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Situation and Spatial Analysis of the COVID-19 Epidemic in Business Establishments: Comparison between the Delta and Omicron Variants in Thailand, July 2021–May 2022

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Abstract

COVID-19 outbreaks in business establishments cause a stagnant economy. In Thailand, the COVID-19 situation in business establishments has never been investigated. This study aims to (1) describe the situation and (2) compare characteristics, including spatial patterns, of COVID-19 cases in business establishments between the Delta (July–December 2021) and Omicron (January–May 2022) predominant periods. A cross-sectional study was conducted using secondary data extracted from the Department of Disease Control's database, which was linked to listed company and factory databases. The study population included all reported COVID-19 cases. The proportions of case characteristics between the delta and omicron dominant periods were compared using Pearson's Chi-square test. Spatial autocorrelation was tested using Moran's I statistics. During July 2021–May 2022, 443,448 COVID-19 cases were reported in business establishments. The proportions of cases in factories and construction camps decreased from 41.3% and 6.7% in the Delta dominant period to 14.4% and 1.7% in the Omicron dominant period, respectively. A high number of cases occurred in businesses operating food production, wholesale/retail, transportation, and accommodation. Clustering patterns were evident in the central and eastern regions of Thailand where many business establishments are located. Public health agencies should promote organizational COVID-19 prevention measures and increase worker's awareness in high-risk industries.

Keywords: COVID-19, spatial autocorrelation, business establishments, Thailand

Introduction

Over the past few years, many countries around the world have been confronted with outbreaks of coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2, and announced by the World Health Organization as a pandemic on 11 Mar 2020.[1] From the first reported case to July 2022, there were approximately 574 million cases and more than 6.4 million deaths.[2] Thailand reported its first case on 13 Mar 2020.[3] Since then, there have been several outbreaks due to constant virus mutations. One of the biggest waves in Thailand began in mid-2021 when the Delta variant was introduced. This variant was very contagious, causing numerous outbreaks in various settings, such as schools, prisons, and business enterprises.[4] After cases subsided, Thailand faced another wave, caused by the Omicron variant in early-2022. This variant was found to be more contagious, but less severe, than Delta.[5]

Widespread COVID-19 outbreaks in communities can introduce the COVID-19 infection into business establishments via workers who live in the community. Uncontrolled infections in these establishments cause businesses to temporarily close. If the outbreak occurs in many establishments, the country's economy will suffer. The Ministry of Public Health realized the importance of COVID-19 outbreaks in such establishments. Consequently, in August 2021 the Thai government introduced the so-called "Bubble and Seal" measure for prevention and control of COVID-19 in specific areas, especially factory settings.[6]

The COVID-19 situation in business establishments has never been investigated, Therefore, this study aims to (1) examine the COVID-19 situation in business establishments, and (2) compare epidemiological

characteristics and spatial patterns of the COVID-19 epidemic in business establishments between the time periods when the Delta and Omicron variants were predominant.

Methods

A cross-sectional study was conducted using secondary data retrieved from three databases, namely (1) confirmed COVID-19 cases and deaths associated with COVID-19 reported to the Department of Disease Control (DDC), Ministry of Public Health, (2) a list of factories that were registered with the Ministry of Industry, and (3) companies that were registered with the Ministry of Commerce. These databases were linked together to acquire the data on COVID-19 cases/deaths in the business establishments.

The study population included all laboratory-confirmed COVID-19 cases diagnosed by real-time reverse transcription polymerase chain reaction (RT-PCR) that were reported to the DDC between July 2021–May 2022. We divided cases into two study periods: July–December 2021 (the period that the Delta variant was dominant) and January–May 2022 (the period that the Omicron variant was dominant). We limited the study to May 2022 because the DDC changed the guidelines for COVID-19 case reporting, which affected the number of cases recorded.

Selected variables included gender, age, nationality, date of case report, province where the COVID-19 cases were isolated, type of establishment, and type of industry. Businesses were divided into three types—companies, factories and construction camps. The type of industry was classified based on the Ministry of Labor's guideline—"Thailand Standard Industrial Classification (TSIC) 2009".[7] Examples of Thailand Standard Industrial Classification 2009 industrial types included wholesale and retail trade, transport and storage, food and beverages manufacturing, accommodation and food service activities, and construction.

Microsoft Excel 2019 and STATA version 14.2 were used for data analysis. Descriptive statistics included frequencies, percentages, and means with standard deviation (SD). A comparison of epidemiological characteristics of the COVID-19 epidemic in the establishments between the two study periods were performed using Pearson's Chi-square test while Student's t-test was used to compare differences in age. The significance level was set at 0.05.

The spatial distribution of COVID-19 cases in the establishments by province were analyzed using GeoDa version 1.20. Percentile maps of cases in the establishments were created. To determine the spatial pattern, the global spatial autocorrelation was computed using Moran's I statistic with the formula shown below:[8,9]

$$I = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\frac{1}{N}\sum_{i=1}^{N}(y_i - \bar{y})^2 \sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}}$$

where I is Moran's I statistic indicating global spatial autocorrelation.

w_{ij} is a matrix of spatial weights. If two provinces are neighbors, a weight of 1 will be given. If not, 0 will be given instead.

y_i, y_j are the numbers of COVID-19 patients in the establishments reported from province i and j.

$\bar{y}$ is the mean number of COVID-19 patients in the establishments reported from each province.

N is the number of provinces.

Values of Moran's I statistic generally range from –1 to +1. A value of +1 indicates "perfect clustering" of similar values. Conversely, a value of –1 suggests "perfect dispersion" while a value of 0 refers to "perfect randomness" or no autocorrelation. A pseudo *p*-value was calculated based on the permutation technique to determine the statistical significance with a level of 0.05.[8]

Results

Comparison of Epidemiological Characteristics of COVID-19 in Business Establishments between the Two Study Periods

During July 2021–May 2022, 4,191,156 COVID-19 cases were reported in Thailand. We characterized this epidemic by two periods or waves; wave 1: July–December 2021, and wave 2: January–May 2022. The total number of cases reported from business establishments during the study period was 443,448 (10.6%) and, as shown in Figure 1, this distribution had a similar epidemic pattern with the whole country. Of 1,964,134 cases reported to DDC in the first wave, there were 21,507 deaths (case-fatality rate (CFR)=1.09%). Compared to the second wave, the CFR was substantially lower at 0.38% (8,390 deaths/2,227,022 cases). As shown in Table 1, the CFR in business establishments was lower than the national rate for both waves. Furthermore, the CFR from COVID-19 in the establishments during wave 1 was significantly higher than that during wave 2 (0.61% versus (vs.) 0.14%).

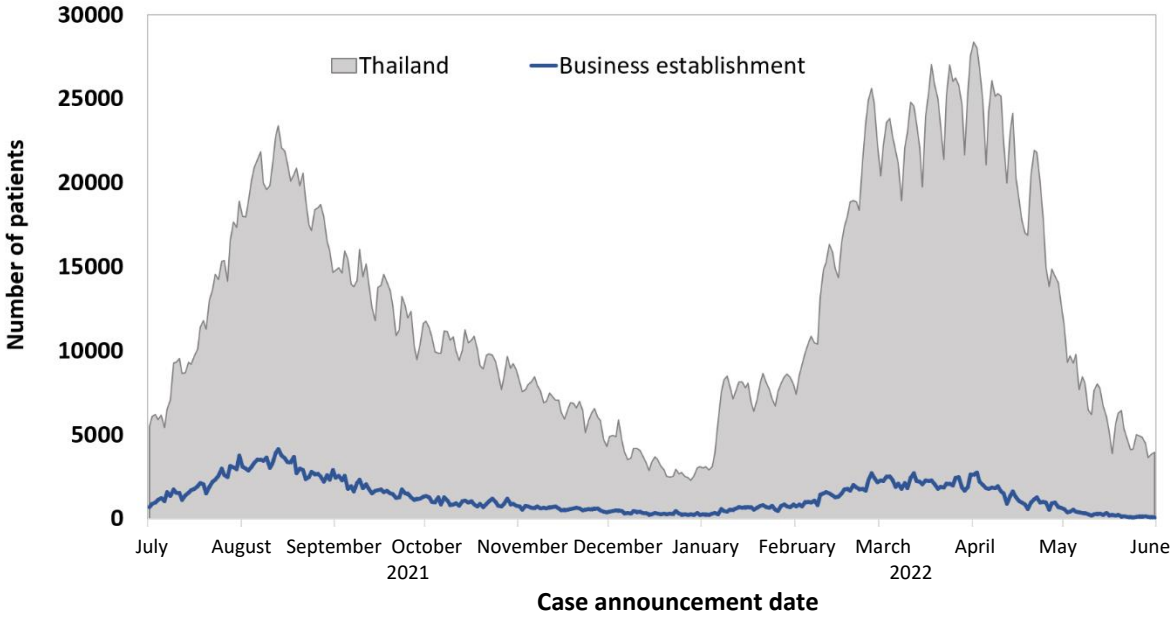


Figure 1. Epidemic curve of COVID-19 cases in business establishments, compared to the situation nationwide in Thailand, July 2021–May 2022

Among cases reported from business establishments, the proportion of males (range: 46.6–49.3%) was slightly lower than that for females (49.7–53.2%). The mean (SD) age of cases in period 1 was significantly lower than in period 2 (35.2±10.5 vs. 35.4±10.2). In period 1, most (75.1%) cases were Thai, followed by Myanmar (15.0%), and Cambodian (3.3%) whereas in period 2, Thais accounted for 94.3%. In period 1, about half (52.0%) of all cases worked in a company while 41.3% and 6.7% worked in factories and construction camps, respectively. However, in period 2, the majority of cases worked in companies (83.9%) while the proportions in factories (14.4%) and construction camps (1.7%) were significantly less compared to period 1 (Table 1).

Table 1. Epidemiological characteristics of COVID-19 cases in Thai business establishments: a comparison between two study periods

Characteristics	July 2021–May 2022	Period 1: July–December 2021	Period 2: January–May 2022	*P*-value[a]
Cases	443,448	266,393	177,055	
Deaths	1,876	1,630	246	
Case fatality rate (%)	0.42	0.61	0.14	<0.001
Gender				<0.001
Male	213,739 (48.2%)	131,209 (49.3%)	82,530 (46.6%)	
Female	226,706 (51.1%)	132,495 (49.7%)	94,211 (53.2%)	
Not identified	3,003 (0.7%)	2,689 (1.0%)	314 (0.2%)	
Age				<0.001[b]
Mean (SD)	35.3 (10.5)	35.2 (10.5)	35.4 (10.2)	
Nationality				<0.001
Thai	366,978 (82.8%)	200,015 (75.1%)	166,963 (94.3%)	
Myanmar	44,836 (10.1%)	39,851 (15.0%)	4,985 (2.8%)	
Cambodian	9,579 (2.2%)	8,698 (3.3%)	881 (0.5%)	
Laotian	1,359 (0.3%)	1,033 (0.4%)	326 (0.2%)	
Others	1,510 (0.3%)	769 (0.2%)	741 (0.4%)	
Not identified	19,186 (4.3%)	16,027 (6.0%)	3,159 (1.8%)	
Type of business establishment				<0.001
Company	287,157 (64.8%)	138,555 (52.0%)	148,602 (83.9%)	
Factory	135,495 (30.5%)	110,071 (41.3%)	25,424 (14.4%)	
Construction camp	20,796 (4.7%)	17,767 (6.7%)	3,029 (1.7%)	

Note: Numbers in table are frequency with percentages in brackets unless stated otherwise.

[a]P-value is based on Pearson's chi-square test unless stated otherwise. [b]P-value is based on Student's t-test.

A comparison of the top 10 ranked companies and factories with COVID-19 cases classified by type of industry is shown in Table 2. In period 1, the industries with the highest proportion of cases were wholesale and retail trade (9.2%), followed by transport and storage (2.5%) and food and beverages manufacturing (1.0%). In period 2, wholesale and retail trade (4.8%) still ranked first while the second and third ranked industries were accommodation and food service activities (2.3%), and transport and storage (1.0%). For factories, in period 1, food and beverages manufacturing (27.1%) had the highest proportion of cases, followed by computer, electronic and electric products manufacturing (14.2%) and rubber and plastics products manufacturing (9.5%). However, in period 2, computer, electronic and electric products manufacturing (15.5%) ranked first, followed by food and beverages manufacturing (13.4%) and machinery, motor vehicles and other transport equipment manufacturing (11.5%).

Table 2. The top 10 ranked companies and factories with COVID-19 cases and, classified by type of industry: a comparison between the two study periods

Period 1: July–December 2021			Period 2: January–May 2022		
Companies classified by industrial types	**No. of cases**	**%**	**Companies classified by industrial types**	**No. of cases**	**%**
1. Wholesale and retail trade	12,731	9.2	1. Wholesale and retail trade	7,152	4.8
2. Transport and storage	3,505	2.5	2. Accommodation and food service activities	3,474	2.3
3. Food and beverage manufacturing	1,422	1.0	3. Transport and storage	1,533	1.0
4. Accommodation and food service activities	1,213	0.9	4. Financial and insurance activities	1,371	0.9
5. Construction	1,198	0.9	5. Food and beverage manufacturing	7,83	0.5
6. Agriculture, forestry and fishing	1,104	0.8	6. Real estate activities	622	0.4
7. Financial and insurance activities	1,095	0.8	7. Construction	561	0.4
8. Textiles and garments manufacturing	1,066	0.8	8. Information and communication	456	0.3
9. Others	7,689	5.5	9. Others	2,745	1.8
10. Unspecified	107,532	77.6	10. Unspecified	129,905	87.4
Factories classified by industrial types	**No. of cases**	**%**	**Factories classified by industrial types**	**No. of cases**	**%**
1. Food and beverage manufacturing	29,812	27.1	1. Computer, electronic and electric products manufacturing	3,951	15.5
2. Computer, electronic and electric products manufacturing	15,663	14.2	2. Food and beverages manufacturing	3,395	13.4
3. Rubber and plastics products manufacturing	10,450	9.5	3. Machinery, motor vehicles and other transport equipment manufacturing	2,925	11.5
4. Machinery, motor vehicles and other transport equipment manufacturing	9,179	8.3	4. Rubber and plastics products manufacturing	1,445	5.7
5. Textile and garment manufacturing	5,693	5.2	5. Metals manufacturing	1,057	4.2
6. Metals manufacturing	5,417	4.9	6. Other non-metallic minerals products manufacturing	975	3.8
7. Transport and storage	2,630	2.4	7. Textiles and garments manufacturing	945	3.7
8. Medical goods and related items	2,617	2.4	8. Chemical and pharmaceutical products manufacturing	349	1.4
9. Others	9,911	9.0	9. Others	2,121	8.3
10. Unspecified	18,699	17.0	10. Unspecified	8,261	32.5

Comparison of Spatial Patterns of COVID-19 in Business Establishments between the Two Study Periods

The spatial distribution of COVID-19 cases in business establishments is displayed on the percentile maps shown in Figure 2 (upper panel). A higher number of cases in business establishments were located in the central and eastern regions of Thailand. Most of the provinces that reported a high number of cases in the first period also reported a relatively high number of cases in the second period. By comparing the number of cases in each province between the two periods, a high correlation coefficient (r) of 0.8958 (p-value <0.001) and the scatterplot shown in Figure 2 (lower panel) indicate a positive linear relationship, suggesting similarity of spatial patterns between both study periods.

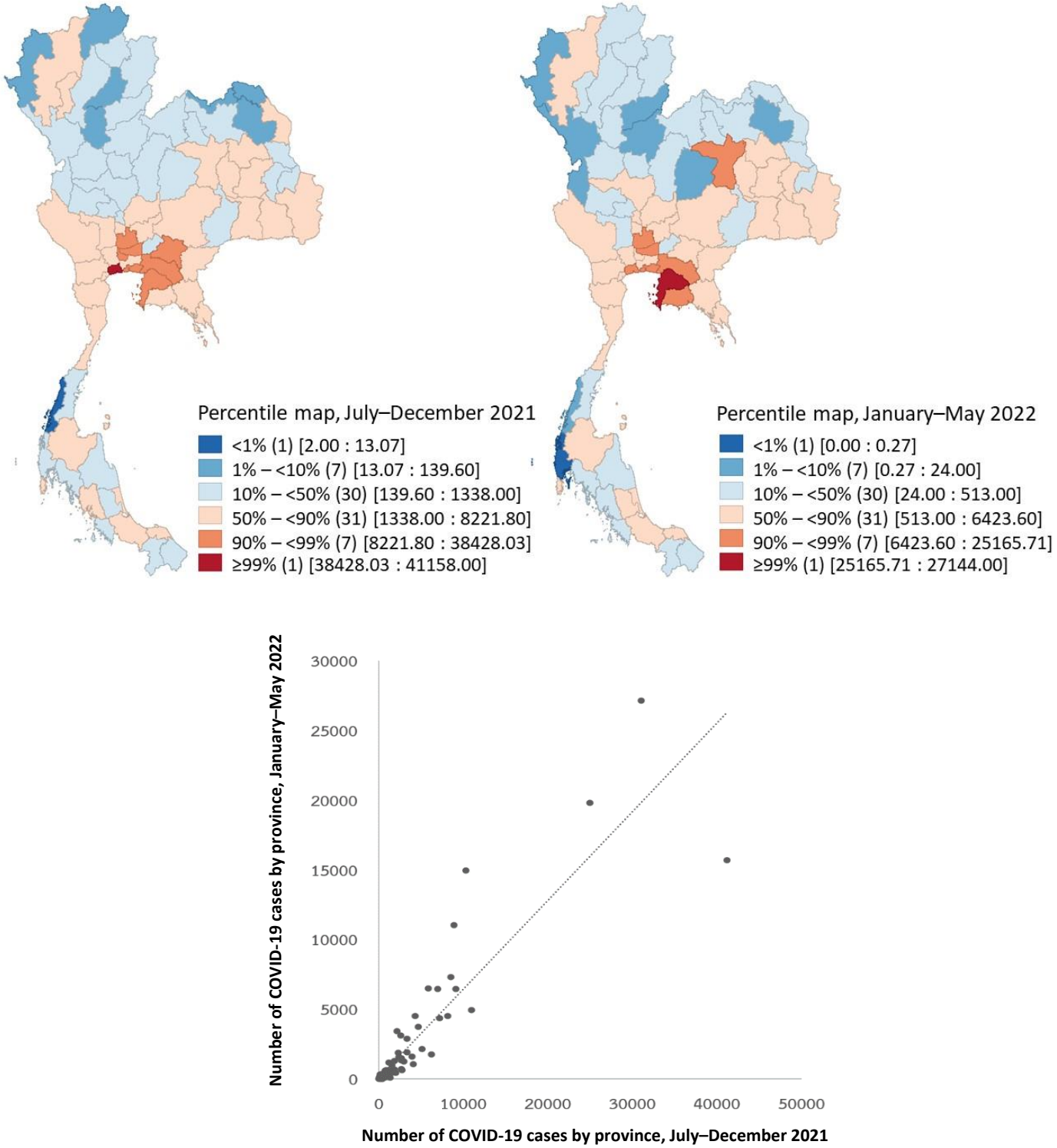
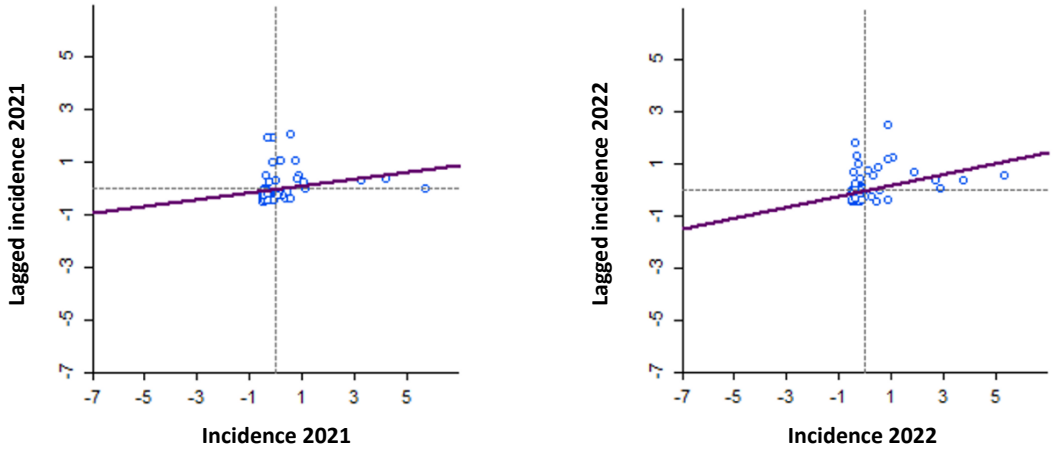


Figure 2. Comparison of spatial patterns of COVID-19 cases in business establishments between two selected time periods (July–December 2021 vs. January–May 2022) using percentile maps (upper panel) for period 1 (left) and period 2 (right) and a scatter plot (lower panel) of the number of COVID-19 cases in each province for the two periods

Concerning the spatial pattern of cases, Moran's I statistic was 0.131 (pseudo *p*-value=0.039) in the first period and 0.210 (pseudo *p*-value=0.009) in the second period (Figure 3), suggesting a clustering pattern for both periods. As can be seen from the percentile maps that correspond to the low positive Moran's I value, besides the large cluster of provinces located in the central and eastern regions, there were also clusters of provinces with high number of cases in other areas in the northern region (Chiang Mai Province), the lower part of northeastern region and the southern region (Songkhla Province) of Thailand.



Moran's I=0.131
pseudo *p*-value=0.039

Moran's I=0.210
pseudo *p*-value=0.009

Figure 3. Analysis of spatial pattern on the COVID-19 cases in business establishments in Thailand using Moran's I statistics: a comparison between two study periods (July-December 2021 (left) vs. January–May 2022 (right))

Discussion

This situational and spatial epidemiological comparative study of COVID-19 among workers in business establishments in two study periods found that the case fatality rate was significantly lower than that among the general population. This suggests a stronger health status among people in the working age compared to the general population. Furthermore, the CFR among workers in the first period was greater than that in the second period. This is not surprising because the first period contained predominately cases with the Delta variant, while the second period saw Omicron emerge as the predominant variant. Several studies have demonstrated that Omicron is more transmissible but less severe than Delta.[10–12]

We found that the proportions of COVID-19 cases in factories and construction camps substantially decreased from 41.3% and 6.7% to 14.4% and 1.7%, respectively. This result can be explained by the COVID-19 prevention and control protocols being implemented in specific areas, the so-called "Bubble and Seal" measure.[6] This measure includes self-assessment, social distancing, hand washing, mask wearing, temperature testing, segregation practices in the establishment, antigen test kit testing, quarantine, case isolation, and vaccination. The "Bubble and Seal" measure was launched by the Ministry of Public Health in August 2021, aiming at controlling the spread to COVID-19 in factories and construction camps. Until June 2022, approximately 2,860 factories had reportedly adopted this measure; however, other establishments might have adopted similar measures.[13] Additionally, Thailand's Ministry of Labor also introduced another COVID-19 control measure called the "factory sandbox", aiming at major industries, such as motor vehicles manufacturers, electronics products, food, and medical equipment, in some provinces where several factories are located.[14] Despite the occurrence of the high infectivity of the Omicron variant, the implementation of these two measures could possibly be a factor limiting the COVID-19 spread in the factories and construction camps. However, the effectiveness of the two measures has not been studied. Another possible explanation for the decrease in the proportion of cases in the second period could be the higher vaccine coverage among workers.

Regarding the industrial types, we found that companies involved in wholesale and retail, transport and storage, and accommodation and food services industries had the highest number of COVID-19 cases among their workers compared to other industries. This is possibly because these industries have more workers than the other industries. Furthermore, workers in these industries tend to have close contact with many people, resulting in an increased chance to contract COVID-19. For factory settings, the highest number of COVID-19 cases were found in factories involved in the

manufacture of food, electronics products, and rubber and plastics products. This finding is consistent with a study in Ontario, Canada where most of the COVID-19 outbreaks (44.7%) in the establishments occurred in the manufacturing industry.[15] Moreover, other studies on COVID-19 outbreaks in food factories in Ireland and Germany were in accordance with the situation in Thailand where manufacturing of food and beverages is a high-risk business.[16–17] However, to prevent and control COVID-19 in food factories, besides promoting personal hygiene and administrative or organizational controls, many studies also recommended that working environment, such as common contact areas, and ventilation, especially in workplaces that are crowded, should be disinfected more often.[16–18] The measures mentioned previously can be applied to other types of industries where appropriate, and should be considered based on the context and size of the enterprises.[19]

We found that spatial patterns of COVID-19 in business establishments was similar in the two study periods, consistent with the high correlation coefficient of 0.8958. The percentile maps suggested that the high-risk areas are located in the central and eastern regions, and some provinces that are considered as economic hubs of the regions, such as Chiang Mai (north), and Songkhla (south). A possible explanation could be that despite these provinces having a relatively high COVID-19 vaccine coverage with 78–100% (as of 5 Mar 2022), many people of working age tend to migrate to work in these areas.[20] Subsequently, they have a higher chance of contracting COVID-19. Additionally, the central and eastern regions are relatively highly populated, which is a key factor for the spread of infectious disease such as COVID-19.[21]

This study has some limitations. First, data on the number of workers in each business establishment were not available at the time of analysis since the databases provide by the ministries of Industry and Commerce contained the number of workers when the factory of company was first registered and the numbers may have changed over time. Secondly, some business establishments reported an infection rate more than 100%. Thus, numerator-based statistics using the number of patients instead of rate were used for data analysis. Moreover, one of the main objectives of this study was to compare the spatial patterns between two time periods when the Delta and Omicron variants were predominant, therefore, the lack of appropriate population size or denominator for calculating rate is not a serious issue. Thirdly, due to the short study period of 11 months, we could not explore the complete time trend of the COVID-19 infections in business establishments in Thailand. Finally, data on COVID-19 cases in companies by industry type were >75% incomplete thus, our results may not reflect the actual situation in Thailand.

Public Health Action and Recommendations

A spatial epidemiological analysis is a useful tool that can assist in identifying and understanding the geographical patterns of infectious diseases and anticipating high-risk areas. Subsequently, we can strengthen surveillance, including prevention and control measures, in the high-risk areas of COVID-19. We found that the central and eastern regions of Thailand, and some provinces that are considered as economic hubs, were at a higher risk than other areas. Our recommendations for control and prevention measures are as follows. Health officials should work in collaboration with network partners, such as the Ministry of Industry and the Ministry of Labor, to provide health literacy and raise awareness of COVID-19 among workers in the industries that are prone to infection, such as food and beverages manufacturing and services. All business establishments should closely monitor the COVID-19 situation in their areas and impose organizational measures to prevent and control the spread of COVID-19 in their establishment. Finally, lessons learned from the enterprises or construction camps that have successfully controlled the COVID-19 should be reviewed in order to find best practices as a model for prevention and control of COVID-19 in other establishments.

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