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Highlights

- Cognitive impairment in a north Indian population
- Package of essential noncommunicable disease intervention in Bhutan
- IMCI implementation in Indonesia

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CONTENTS

Editorial

- Measles elimination by 2020: a feasible goal for the South-East Asia Region? 123

Review

- Overcoming access barriers to health services through membership-based microfinance organizations: a review of evidence from South Asia
Somen Saha, Peter Leslie Annear 125

Original research

- Prevalence and correlates of cognitive impairment in a north Indian elderly population
Paramita Sengupta, Anoop I Benjamin, Yashpal Singh, Ashoo Grover 135
- Prevalence and risk factors for psychological distress and functional disability in urban Pakistan
Nusrat Husain, Nasim Chaudhry, Farhat Jafri, Barbara Tomenson, Ishaq Surhand, Ilyas Mirza, Imran B Chaudhry 144
- Package of essential noncommunicable disease (PEN) interventions in primary health-care settings of Bhutan: a performance assessment study
Dukpa Wangchuk, Navkiran Kaur Viridi, Renu Garg, Shanthi Mendis, Nani Nair, Dorji Wangchuk, Rajesh Kumar 154
- Challenges to the implementation of the integrated management of childhood illness (IMCI) at community health centres in West Java province, Indonesia
CR Titaley, H Jusril, I Ariawan, N Soeharno, T Setiawan, MW Weber 161
- Benefits and costs of alternative health-care waste management: an example of the largest hospital of Nepal
Shiva R Adhikari, Siripen Supakankunit 171
- Clustered tuberculosis incidence in Bandar Lampung, Indonesia
Dyah WSR Wardani, Lutfan Lazuardi, Yodi Mahendradhata, Hari Kusnanto 179

Psychoactive substance use by psychiatric patients in the National Referral Hospital, Bhutan: a retrospective analysis <i>Sonam Choki, Tashi Dorji, Thinley Choden</i>	186
---	-----

Research brief

Assessment of cold-chain maintenance in vaccine carriers during Pulse Polio National Immunization Day in a rural block of India <i>Abhijit P Pakhare, Surya Bali, Radhakishan B Pawar, Ganesh S Lokhande</i>	190
---	-----

Letter

Helpline facility to assist reporting of adverse drug reactions in India <i>Vivekanandan Kalaiselvan, Prabhakar Mishra, Gyanendra N Singh</i>	194
--	-----

Recent WHO Publications	195
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Clustered tuberculosis incidence in Bandar Lampung, Indonesia

Dyah WSR Wardani,¹ Lutfan Lazuardi,² Yodi Mahendradhata,^{2,3} Hari Kusnanto²

ABSTRACT

Background: The incidence of tuberculosis (TB) in the city of Bandar Lampung, Indonesia, increased during the period 2009–2011, although the cure rate for TB cases treated under the directly observed treatment, short course (DOTS) strategy in the city has been maintained at more than 85%. Cluster analysis is recognized as an interactive tool that can be used to identify the significance of spatially grouping sites of TB incidence. This study aimed to identify space–time clusters of TB during January to July 2012 in Bandar Lampung, and assess whether clustering co-occurred with locations of high population density and poverty.

Methods: Medical records were obtained of smear-positive TB patients who were receiving treatment at DOTS facilities, located at 27 primary health centres and one hospital, during the period January to July 2012. Data on home addresses from all cases were geocoded into latitude and longitude coordinates, using global positioning system (GPS) tools. The coordinate data were then analysed using SaTScan.

Results: Two significant clusters were identified with *P* value of 0.05 for the primary cluster and 0.1 for the secondary cluster. Clusters occurred in areas with high population density and a high proportion of poor families and poor housing conditions. The short radius of the clusters also indicated the possibility of local transmission of TB.

Conclusions: The incidence of TB in Bandar Lampung was not randomly distributed, but significantly concentrated in two clusters. Identification of clusters of TB, together with its etiological factors such as social determinants, and risk factors, can be used to support TB control programmes, particularly those aiming to reach vulnerable populations, and intensified case-finding.

Key words: Cluster, housing condition, poor family, population density, tuberculosis

INTRODUCTION

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium tuberculosis*. About one third of the world's population is infected with *M. tuberculosis* and the incidence of TB has a great potential to increase.¹ Since 1947, the World Health Organization (WHO) has been conducting TB control through various control programmes, such as mass BCG vaccination and improved chemotherapy, management and service programmes, as well as implementation of the directly observed treatment, short course (DOTS) strategy. In 2000, WHO initiated the Stop-TB Partnership, in order to improve the effectiveness of TB-control programmes globally. The Stop-TB Partnership targets, included in the Millennium

Development Goals (MDGs), are to halve the prevalence and mortality of TB by 2015 in comparison to their levels in 1990.^{2–4}

TB control averted up to 6 million deaths and cured 36 million people in 1995–2008. Unfortunately, control programmes had less success in reducing the incidence of TB, which only declined by 0.7% per year during 2004–2008. Moreover, the decline occurred only in some American and European countries, which are mainly in sub-Saharan Africa and South-East Asia.^{3,5–7} The incidence of TB globally in 2010 was estimated to be 8.8 million, which is equivalent to 128 cases per 100 000 in the population. Indonesia was one of the five

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countries with the highest TB incidence in 2010 (0.37–0.54 million cases), which was also an increase compared with the incidence in 2009 (0.35–0.52 million cases).^{3,6}

There is growing consensus that there is a need to “move out of the TB box” by supplementing traditional control methods with innovative interventions, including those that target the social determinants of the disease.⁸ Social determinants include weak health systems and poor access to health care, poverty, low education, and inappropriate health-seeking and unhealthy behaviours. These determinants in turn affect the risk factors: (i) active TB cases in the community and overcrowding, which affects high-level contact with infectious droplets; and (ii) risk factors such as HIV and malnutrition, which impair host defence.^{9,10} Socioeconomic status (measured indirectly via an assets score) was consistently found to be inversely related to TB prevalence in surveys conducted in Bangladesh, Kenya, Philippines and Viet Nam.¹¹

Bandar Lampung is the capital city of Lampung Province in Indonesia. Based on the Bandar Lampung Municipality Health Office TB reports of 2010 and 2011, although the TB cure rate in 2009 and 2010 reached 80–85%, TB case notification in the city during that period increased, from 112/100 000 population in 2009 to 114/100 000 population in 2010.^{12,13} Spatially, TB case notification within the city was not equally distributed: some submunicipalities had TB case notification of more than 100/100 000 population, but there were also submunicipalities with TB case notification below 50/100 000 population.^{12,13}

SaTScan is free software, developed by Martin Kulldorff, that can be used to analyse spatial, temporal and space–time data, using scan statistics to detect disease clusters and determine whether they are statistically significant.^{14–17} The space–time spatial scan statistics examine the null hypothesis that the data are randomly distributed, against the alternative hypothesis that the probability of a case being inside a specific zone is greater than that of it being outside the zone. This type of cluster analysis can be used not only to map TB distribution but also to identify potential underlying etiological factors. Spatiotemporal statistical analyses therefore have wide applications in TB surveillance and control.¹⁴ In this study, space–time scan statistics were used to identify statistically significant TB cluster locations in Bandar Lampung during January to July 2012 and assess whether clustering showed any co-occurrence with population density and poverty levels.

METHODS

Bandar Lampung is located in southern part of the Sumatra Island, about 200 km west of the Indonesian capital city of Jakarta (*see* Figure 1). Medical records of smear-positive TB patients who were receiving TB treatment during January to July 2012 were obtained from 27 primary health centres and one hospital across the 13 submunicipalities of Bandar Lampung City. These have been implementing the DOTS strategy. The time-aggregation period used in this study was 3 months, based on the fact that smear-positive TB patients



Figure 1: Location of Bandar Lampung

became smear-negative after 2 months, and the median delay for patients with suspected TB (i.e. with a cough for at least 2 weeks) presenting at a lung clinic in urban Indonesia is 14 days.^{18,19}

The home addresses of all smear-positive TB patients were checked then geocoded into latitude and longitude coordinates, using global positioning system (GPS) tools. Defined clusters were then layered over a thematic map of identified social determinants and TB risk factors (population density and proportion of poor families) using geographical information system (GIS) tools.

Population density was classified as low (1–50 people/km²), middle–low (51–250 people/km²), middle–high (251–400 people/km²) or high (>400 people/km²).²⁰ However, as there is no submunicipality in Bandar Lampung City with a population density of 251–400 km² (middle–high), only three classifications of population density were used in this research.

The proportion of poor families in this research is the proportion of poor families in each submunicipality level, which is classified into four categories: low (<10%), middle–low (10–25%), middle–high (25–40%) and high (>40%).²¹ A poor family is defined as one that cannot fulfil its basic needs

for food, clothing and housing.²² Data on family poverty were taken from *Bandar Lampung City in figures 2012*.²³

In addition to analysis by population density and proportion of poor families, TB clustering was also analysed in relation to housing conditions.

Ethical clearance

Ethical clearance was approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, Gadjah Mada University. Respondents in this research received written informed consent and signed the form as a confirmation of approval. There is no declined from the respondents.

RESULTS

Distribution of TB in Bandar Lampung

There were 682 smear-positive TB cases in Bandar Lampung during the period of January to July 2012, distributed among 13 submunicipalities. Figure 2 shows that the incidence of smear-positive TB cases in Bandar Lampung was not equally

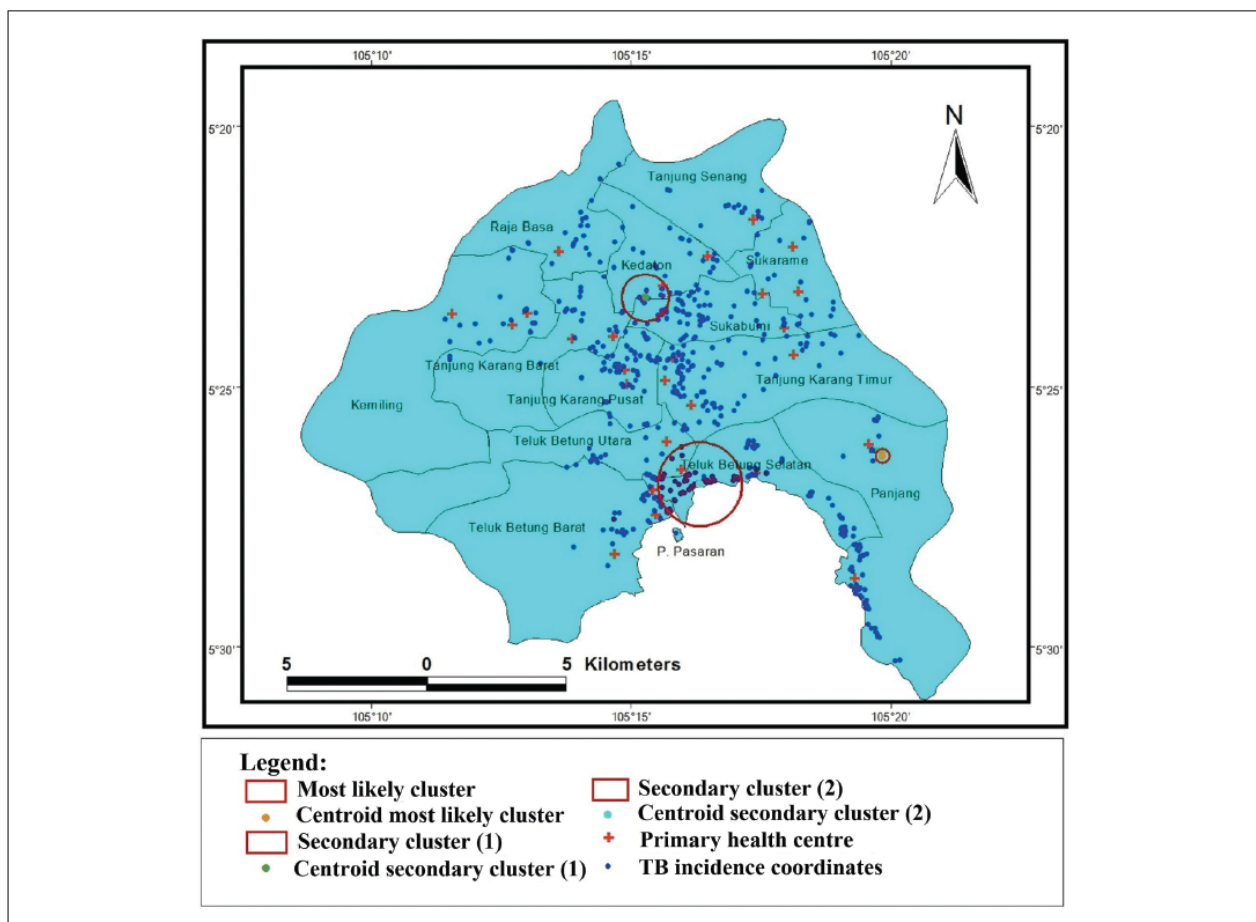


Figure 2: Distribution and clustering of TB incidence in Bandar Lampung (January to July 2012)

distributed. During this period, there were some areas with few or even zero TB cases. On the other hand, there were other areas with a cluster of smear-positive TB cases. Furthermore, overlaying the coordinates of the clusters and the city's map using Google Earth showed that the areas with zero TB incidence were areas that were protected forest and prohibited for settlement.

The concentration of smear-positive TB cases occurred in the following submunicipalities: Kedaton, Panjang, Tanjung Karang Timur, Tanjung Karang Pusat, Teluk Betung Selatan and Sukabumi. Most of the smear-positive TB cases in Panjang and Teluk Betung Selatan were located at settlements along the coast and in housing around industrial sites with high population density. In addition, most of the smear-positive TB cases in Kedaton, Tanjung Karang Timur and Tanjung Karang Pusat were found in dense settlements. Moreover, in Sukabumi submunicipality, most of the smear-positive TB cases were located in densely populated new residential areas with small houses.

Smear-positive TB clustering in Bandar Lampung

By using the space-time permutation model SaTScan statistics analysis, three clusters of TB were identified in the city during the period of January to July 2012 (see Figure 2). Two were significant clusters (most likely clustering; and the first of secondary clustering); in addition, one cluster was not significant (the second of secondary clustering). The most likely clustering was considered as significant, with P value of 0.05, while the secondary clustering was assumed to be significant with a P value of 0.1.

The coordinates of TB clustering were then overlaid with both population density (see Figure 3) and the proportion of poor families (see Figure 4). The most likely clustering occurred at Panjang submunicipality, while a secondary clustering occurred at a region covering Kedaton and Sukabumi submunicipalities. Panjang submunicipality is an area with a high population

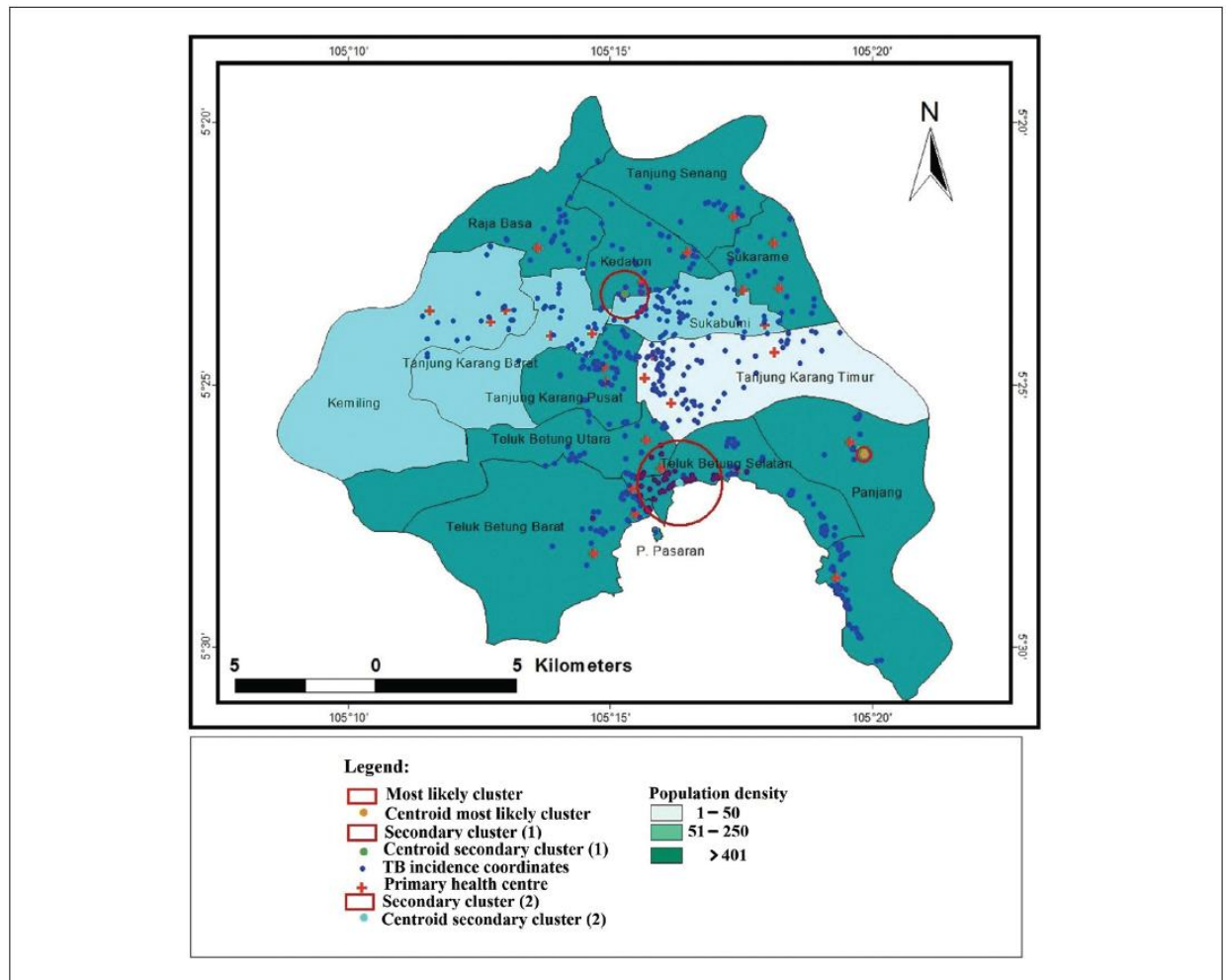


Figure 3: Clustering of TB incidence over the map of population-density map

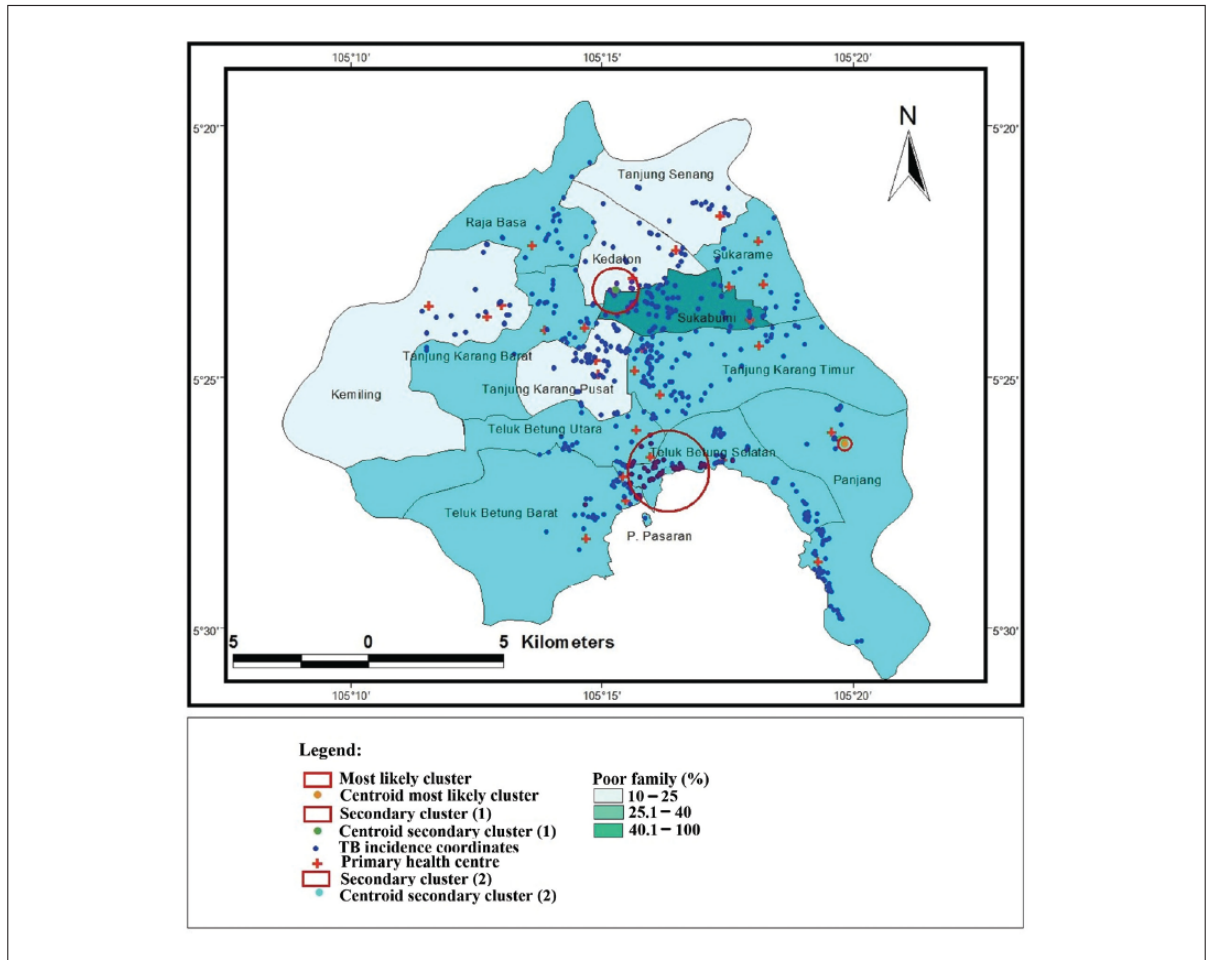


Figure 4: Clustering of TB incidence over the map of the proportion of poor families

density (2760 people/km²), as well as a middle–high proportion (33.0%) of poor families. Kedaton submunicipality is also an area with a high population density (8205 people/km²). Sukabumi submunicipality is not an area with an overall high population density but has a high proportion of poor families (47.48%).

Regarding the clusters, the radius of the most likely clustering was 0.25 km, with 5 cases. The radius of the secondary clustering was 0.84 km, with 12 cases. The most likely clustering occurred in lodging houses in an industrial area. The small-sized lodging houses were mostly rented by labourers for the local industries. Meanwhile, the secondary cluster occurred in a densely populated residential area in downtown Bandar Lampung City. Most of the accommodation in the two areas is characterized by conditions linked with TB, such as overcrowding, insufficient ventilation and in-house air pollution.^{24,25}

DISCUSSION

In this research, cases of smear-positive TB are cases recorded at DOTS facilities in Bandar Lampung, from 27 primary health centres and one hospital. This research did not cover smear-positive TB cases that had been treated at other health facilities or that had no access to DOTS facilities, owing to limitations of recording data. Considering the underreporting of TB cases, it is possible that the selection of health facilities for this study may overestimate the clustering.

The results showed that the incidence of smear-positive TB in Bandar Lampung was not equally distributed throughout the 13 submunicipalities; instead, cases tended to be concentrated in areas of high population density, such as settlements along the coast, and around industrial sites and new residential areas with small houses. This result is similar to the distribution of smear-positive TB patients in suburban areas of Ravensmead

and Uitsig, Cape Town, Africa during the period 1993–1998, which was also not equally dispersed but tended to be concentrated in areas of high population density.²⁶ The result is also similar to the concentration of smear-positive TB cases in Linyi, China, which was also located in densely populated residential areas.²⁷ Living in densely populated settlements is one of the risk factors for TB, as living in close proximity to others is closely related to TB transmission. Furthermore, living in dense settlements is closely related to the social determinants that also affect TB. Reviews have shown that people with low education, occupation, income and assets tend to live in densely populated settlements.^{5,10}

Analysis using space–time permutation model SaTScan statistics showed that the concentration of smear-positive TB cases was significantly grouped into two clusters. This clustering is similar to that in a study in Fukuoka, Japan, which found one most likely cluster during 1999–2004. The result is also similar to a study in Linyi, China, which also found one most likely clustering and nine secondary clusterings, during 2005–2010.^{15,27}

In this study, clusters occurred in submunicipalities that had a high population density and a high proportion of poor families. Research done in Vittoria, Brazil, similarly found that TB incidence had a spatial relationship with lower socioeconomic level.²⁸ This result is also similar to the research finding in South Africa, that TB incidence had a spatial relationship with high population density.²⁶ Moreover, a person with TB, who usually has related low social determinants, tends to live with other people who also have low social determinants. These conditions will further increase the risk of TB, which, in turn, increases the incidence of TB in the area compared with other areas, resulting in clusters.^{14,15}

The clusters found in this study had a short radius. Moreover, it is understood that a shorter radius of clustering indicates a higher probability of local transmission, as there will be a high likelihood of social interaction. This phenomenon is similar to research results found in Tarrant County, Texas, United States of America, which showed that the same strain of *M. tuberculosis* among TB patients living as neighbours was a strong indication of local transmission of TB.²⁹ Therefore, further study is needed to clarify whether the TB patients in the two clusters found in this study were also infected with the same strain of *M. tuberculosis*.

This study also found that clusters occurred in areas where housing conditions were poor.^{24,25} This finding is similar to the results of research carried out in Portugal, which found that clustering of TB occurred in locations where housing conditions were poor.³⁰ Moreover, overcrowding, insufficient ventilation and in-house air pollution are some risk factors for TB.^{5,10,24,25}

In summary, the incidence of TB in Bandar Lampung was not randomly distributed but, from a spatial point of view, was significantly clustered in two areas. The clusters tended to be located in areas with a high population density, a high proportion of poor families and poor housing conditions. Both population density and housing conditions are considered as

risk factors for TB, while the proportion of poor families is closely related to the social determinants. The occurrence of the TB cluster also indicates a possibility of local transmission of TB. Therefore, the implementation of DOTS should be more focused on cluster areas and accompanied by a supporting strategy involving improvement of social determinants and housing conditions. Moreover, as a strong relation between TB and the social determinants is also encountered in some of the countries of South-East Asia,¹¹ the knowledge gained from this research should be useful for TB control programmes in those related countries.

To conclude, knowledge about TB clustering can be used to support TB control programmes, particularly those that aim to reach vulnerable populations. Together with the underlying etiological factors, cluster analysis can also be applied as a supporting strategy for implementation of DOTS.

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