Original Article

Age, Sex, Population Density and COVID-19 Pandemic in Thailand: A Nationwide Descriptive Correlational Study

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Abstract:

Objective: It is reported that age and sex have been identified as potential risk factors for severe outcomes and the distribution of coronavirus disease (COVID-19), although the specifics of these relationships are unclear. Furthermore, little is known about the relationship between age, sex, COVID-19, and population density in Thailand. This study proposed to examine the relationships among age, sex, population density, and the number of COVID-19 patients in Thailand.

Material and Methods: In this nationwide descriptive correlational study, the dataset of daily COVID-19 cases in Thailand between January 12, 2020, and November 30, 2020, and population density (people/km^2) in each province of Thailand was retrieved from the Open Government Data of Thailand, the Registration Office Department of the Interior, the Ministry of the Interior, and the National Statistical Office of Thailand. Chi-square and Pearson product-moment correlation were used to determine the difference and relationships among studied variables. Simple linear regression was used to predict the number of COVID-19 cases based on population density.

Results: The findings illustrated a significant difference between male and female patients, in which the number of male patients was higher than female patients across age groups 31-45 years, 40-60 years, and >60 years (p-value<0.010). Further, population density was significantly associated with the number of COVID-19 cases.

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Conclusion: This investigation would provide intervention planning implications during potential future pandemics, especially in groups at higher risk (males, age 17-46 years old, and people living in high-density population areas).

Keywords: age, COVID-19, population density, public health, sex

Introduction

In December 2019, the first pneumonia case of undiscovered origin was identified in Wuhan, Hubei province, China, and was later confirmed as coronavirus disease COVID-19, which was generated by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2).[1] Thereafter, the World Health Organization officially declared COVID-19 a public health emergency of international concern. In February 2020, there were roughly 81,000 COVID-19 cases worldwide.[2] Currently, as of March 17, 2020, COVID-19 has taken around 2.6 million lives worldwide, with about 97 million accumulated documented cases.[3] Thailand, a country located in Southeast Asia, announced the first COVID-19 case on January 13, 2020.[4] Most recently, as of March 17, 2020, nationally there have been 27,402 confirmed COVID-19 cases, 88 deaths, and 26,339 recovered, with total testing of 23,234 per 1 million population.[3]

It is reported that certain ages and sex have been identified as potential risk factors for severe outcomes and the distribution of COVID-19.[5] The Morbidity and Mortality Weekly Report revealed that among the United States of America (USA) population, younger adults (20-29 years) were more likely to contribute to community transmission of COVID-19, as they accounted for more than 20.0% of all confirmed cases.[5] Furthermore, fatality was highest in persons aged equal to or more than 85 (10.0% to 27.0%), and no fatalities were reported among persons aged equal to or less than 19 years.[6] Regarding sex, although numerous reports have shown the difference between male and female COVID-19 cases, there has been inconsistency. For example, reports from China and several European countries stated that there were roughly similar numbers of COVID-19 cases between men and women.[7] However, a study aimed to determine the distribution of COVID-19 by sex amongst the Danish population showed that male COVID-19 infections had more than 50.0% higher risk than women of all-cause death, severe COVID-19 infection, or Intensive Care Unit (ICU) admission.[8] Likewise, Klein and colleagues (2020)[7] reported a higher number of men than women regarding COVID-19 cases, hospitalization, and deaths per 100,000 people in New York city. Since little is known about the relationship between age, sex, and the number of COVID-19 cases in Thailand, this study aimed to examine the correlation amongst these variables.

Age and sex were not the only potential factors identified in the spread of COVID-19; environmental factors such as temperature, humidity, or air pollution were also noted as potential risk factors.[9] Moreover, a previous study in Japan illustrated that population density was a significant factor affecting the spread of COVID-19 (p-value<0.050).[9] However, the difference in environment between Japan and Thailand would provide a different perspective.

In this nationwide descriptive correlational study, the difference between age and sex in the number of COVID-19 cases was determined. Moreover, the correlation between population density and the spread of COVID-19 in Thailand was also examined. To date, this is the first study to present the effect of age, sex, and environmental factors on COVID-19 in Thailand. The findings of this study contribute important knowledge to environmental and medical disciplines which could be used for intervention planning during potential future pandemics, including the second or third wave of the COVID-19 pandemic.

Material and Methods

The dataset on daily COVID-19 cases in Thailand was collected between January 12, 2020, and November 30, 2020 (based on the date of announcement). This data was composed of 3,998 confirmed COVID-19 patients' age, sex, nationality, notification date, announcement date, and the province of onset. Data were retrieved from the Open Government Data of Thailand, Data ID: 8a956917-436d-4afd-a2d4-59e4dd8e906e, Contact person: oudycovid@gmail.com, License: DGA Open Government License. The data regarding population density (people/km^2) in each province in Thailand was retrieved from The Registration Office Department of the Interior, the Ministry of the Interior of Thailand, and The National Statistical Office of Thailand. Since the authors identified and reviewed data from open government data resources with permission and did not involve human participants, the study was exempt from Institutional Review Board approval.

Firstly, chi-square test was used to determine the difference between age groups (year) (0-16, 17-30, 31-45, 46-60, and >60) and sex (male and female). Furthermore, frequency, percentage, chi-square tests with a significant value (Pearson chi-square, Likelihood Ratio, Linear-by-Linear Association) were reported to answer the research question of the likelihood of the distribution of males and females in each age group. The frequency and percentage of COVID-19 cases ranked by nationality were also reported using the Pie chart to show the proportion of COVID-19 cases by different nationalities. The number of COVID-19 cases by area (based on the province of onset) was reported using the COVID-19 case density map, divided into six categories by the number of COVID-19 cases (0, 1-100, >100-200, >200-300, >300-400, and >400). Furthermore, Thailand's population density by province was reported using a population density map, divided into five

categories (people/km^2) (0-49.9, > 49.9-74.9, >74.9-99.9, >99.9-124.9, and >124.9). Finally, since the population density (people/km^2) and the number of COVID-19 cases were continuous level variables, Pearson's product-moment correlation coefficient was used to examine the relationships between the population density and the COVID-19 cases. Moreover, simple linear regression was conducted to predict the number of COVID-19 cases based on population density (people/km^2). Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) Statistics V. 20.0.

Results

Table 1 shows difference in age groups of patients with COVID-19 by sex and Table 2 displays chi-square tests of age groups of patients with COVID-19 by sex (Pearson Chi Square=92.259, (degrees of freedom) df= 4, p-value<0.001, Likelihood Ratio=93.361, df=4, p-value <0.010, Linear-by-Linear Association=86.222, df=1, p-value<0.010). In this analysis, 3,998 COVID-19 patients were composed of 2,235 males (55.9%) and 1,763 females (44.1%). In 0-16 years age group (male (n=77, 1.9%) VS female (n=81, 2.0%)) and 17-30 years (male (n=615, 15.4%) VS female (n=674, 16.9%)) showed a slight difference between male and female patients. However, in age groups 31-45 years (male (n=739, 18.5%) VS female (n=598, 15.0%)), 46-60 years (male (n=547, 13.7%) VS female (n=293, 7.3%)), and >60 years (male (n=257, 6.4%) VS female (n=188, 3.0%)) a significant difference was shown between male and female patients, where the number of male patients was clearly higher than female patients across these age groups (p-value<0.010). Moreover, age groups 17-30 years and 31-46 years accounted for almost 66.0% of all COVID-19 cases (Table 1).

**Table 1** Age groups of patients with COVID-19 by sex

Age groups of patients with COVID-19		Sex		Total
		Male	Female	
Age group				
0–16 years	Count	77	81	158
	Expected count	88.3	69.7	158.0
	% within sex	3.4%	4.6%	4.0%
	% of total	1.9%	2.0%	4.0%
17–30 years	Count	615	674	1,289
	Expected count	720.6	568.4	1,289.0
	% within sex	27.5%	38.2%	32.2%
	% of total	15.4%	16.9%	32.2%
31–45 years	Count	739	598	1,337
	Expected count	747.4	589.6	1337.0
	% within sex	33.1%	33.9%	33.4%
	% of total	18.5%	15.0%	33.4%
46–60 years	Count	547	292	839
	Expected count	469.0	370.0	839.0
	% within sex	24.5%	16.6%	21.0%
	% of total	13.7%	7.3%	21.0%
>60 years	Count	257	118	375
	Expected count	209.6	165.4	375.0
	% within sex	11.5%	6.7%	9.4%
	% of total	6.4%	3.0%	9.4%
Total	Count	2,235	1,763	3,998
	Expected count	2,235.0	1,763.0	3,998.0
	% within sex	100.0%	100.0%	100.0%
	% of total	55.9%	44.1%	100.0%

Table 2 Chi-square tests of age groups of patients with COVID-19 by sex

	Value	df	p-value
Pearson chi-square	92.259	4	<0.001
Likelihood ratio	93.361	4	<0.001
Linear-by-linear association	86.222	1	<0.001
N of valid cases	3,998		

df=degree of freedom, N=number of COVID-19 cases

Overall, when classifying the data by nationality, the total of 3,998 COVID-19 patient cases consisted of 65 nationalities. Figure 1 shows the top 10 COVID-19 cases in Thailand ranked by nationality. Most COVID-19 patients were from Thailand (n=3,425, 85.6%) followed by Myanmar (n=72, 1.8%), India (n=64, 1.6%), France (n=43, 1.1%), China (n=36, 0.9%), United Kingdom (n=36, 0.9%), USA (n=34, 0.9%), Russia (n=23, 0.6%), Japan (n=17, 0.4%), and Unspecified (no nationality reported) (n=21, 0.5%), respectively. Other nationalities accounted for <0.5% each (all information from Open Government Data of Thailand) (https://data.go.th/dataset/covid-19-daily).
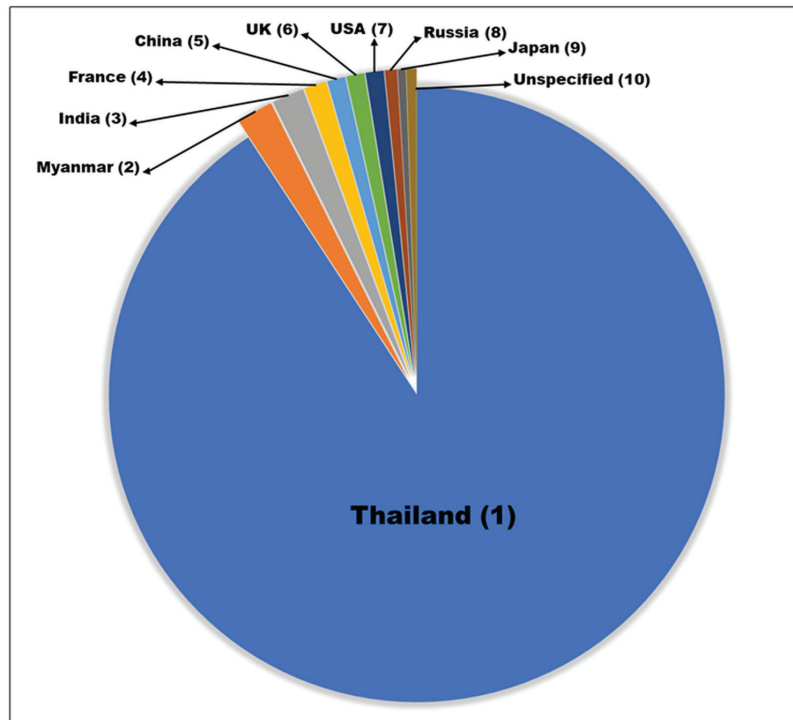
Note 1-10 are the top 10 COVID-19 cases in Thailand ranked by nationality

Figure 1 Top 10 COVID-19 cases in Thailand ranked by nationality

Figure 2 (Left) reveals the number of COVID-19 patients in Thailand by area (province of onset). From the 76 provinces in Thailand, 67 provinces reported confirmed COVID-19 cases. The number of cases varied from 0, 1-100, >100-200, >200-300, >300-400, and greater than 400 cases, respectively. The 8 provinces, with the highest reported number of COVID-19 cases, included Bangkok (n=1879, 47.0%), Chonburi (n=414, 10.4%), Samut Prakan (n=235, 5.9%), Phuket (n=230, 5.8%), Nonthaburi (n=150, 3.8%), Yala (n=129, 3.2%), Songkhla (n=127, 3.2%), and Pattani (n=96, 2.4%), respectively. Moreover, the number of cases from these eight provinces accounted for 81.7% of confirmed cases in Thailand. Other provinces accounted for <2.0% each (all information from the Open Government Data of Thailand) (https://data.go.th/dataset/covid-19-daily)

Figure 2 (Right) shows the population density in each province of Thailand. Compared to the number of COVID-19 patients in each province of Thailand (Left), the first seven provinces that recorded the highest number of COVID-19 cases (Bangkok, Chonburi, Samut Prakan, Phuket, Nonthaburi, Songkhla, and Pattani) are among the provinces with the highest population density in Thailand (>124.9 people/km^2). This excludes Yala province, where the population density is >74.9-99.9 people/km^2.

Using the Pearson correlation coefficient to examine the relationships between the population density (people/km^2) and the COVID-19 cases in each province, the result showed that the greater the population density, the higher the number of COVID-19 cases (r=0.829, p-value=0.011) demonstrating a strong relationship (Table 3).
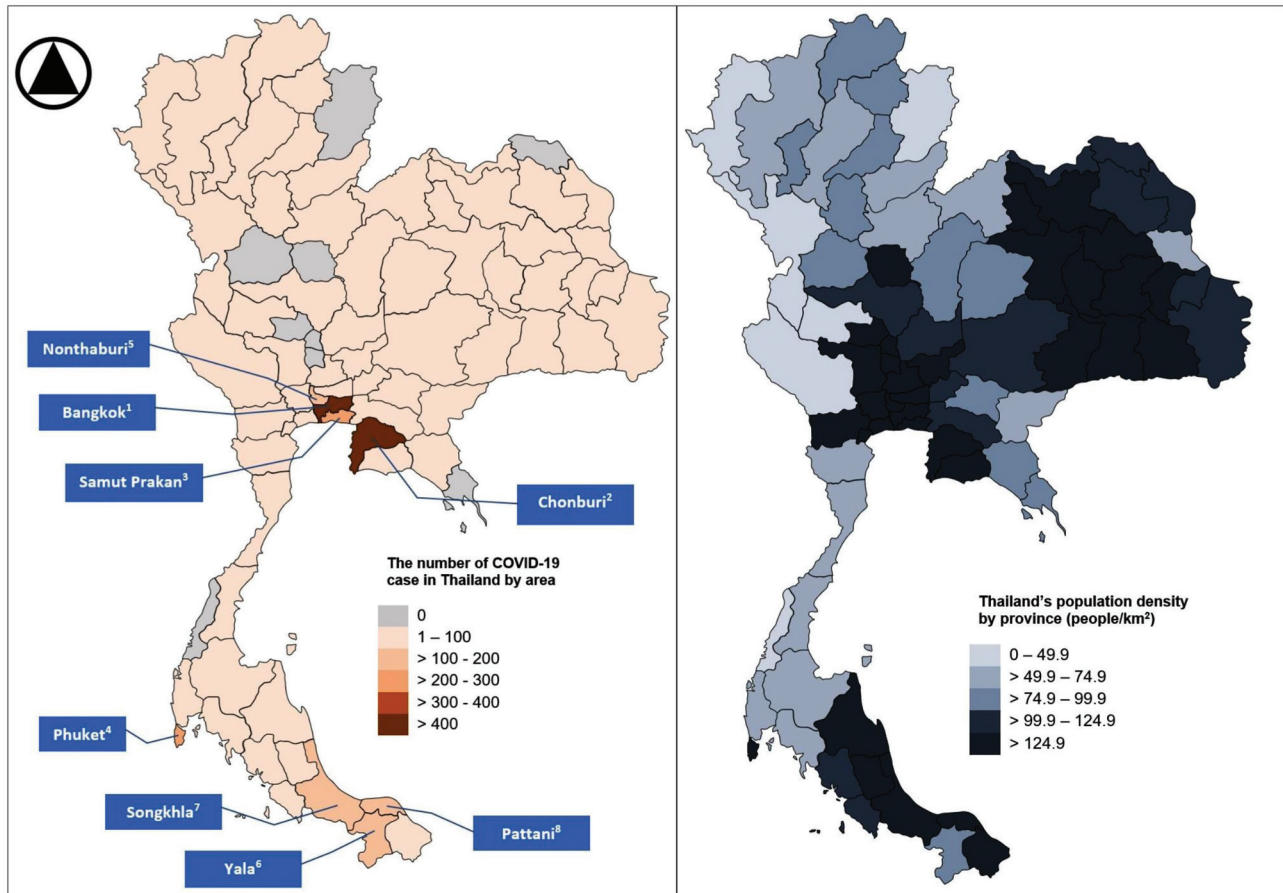
Note (Left) 1–8 is the top 8 COVID-19 cases ranked by the number of COVID-19 patients in each province of Thailand. (Right) The data regarding population density (people∕km2) in each province in Thailand was retrieved from The Registration Office Department of the Interior, Ministry of the Interior of Thailand, and The National Statistical Office of Thailand. This figure was modified from "Editable Map of Thailand for PowerPoint," created by PresentationGO (https://www.presentationgo.com∕), and the permission to use was provided

Figure 2 (Left) The number of COVID-19 cases in Thailand by area (province of onset). (Right) Thailand's population density by province (people∕km^2)

Table 3 Pearson's correlation coefficients between the number of COVID-19 case and population density

Variables		(1)	(2)
The number of COVID-19 case	Pearson correlation	1	0.829[*]
	Sig. (2-tailed)		0.011
Population density	Pearson correlation	0.829[*]	1
	Sig. (2-tailed)	0.011	

Note *Correlation is significant at the 0.05 level (2-tailed)

Sig.=significance

Table 4 Simple linear regression to predict the number of COVID-19 cases based on population density (people/km^2)

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95% confidence interval for B		Correlations		
	B	Std. error	Beta			Lower bound	Upper bound	Zero-order	Partial	Part
1 (Constant)	−46.94	179.78		−0.26	0.803	−486.85	392.96			
Population density	0.41	0.11	0.83	3.63	0.011	0.13	0.69	0.83	0.83	0.83

Note Dependent variable: The number of COVID-19 cases
B=The unstandardized beta, t=t-distribution, Std. error=standard error, Sig.=significance

In addition, simple linear regression was used to predict the number of COVID-19 cases based on population density (people/km^2). A significant equation was found (F$_{(1,6)}$=13.152, p-value<0.050), with an R^2 of 0.687. The equation was based on the intercept and the unstandardized beta is as follows: The number of COVID-19 cases is equal to (−46.94 + (0.41 X (population density)), where population density is measured in people/km^2. For interpretation, suppose we need to predict the number of COVID-19 cases when the population density is 200 people/km^2. Based on this equation, the predicted number of COVID-19 cases would be (−46.94 + (0.41X200))=36 cases (Table 4).

Discussion

Firstly, the results showed that males comprised the majority of COVID-19 patients in Thailand based on gender, especially in those above 31 years old. This study yielded similar findings to the reports Wuhan, China,[10] the USA[11], Italy[12], and Denmark.[8] This male bias also existed in past pandemics such as the 1918 influenza pandemic[13], Severe Acute Respiratory Syndrome (SARS)[14], and Middle Eastern Respiratory Syndrome (MERS).[15] This phenomenon could be described as the fundamental roles of biological mechanisms and gender differences between males and females. In terms of the biological mechanisms, it is well-established that females have a significant immunological advantage over males.[16] Females have more enhanced innate and humoral immune responses than males, mounting greater antiviral, inflammatory, and humoral immune responses during infections, thus helping females be less vulnerable to bacterial, fungal, parasitic, and viral infections.[16] An additional explanation regarding the difference in biological mechanisms is that of studies conducted in an animal samples. As observed in a mouse model of SARS-CoV infection, the endogenous production of estradiol in female mice sheltered their lungs from monocyte-macrophage infiltration and cytokine production to some extent leading to lower virus titers and less severe pulmonary damage.[17] Additionally, the Angiotensin-Converting Enzyme 2 (ACE2) receptor, to which the SARS-CoV2 virus S1 spike protein binds in alveolar epithelial cells of the lungs, is 2-fold more in the kidney of male mice, resulting in more significant ACE2 activity in the male kidney.[18] This reduced ACE2 activity in female mice and is also due to estradiol irrespective of the sex chromosome complement.[7] Though this has not yet been verified, there is a possibility that ACE2 may play a role in the sex bias in COVID-19 cases. There is an urgent need for exploration of sex-specific regulation of ACE2 in COVID-19 pathogenesis, including that of the lung, heart, and brain, as well as the underlying effects estrogens may have on the reduction of the expression levels of the receptor for the SARS-CoV2 virus.[19]

As for possible gender factors associated with the male bias in COVID-19, less likelihood of taking protective actions (e.g., handwashing, wearing masks, staying home, canceling travel, social distancing)[20], seeking medical help (e.g., testing for SARS-CoV-2, turn to medical professionals early)[21], engaging in a better lifestyle (e.g., not smoking, not drinking alcohol)[22], and fewer comorbidities (e.g., cardiovascular diseases)[23] in males might play a role. Therefore, the government should focus publicity towards this male-bias situation and focus on motivating male citizens to take a more active part in fighting against COVID-19. Furthermore, considerations of the possible unwillingness of men to receive the vaccine injection or other treatments should also be given when propagating the use of the treatments. The present study's findings showed that younger adults aged 17-46 years old were the most infected group in Thailand (65.6%), which is similar to findings in studies from the USA and India.[5,24] The possible explanation is that, since younger adults are the mainstay of the frontline workforce (e.g., medical staff, retailers, and public transportation drivers), the protection standard may be more difficult to achieve in these occupations, putting them at a higher risk of contracting the infection and thus are more vulnerable to COVID-19. Moreover, the younger population tends to live a more colorful social life leading to more exposure to others, in addition to the likelihood of them having mild or no symptoms[5], and the probability of unintentional transmission. It was also reported that those with comorbidities (e.g., hypertension, diabetes, cardiovascular disease), especially older adults, are more susceptible to COVID-19 and have a higher mortality rate.[25] Whereas, younger adults are less likely to have underlying diseases and thus, might be less cautious of taking adequate preventions against COVID-19.[26]

Thailand has a cumulative number of COVID-19 cases, lower than many countries in Asia.[27] Although the reported number of COVID-19 cases occurred sporadically, uncontrolled cases were minimal. Overall, of 3,998 COVID-19 cases, 85.6% were Thai people, and 14.4% were patients of 64 nationalities—most of them from Asian countries, such as Myanmar, India, China, and Japan (Figure 1). This accounted for almost 33.0% of non-Thai citizen COVID-19 patients in Thailand. The reason most foreign COVID-19 patients are from these countries may be their close proximity to Thailand, especially Myanmar and China. Therefore, at the beginning of the pandemic, people were still able to travel in and out of Thailand through tourism and non-formal occupations.[28] Another explanation could be that most tourists in Thailand are from these countries; China (39.8%), Japan (10.2%), India (8.3%), and Myanmar (1.7%), which account for approximately 60.0% of travelers in Thailand.[29]

This study indicated that population density is significantly associated with the number of COVID-19 cases and that almost all the provinces with the highest population densities have the most infection numbers. The present study yielded similar findings to a previous study from India.[30] Thus, population density may be related to the ability to social distance[9], which is a crucial factor in the transmission of COVID-19 as well as most effective prevention to disease transmission, especially from asymptomatic individuals or those with mild and inconspicuous symptoms.[31] A nationwide study measuring the effectiveness of social distancing policies in the United States suggested that stay-at-home orders were associated with an increase (35.0%) in social distancing and subsequent marked reductions in COVID-19 incidence (29.0%) and mortality (35.0%).[32] revealing the benficial contribution of social distancing in the control of COVID-19. Additionally, contact rates may be enhanced in areas with greater population density, such as large or metropolitan cities, which have a higher possibility of coming into close contact with others.

It is also suggested that the opportunity for effective contacts is mostly driven by crowding in denser areas

regardless of transportation accessibility and median income, boosting the contact rates necessary for disease spread.[33] It was reported in several studies that there is a strong correlation between population density and absolute humidity, which encourages the spread of the COVID-19.[9] However, the effect of higher absolute humidity on transmitting the disease remains controversial. A systematic review that included worldwide related studies found that wet climates seem to reduce the spread of COVID-19.[34] While a study conducted in Brazil, where the climate is similar to Thailand, found that in the coldest countries or periods under cool temperatures, average relative humidity favors COVID-19 transmission.[35]

The study has several limitations. Firstly, given the retrospective nature of the data, inherent biases exist. Secondly, given that this is an observational, archival, retrospective study, there is a remarkable difference in the number of patients included in each group. Thirdly, considering the study used secondary data, there was a lack of control over the data collection process. With secondary data, authors are less able to correct the source's errors during data collection. However, the authors treated the data with caution.

Conclusion

Our study's findings yielded similarities to previous studies from several countries such as China, the United States, Italy, and Denmark, revealing that Thai males seemed to become infected by COVID-19 more than females. Furthermore, 66.0% of the COVID-19 patients were individuals whose ages ranged between 17 and 46. Moreover, this is the first study to present the effect of age, sex, and environmental factors on COVID-19 in Thailand. The result showed that the higher the population density, the higher the number of COVID-19 cases, as the population density is significantly associated with COVID-19 cases. This investigation provides intervention planning implications

during potential future pandemics, especially in people at higher risk, such as males aged 17-46 and people living in a high-density area.

Conflict of interest

There are no conflicts of interest to declare.

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