IDR 4.231.339-5163743/month), very high (IDR >5.163.743/ month).

Data analysis

Ordinal Scan Statistic Model by using SaTScan v9.6 was applied to determine: 1) association between the level of population density and the Measles cases distribution in 2015 and 2) association between the level of income is associated and the Measles cases distribution in 2015. Cluster significance was considered at< 0.05 of p-value. Map was generated from Arc-GIS.

4. RESULTS

There were 49 cases of Measles which spread across the Bantul district in 2015. Among the cases, more than 36% and 30% of Measles cases found in the very high and medium population density area respectively. Meanwhile, almost 45% of Measles cases discovered in a very high-income level and only 6% of which located in low-income level (Table 1).

Variable	Case	
	N	%
Population density /sub district/km^2		
Low	10	20.41
Medium	15	30.61
High	6	12.24
Very High	18	36.73
Total	49	100.00
Level of income/sub district/month		
Low	3	6.12
Medium	13	26.53
High	10	20.41
Very High	23	46.94
Total	49	100.00

Table 1. Description of Measles case in Bantul, Yogyakarta, Indonesia by 2015

Table 2 shows the cluster detected from two different variables. First, there was one significance cluster with the p-value of less than 0.05 for Measles incidence vs. population density. SaTScan regrouped the classification into three categories by merging the category 2 and 3 (district with medium and high population density respectively). According to the analysis, people who live in the area with medium and high population density predicted to have 4.5 fewer risks to be infected with Measles. While for very high population density the risk could not be identified. Cluster location is present in Figure 1.

Second significance cluster is showing the association

Analysis				Cluster			
Variable	Loc*	Cases	Exp*	Category	RR*	LLR*	P*
Measles vs Population Density	3	21	4.29, 9.00, 7.71	[1], [2, 3], [4]	0 0.22 infinity	24.850054	0.000
Measles vs Income Level	3	21	6.86, 4.29, 9.86	[1, 2],[3], [4]	0 0.57 4.80	15.311368	0.000

Table 2. List of Measles Cluster using Ordinal Model in Bantul, 2015. Loc: the total of location included. Exp: expected cases. RR: relative risk. LLR: log likelihood ratio. P: p-value.

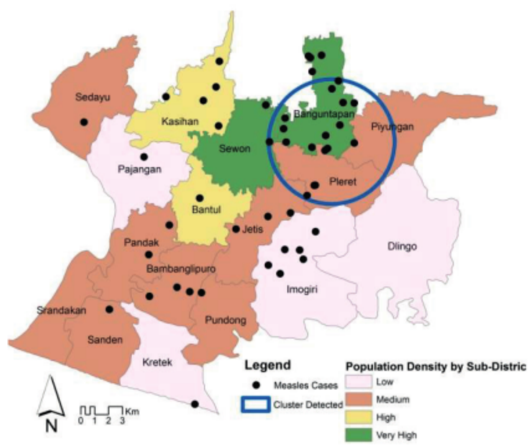


Figure 1. Measles cluster vs population density in Bantul, 2015.

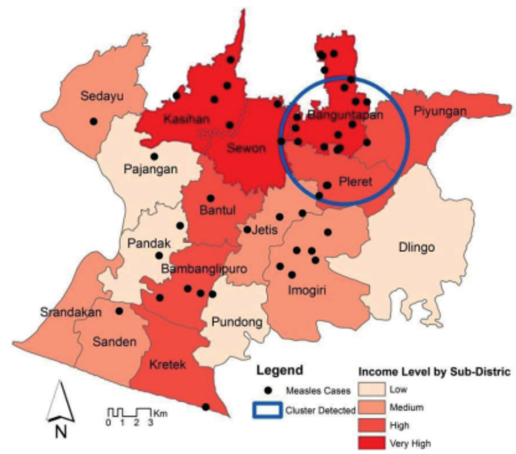


Figure 2. Measles cluster vs income level in Bantul, 2015

between the level of income and Measles incidence. Refers to the SaTScan analysis express that people who live in category 4 or very high-income level district will have 4.8 higher possibility to be exposed with Measles. Cluster detected shown in Figure 2.

5. DISCUSSIONS

Measles remains to draw attention globally, due to the highly contagious viral disease. Nowadays the number of Measles mortality reduced by about 84% from the year 2000 to 2016 (15). Thus, possibly the consequences of intensive Measles prevention through the vaccination program. However, Measles remains to become a problem in some middle-income country in Africa and Asia, including in Indonesia (15). Vaccination program remains essential to execute, on the other hand, an approach that supports that program is necessary to produce. Identification cluster using GIS technic is an approach that could assist the Measles programmer to determine the high-risk area as vaccination target.

In this study, we assessed the using of spatial analysis technic to detect Measles cluster incidence. Through an ordinal model of SaTScan, we identified significant cluster among Measles incidence which considering population density and income level as the determinant. Population density or population size has been recognized as the dependency of Measles transmission in a particular area or country (16, 17)i.e., a higher population size was correlated with a disproportionate high incidence of measles and rubella. No such tendency was found in other infections with possible exceptions of pertussis and keratoconjunctivitis. The dependency of rubella and measles on population density was examined by log-log plots of patient number/population vs. population density, which revealed strong population density dependency of rubella; the dependency of measles on population density was equivocal. Measles could transmit directly from infected person droplet when they are breathing, talking, sneezing, coughing that produce Measles virus (18). The virus stays in the air for up to two hours to infects the others people (19). Accordingly, when the density of people increases, it will increase the risk of Measles transmission in a particular area because the easiness of the virus to contaminate the next people. Previous studies have elaborated on the ability of SaTScan to detected spatial, temporal and spatiotemporal Measles cluster by using the population size (20, 21). These research in line with our finding which found a statistically significant Measles cluster within population density. According to that result approved that the Measles incidence is closely associated with population density.

Using the same analysis, this study furthermore, identified a significant cluster of Measles with attribute variable was income level. Income is known as a determinant of health. A study in the United States of America said that people with lower income reports having poor health quality (22). That statement is supported by the theoretical causal mechanism that stated income inequality affected fewer live opportunity, less social capital, direct psychosocial effects, and immediate socio-biological effect. After that, all of which influences the health status (23).

Conversely, we found a contrast result with the two previous studies. In our study, people who live in very high-level income have the highest possibility to expose with Measles. Our communication with the Measles program officer of Bantul District strengthens the capability of the SaTScan role as decision support system. The officer explained, the anomaly on that cluster because there was immunization refusal cluster on that community. This cluster which likewise educated and in high economic status refuses to vaccine their children on the Measles vaccination program. The refusal is due to their believing and religious reason. Local health authorities have been trying to encourage this cluster however it has not successful thoroughly.

Another interesting finding is regarding the cluster location. According to the previous research in Bantul at 2014 (24) who conducted analysis using clustering method, they found a Measles cluster in the same area as our finding that is in Banguntapan sub-district. Based on this two data set, it shows such temporal consistent pattern that location is a potential as Measles hotspot. Therefore, it could be a sign for the local health authorities to priorities this area on running their Measles program.

Limitations

This study may have some limitations regarding the variable comprehensiveness. For instance, this study involving two variables to predict the cluster thus associates with time and finance issue. However, this study remains had a contribution to provide evidence for local health authorities and proved the ability of SaTScan to detect cluster for the policy-making purpose. For next coming study is suggested to involve more variable to predict the cluster. Also, running temporal mapping for a couple of years probably give evidence accurately.

6. CONCLUSIONS

Measles is a contagious disease that infects mostly children. There is no specific antiviral therapy for Measles infection (25). As a result, vaccination is the recommended solution to tackle the infection. In some developing countries, even though the vaccination campaign intensively conducted, but outbreaks remain in some areas. Accordingly, GIS such as SaTScan can be a role as decision support for health authorities to priorities a particular area as program target. This research pointed out that the ability of SaTScan to detect Measles cluster with underline density and income level as the determinant.

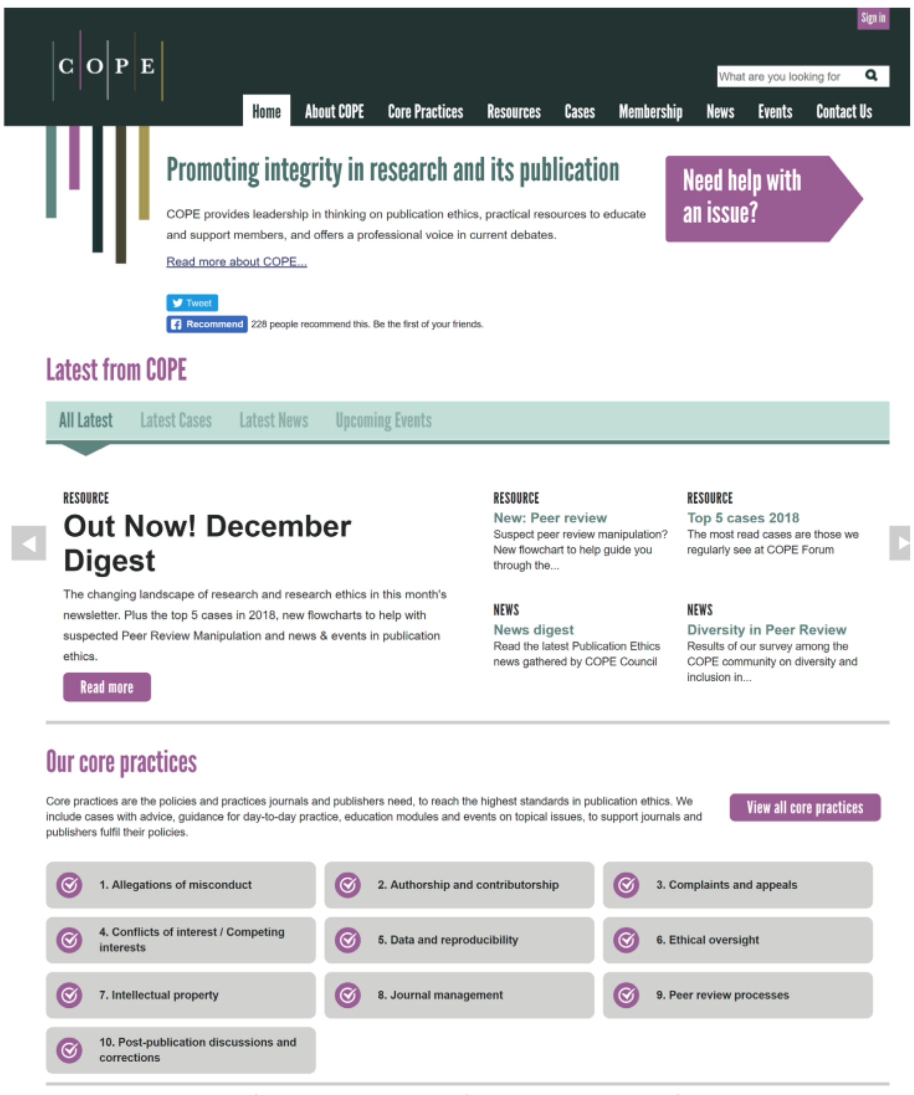
- **Acknowledgements:** We would like to thank the Bantul District Health Office for helping us during the research. We also wish to thank all the participants who contributed to this study.
- **Author contribution:** S.S. and S.S. gave substantial contribution to the conception or design of the work and in the acquisition, analysis and interpretation of data for the work. Each author had role in drafting the work and revising it critically for important intellectual content. Each author gave final approval of the version to be published and they are agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
- **Financial support and sponsorship:** None.
- **Conflicts of interest:** There are no conflicts of interest.

REFERENCES

1. WHO. Measles [Internet]. WHO Web Page. 2018 [cited 2018 Jun 27]. Available from: http://www.who.int/news-room/fact-sheets/detail/measles
2. Indonesia Ministry of Health. Data and information, Indonesia health profile year 2016 [Internet]. Jakarta; 2017. 100 p. Available from: http://www.depkes.go.id/resources/download/pusdatin/lain-lain/Data dan Informasi Kesehatan Profil Kesehatan Indonesia 2016–smaller size–web.pdf
3. Mukhibin A, Ahmad RA, Kusnanto H. Economic expenses analysis of the Measles outbreak in Yogyakarta year 2015. Ber Kedokt Masy J Community Med Public Heal. 2016;33(12).
4. WHO. Annual Report 2013. Switzerland; 2013.
5. Haelle T. Measles cases are spreading, despite high vaccination rates. What's going on? The Washington Post [Internet]. 2014 Jun 23;Health and Science. Available from: https://www.washingtonpost.com/national/health-science/measles-cases-are-spreading-despite-high-vaccination-rates-whats-going-on/2014/06/23/38c86884-ea97-11e3-93d2-edd4be1f5d9e_story.html?noredirect=on&utm_term=.8178b0126594
6. Nicholl S, Seale H, Campbell-lloyd S. Measles high school vaccination program, 2014 – 2015 : online survey of parents in NSW, Australia. Public Heal Res Pract. 2018;28(June):1–7.
7. Fradelos EC, Papathanasiou I V., Mitsi D, Tsaras K, Kleisiaris CF, Kourkouta L. Health based geographic information systems (GIS) and their applications. Acta Inform Medica. 2014;22(6):402–5.
8. Snow J. On the Mode of Communication of Cholera [Internet]. London: John Churchill; 1855. Available from: https://collections.nlm.nih.gov/ext/cholera/PDF/0050707.pdf
9. Gran JM, Wasmuth L, Amundsen EJ, Lindqvist BH, Aalen OO. Growth rates in epidemic models: application to a model for HIV/AIDS progression. Stat Med. 2009;28(July 2006):221–39.
10. Murhandarwati EEH, Fuad A, Nugraheni MDF, Sulistyawati S, Wijayanti MA, Widartono BS, et al. Early malaria resurgence in pre-elimination areas in Kokap Subdistrict , Kulon Progo , Indonesia. Malar J [Internet]. 2014;13(130):1–15. Available from: Malaria Journal
11. Sulistyawati S, Nirmalawati T, Mardenta RN. Spatial analysis of leptospirosis diseas in Bantul Regency Yogyakarta. KEMAS. 2016;12(1):111–9.
12. Fitzpatrick G, Ward M, Ennis O, Johnson H, Cotter S, Carr MJ, et al. Use of a geographic information system to map cases of measles in real-time during an outbreak in Dublin, Ireland, 2011. Eurosurveillance. 2012;17(49):1–11.
13. Bharti N, Djibo A, Ferrari MJ, Tatem A., Cabe AM, Bjornstad ON, et al. Measles hostspots epidemiological connectivity. Epidemiol Infect. 2010;138(9):3108–1316.
14. Indonesia Statistical Bureau. Urban dan Rural Clasiffication in Indonesia [Internet]. 2nd ed. Jakarta: Indonesia Statistical Bureau; 2010. 3 p. Available from: https://sirusa.bps.go.id/webadmin/doc/MFD_2010_Buku_1.pdf
15. WHO. Measles [Internet]. Web. 2018 [cited 2018 Jun 24]. Available from: http://www.who.int/immunization/diseases/measles/en/
16. Yoshikura H. Impact of population size on incidence of rubella and measles in comparison with that of other infectious diseases. Jpn J Infect Dis. 2014;67(6):447–57.
17. Yoshikura H. Population size/density dependency hypothesis for measles epidemic: Application of the hypothesis to coun-

tries in Five WHO regions. Jpn J Infect Dis. 2013;66(2):165–71.

18. Kutter JS, Spronken MI, Fraaij PL, Fouchier RA, Herfst S. Transmission routes of respiratory viruses among humans. Curr Opin Virol [Internet]. 2018;28:142–51. Available from: http://dx.doi.org/10.1016/j.coviro.2018.01.001
19. CDC. Transmission of Measles [Internet]. CDC Website. 2017 [cited 2018 Jun 25]. Available from: https://www.cdc.gov/measles/about/transmission.html
20. Tang X, Geater A, McNeil E, Deng Q, Dong A, Zhong G. Spatial, temporal and spatio-temporal clusters of measles incidence at the county level in Guangxi, China during 2004-2014: Flexibly shaped scan statistics. BMC Infect Dis. 2017;17(1):1–10.
21. Zhu Y, Xu Q, Lin H, Yue D, Song L, Wang C, et al. Spatiotemporal analysis of infant measles using population attributable risk in Shandong Province, 1999-2008. PLoS One. 2013;8(11).
22. Woolf SH, Simon SM, Aron L, Zimmerman E, Dubay L, Luk KX. How Are Income and Wealth Linked to Health and Longevity? [Internet]. Urban Institute. 2015. Available from: http://www.urban.org/research/publication/how-are-income-and-wealth-linked-health-and-longevity
23. Vafaei A. Relationships between income inequality and health: an ecological Canadian study [Internet]. Queen's University Kingston,; 2008. Available from: http://www.collectionscanada.gc.ca/obj/thesescanada/vol2/OKQ/TC-OKQ-1438.pdf
24. Ayu RD, Nugroho A, Kusnanto H. Spatial analysis to determine of measles risk areas in Bantul Regency year 2014. Ber Kedokt Masy. 2016;32(10):393–400.
25. CDC. Measles (Rubeola) [Internet]. CDC Website. 2018 [cited 2018 Jun 27]. Available from: https://www.cdc.gov/measles/hcp/index.html



Measles Cluster Detection Using Ordinal Scan Statistic Model

ORIGINALITY REPORT

6%

SIMILARITY INDEX

PRIMARY SOURCES

1	www.dovepress.com Internet	30 words — 1%
2	Guohui Liu, Feng Liu, Chunbo Wang, Tian Lan, Mingyan E. "Doctor-patient Communication skills training for Postgraduate majoring in Oncology Radiotherapy", Research Square, 2020 Crossref	24 words — 1%
3	eurosurveillance.org Internet	23 words — 1%
4	www.aimspress.com Internet	20 words — 1%
5	Zhang Chen, Tianyang Wang, Qintuo Pan, Zhaoliang Zhang, Zongduan Zhang. "Clinicopathologic Characteristics and Surgical Outcome of Synthetic Fiber Conjunctival Granuloma", Research Square, 2020 Crossref Posted Content	19 words — 1%
6	Abayomi Tolulope Oyewale, Taiwo Adesakin. "Mycotoxigenic fungi distribution and Water Quality of raw and treated water from Ede-Erinle and Opa waterworks systems, Osun State Nigeria", ScienceOpen, 2020 Crossref Posted Content	19 words — 1%
7	lungindia.com Internet	15 words — 1%
8	orbi.uliege.be Internet	10 words — < 1%

9	www.smj.org.sa Internet	8 words — < 1%
10	E Elsa Herdiana Murhandarwati, Anis Fuad, Sulistyawati, Mahardika Agus Wijayanti et al. "Change of strategy is required for malaria elimination: a case study in Purworejo District, Central Java Province, Indonesia", Malaria Journal, 2015 Crossref	8 words — < 1%
11	Sulistyawati Sulistyawati, Izzatun Nisa. "Climate Change and Health Teenager's Perceptions as a Basis for Interventions", International Journal of Public Health Science (IJPHS), 2016 Crossref	7 words — < 1%

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	ON		