COVID-19 case fatality rates across Southeast Asian countries (SEA): a preliminary estimate using a simple linear regression model

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Abstract

Purpose – The purpose of this study was to determine COVID-19 preliminary case fatality rates (CFR) across Southeast Asian (SEA) countries.

Design/methodology/approach – The study accessed the data on COVID-19 accumulated cases of fatalities and infections across SEA countries from the World Health Organization (WHO) website, covering the early days of March to May 21, 2020. The approach involved the computation of the CFR using the simple linear regression model. The slope of the regression line was the estimate of the CFR at a 95% confidence interval. The study also reviewed the different approaches of the SEA countries in dealing with the pandemic.

Findings – As of May 21, 2020, Singapore, Indonesia and the Philippines were the top three SEA countries with the highest record of COVID-19 infections. Brunei had one fatality, while Cambodia, Laos, Timor-Leste and Viet Nam had nil fatalities. Indonesia and the Philippines had the highest CFR with 6.66 and 6.59%, with R^2 of 97.95 and 99.43%, respectively. Singapore had the lowest CFR (0.068%) despite high infections.

Originality/value – Increased CFR in Indonesia and the Philippines suggests that COVID-19 in the two countries is rising at an alarming rate. Strict implementation of shared management approaches to control the pandemic is seen to be closely associated with the decrease of CFR.

Keywords Best management practices, Case fatality rate, COVID-19, Southeast Asia

Paper type Research paper

Introduction

Emerging from the city of Wuhan, Hubei, China, in December 2019, the novel coronavirus disease 2019, also known as COVID-19 [1], is spreading rapidly and causing global devastation. The disease fast developed into a global pandemic and was declared as a serious public health emergency [2]. COVID-19 has disrupted the functioning of the health sector, education, culture and religion, transportation, sports and entertainment, food security and agriculture, business and entrepreneurship and the world's economy [3,4].

The pandemic shocked many political leaders around the world, especially in countries where the incidence of confirmed cases and deaths rose quickly beyond expectation. In an attempt to support the government, experts from different fields either in a group or individually, have sensibly generated information attempting to resolve the crisis. COVID-19 has now become a key subject for research, not only in the areas of medicine and epidemiology but also in various related fields. Some researchers are working toward vaccine development, while others, from different perspectives, are formulating mathematical models to forecast [5] and determine the initial case fatality rate (CFR) of the disease [6,7]. As defined, CFR is the measure of the severity of the virus or pathogens to infect a host and expressed as the ratio of deaths and the infected population due to a particular disease [8]. The estimate of CFR is helpful since it is one of the key parameters for the epidemiology of this kind of pandemic [9]. CFR is necessary for setting priorities and strategies to reduce the severity of the risk and the possible flattening of the curve of rising COVID-19 rates [8].

To date, researchers and modelers suggested many estimates of the CFR for COVID-19 as products of different mathematical models [7]. These include the use of the basic ratio and proportion between deaths and confirmed cases [8], Poisson mixture models, use of lag time, cohort-based methodology, simple linear regression models, fixed-effect models and meta-analysis. Normally, a mathematical model has its peculiarity in terms of simplicity of use and accuracy of results. For example, the basic method of estimating the CFR may differ from other approaches as it does not consider the period of the disease incubation in the calculation [10]. The method does not provide a range of values where the CFR would fall within a certain level of the confidence interval. It was also a poor estimation of CFR during the early stage of the pandemic [11]. In general, however, capturing the complex environmental and anthropogenic factors in the estimate of the final CFR using mathematical models remains to be the most challenging phase of the process.

The multidisciplinary team of experts from China applied the simple linear regression model to estimate the initial CFR in their country. The team disclosed that the linear regression model was easy to apply and has the feature to filter the other factors such as incubation period, hospitalization time, policy-driven actions and strategies, among others, through the interception of the fitted line while the slope remains constant. The model allows the calculation of the slope of the fitted line, termed as the CFR estimate, using the cumulative number of confirmed cases and the number of deaths as the predictor and outcome variables [9]. A report from the Philippines also presented the use of the same model to calculate the preliminary CFR from the early set of data about the disease [12].

As the pandemic persists in bringing disruption to humanity, more sources of worldwide data about the disease are now available and readily accessible by the public from the Internet [13]. As of May 21, 2020, the WHO reported that the cumulative confirmed cases of infections and deaths due to COVID-19 in the SEA countries alone had reached a total of 73,835 and 2,323 respectively [14]. The data from the WHO offer an avenue for the initial estimate of CFR relative to the coronavirus pandemic. While the determination of CFR of emerging infectious morbidity is appropriate after the pandemic, a preliminary calculation during the early stage is useful for health decisions as it enables sharing of best management practices and decisions in dealing with the COVID-19 problem among countries.

This paper aims to determine the initial CFR in Southeast Asian (SEA) countries using the simple linear regression model and available data sets from the WHO on the cumulative confirmed cases and deaths due to COVID-19. This paper also sets out to provide an account of some commendable government actions and best management practices to lower the CFR of the disease among countries within the region. The output of the analysis is expected to provide useful insights for the immediate action and planning responses on the COVID-19 pandemic among SEA countries.

Methodology

Data acquisition

This preliminary analysis used the available data from the WHO [13] website on the accumulated confirmed cases and accumulated deaths due to COVID-19 from the early days of March to May 21, 2020. The number of samples for the respective 11 SEA countries varied, depending on the date when the first case of death occurred. The countries included Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Singapore, Timor-Leste and Viet Nam. The calculation of CFR included only seven countries because the other 4 countries – Cambodia, Laos, Timor-Leste and Viet Nam – had no cases of death as of May 24, 2020. Brunei Darussalam was also excluded as it had only one recorded death during the period considered. The team also used the data from the Worldometer for other information such as the total number of tests and the population by country.

CFR calculation

The calculation of the CFR was through the use of a simple linear regression model, taking the accumulated confirmed cases of COVID-19 infection as the independent variable and the accumulated cases of deaths as the dependent variable [9]. The simple linear regression model was expressed in the following equation;

$$Y' = bx + a \quad (1)$$

where y' was the outcome variable or the predicted cases of deaths, x was the predictor variable or the number of accumulated confirmed cases, b was the slope of the fitted line or the estimate of the CFR and a was the intercept. The confidence interval (CI) was calculated using the equation of the form;

$$CI = b \pm t_{(n-2)}(SE_b) \quad (2)$$

where $t_{(n-2)}$ was the value from the t -table for the degrees of freedom $n-2$ and SE_b was the standard error of the slope of the linear regression model. The period between the first confirmed case of infection and the day before the first incidence of death was excluded in the calculation to avoid bias on the slope component. The regression analysis used the Microsoft Excel tool to derive the values of the different statistical terms such as the coefficient of determination or R^2 , the slope of the fitted line, standard error of the slope and its 95% confidence interval. The value of the slope component of the fitted line expressed in percent was the estimate of the CFR. The model provided the standard error of the slope to calculate the confidence interval of the CFR.

Ethical issue: This study uses publicly available COVID-19 surveillance data from WHO and Worldometer.

Results

Accounts of COVID-19 in Southeast Asia

The COVID-19 statistics for the SEA countries as of May 24, 2020, from the Worldometer report, are shown in Table 1. The frequency and percentage of tests conducted by each country were important to this study to better understand the pandemic and its impact on each nation, whilst each country's data needed testing [15]. Four countries in the SEA, namely; Cambodia, Laos, Timor-Leste and Viet Nam, had no fatality records, with Brunei having only one case of death reported. Singapore had the highest case of confirmed COVID-19 infections followed by Indonesia. But surprisingly, the former had far lower numbers in terms of deaths compared to the latter. During the period of this analysis, Indonesia recorded the second-highest confirmed cases with the highest number of deaths. The data also

Country	Infections	Deaths	Recovery	Tests	Pop./km ²	% tests*	COVID-19 case fatality rates across SEA
Brunei	141	1	136	18,411	76	4.21	
Cambodia	124	0	122	16,007	92	0.10	
Indonesia	21,745	1,351	5,249	239,740	143	0.09	
Laos	19	0	14	5,194	31	0.07	
Malaysia	7,185	115	5,912	500,469	98	1.55	
Myanmar	201	6	120	17,875	80	0.03	
Philippines	13,777	863	3,177	287,294	365	0.26	
Singapore	31,068	23	13,882	294,414	8,102	5.04	
Thailand	3,040	56	2,916	328,073	136	0.47	
Timor-Leste	24	0	24	738	88	0.06	
Viet Nam	324	0	267	275,000	294	0.28	

Note(s): *Test from total population

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Table 1.
Statistics of COVID-19 in SEA countries as of May 24, 2020

revealed that Singapore was the leader in terms of recovery, tests conducted and the percentage of the total population who had undergone COVID-19 testing.

The emergence of COVID-19 in the SEA countries

Since its first emergence from Wuhan, China, on December 29, 2019, it took approximately 16 days before the coronavirus was detected in Thailand, the first SEA country infected on January 13, 2020. It took approximately 89 days before the disease was first detected in Laos and Myanmar; the last two SEA countries infected simultaneously on March 24, 2020. In terms of fatality among SEA countries, the Philippines reported its first death incidence due to the virus on February 2, 2020, while Myanmar reported its first death incidence on April 1, 2020. Of the 11 SEA countries, Malaysia recorded 3 cases of infections by the time of the first date of reporting on January 25, 2020.

The lag time between the first case of COVID-19 and the first fatality varies noticeably by country (Table 2). The Philippines had the shortest lag time with one fatality recorded on February 2, 2020, while Singapore had the longest lag time with two fatalities recorded on March 20, 2020.

The total COVID-19 cases of infection and fatalities in the SEA countries based on the WHO data as of the day when it was first detected in Laos and Myanmar (March 24, 2020) are shown in Table 3. The values were comparatively smaller than any of the top three countries (Singapore, Indonesia and the Philippines) with the most cases and fatalities. At that time, Italy recorded the highest death rates due to COVID-19 since its first emergence on January 29, 2020, about 16 days later than that of Thailand (Table 3). Similarly, the USA recorded at

Country	Date of first infection	Date of first death	Lag time (days)	First infection	Table 2. Dates of COVID-19 first infections and first death incidence in SEA countries
Brunei	Mar 10, 20	Mar 28, 20	19	1	
Cambodia	Jan 27, 20			1	
Indonesia	Mar 2, 20	Mar 11, 20	10	2	
Laos	Mar 24, 20			2	
Malaysia	Jan 25, 20	Mar 18, 20	54	3	
Myanmar	Mar 24, 20	Apr 1, 20	9	2	
Philippines	Jan 30, 20	Feb 2, 20	4	1	
Singapore	Jan 23, 20	Mar 20, 20	58	1	
Thailand	Jan 13, 20	Mar 1, 20	49	1	
Timor-Leste	Mar 20, 20			1	
Viet Nam	Jan 24, 20			2	

least 673 cases of deaths due to the virus since its first detection on January 20, 2020, about 7 days later than Thailand. The SEA countries have a relatively slower increment of infections and fatalities compared with Italy and the USA despite the early infection on January 13, 2020.

COVID-19 case fatality rate

Using a simple linear model, the estimate of CFR covered only the six SEA countries, namely, Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Singapore, because the other countries had no cases of death except Brunei which had only one fatality based on WHO data as of May 21, 2020. The inclusion of Myanmar, however, is still uncertain as the CFR was a poor estimate for a relatively small sample size [15].

An increasing trend of the disease during the early stages of this analysis (early days of March) of the respective countries is evident in Figure 1. Indonesia and the Philippines show a continuous rise in COVID-19 as of the inclusive date of this study (March 11, 2020, to May 21, 2020 for Indonesia, and February 2, 2020, to May 21, 2020 for the Philippines). The remaining countries had cases of infections that stabilized toward the end of the period covered in the analysis.

Figure 2 shows the scatterplots and the linear fittings using the simple linear regression models. The computed coefficient of determination (R^2) values ranged from 86.95% in Myanmar to 99.51% in the Philippines. These values indicate that there was a strong linear relationship between the accumulated confirmed cases and the accumulated deaths of all the countries as of the dates covered in the analysis, that is, from the respective starting dates by country to May 21, 2020. However, the relatively low R^2 in Myanmar is probably explained by its small sample size. There were only 6 cases of deaths in the country as of the period covered. All R^2 and the corresponding confidence interval and standard error of the slope line for the six countries are significant at a 95% confidence interval (Table 4).

During the period covered, three different trends appeared, as shown in Figure 2. First, Indonesia, Malaysia and the Philippines had similar linear trends with higher R^2 values, implying that the fatality rate would continue through time should there be no major modifications in the testing methods, healthcare facilities, management interventions and other factors. Second, Myanmar and Singapore experienced an abrupt increase of the slope during the earlier stage of the pandemic and slight decrease across time. The decreasing trends of the slopes show that Myanmar and Singapore had successfully managed to flatten the curve of the disease through time, although further observations had to be taken into consideration due to its limited sample size from these two countries. It is still difficult to explain by relying solely on the result of the model due to the relatively lower values of R^2 for Myanmar and Singapore. Third, in the case of Thailand, the slope shows an increasing trend, indicating an increase in the number of cases during the period covered in this analysis. Generally, Indonesia, Malaysia and the Philippines were revealed to have the best line fittings

Table 3.
COVID-19 cases of the
SEA countries and the
top three countries as
of March 24, 2020

Country	13-Jan-2020 ¹		24-Mar-2020 ²	
	Total cases	Total deaths	Total cases	Total deaths
China	41	1	81,767	3,283
Italy	0	0	63,927	6,077
USA	0	0	51,914	673
SEA	1	1	4,513	132

Note(s): ¹Date of COVID-19 first case report from the first infected SEA country (Thailand)

²Date of COVID-19 first case report from the last infected SEA countries (Laos and Myanmar)

COVID-19 case fatality rates across SEA

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Figure 1. Deaths and confirmed cases of infections of COVID-19 among the SEA countries as of May 21, 2020

in the regression analysis, with R^2 of 97.95, 99.43 and 99.51 %, respectively. The linear fittings for Myanmar, Singapore and Thailand were not as effective as the former three countries, with R^2 of 86.95, 93.71 and 92.10 %, respectively.

Discussion

During the period covered, Singapore had the highest cases of infection among the 11 SEA countries. The increase of COVID-19 infections in Singapore was probably attributed to its relatively high population density. This observation conforms with the previous findings from a study where the rate of spread of a disease in a particular area was directly associated with the population density of the area where the virus was spreading [16]. Singapore was the highest in terms of population density in the SEA countries.

The rise of COVID-19 in Singapore started with the return of infected residents from overseas [17]. However, the country was able to cautiously control relatively low cases of deaths despite having high cases of infections. This could suggest that Singapore was successful in handling the pandemic with its best management practices and strategies. Of the 11 SEA countries, Singapore leads in terms of the number of COVID-19 tests conducted. The capacity of the country to conduct widespread testing of the disease is highly sufficient concerning the confirmed cases. The number of tests conducted is remarkable because it signifies how equipped the country is on testing its constituents and making data readily

Figure 2. Scatterplots and regression lines of COVID-19 confirmed cases of infections and deaths of the six SEA countries as of May 21, 2020

Table 4. Case fatality rates and other statistics

Country	CFR (%)	SE _b	R ² (%)	95% CI of CFR
Indonesia	6.66	0.115	97.95	6.42–6.88
Malaysia	1.85	0.018	99.43	1.82–1.90
Myanmar	2.56	0.142	86.95	2.27–2.84
Philippines	6.59	0.045	99.51	6.50–6.68
Singapore	0.068	0.002	93.71	0.064–0.073
Thailand	1.88	0.062	92.10	1.75–2.00

available and meaningful. As reported, some of the noteworthy accounts in Singapore included early detection and quick response with restrictions and support packages. Singapore’s immediate action has served as a global example and has been sharing its best management practices worldwide [18].

As of May 21, 2020, the CFR varies widely between SEA countries, from 0.068% in Singapore and 6.66% in Indonesia. Variations of the CFR values, however, are influenced by several factors. These are probably temporal, spatial and climatic. CFR may also vary due to anthropogenic factors such as health control systems, standards and protocols, testing kit availability and hospital facilities. For example, the increase in the mortality rate of COVID-19 in Indonesia was reported to have been related to its regional disparities within its health system and limited widespread testing [19]. Indonesia had only 0.09% of its total population

who were tested for COVID-19, while Singapore had 5.04% at the time of this study. Reports also emphasized the role of the socioeconomic and political regime as possible drivers of CFR, with democracies suffering a higher fatality burden than that of autocratic regimes [20]. As practiced in other nations, low CFR countries tended to have implemented active control measures such as mass testing, contact tracing of infections, mobility restrictions and effective quarantine measures, among others. Malaysia's low CFR is indicative of the quality of service offered at the ward and in the intensive care unit. Brunei also disclosed that effective communication through a piece of reliable and accurate information is vital to maintain peace and encourage cooperation among its citizens with the government to fight the pandemic. Generally, the SEA countries have their respective pros and cons in dealing with the pandemic and exerted efforts to the best of their capacity to end the problem as quickly as they could [18].

Conclusion

This paper presented the method of estimating CFR using a simple linear regression model of the SEA countries based on WHO data as of May 21, 2020. The results were categorized into two distinct groups in terms of CFR variability. The first group showed the increased CFR values in Indonesia and the Philippines. Second, the decreased or zero CFR characterized the other SEA countries. As computed, the CFR (6.65%) of Indonesia is close to the CFR (6.59%) of the Philippines. These countries have the highest rates in terms of fatalities per case of infection. In terms of COVID-19 infections, Singapore, Indonesia and the Philippines are on the top of the list. The findings suggest that the situation of the pandemic in Indonesia and the Philippines is quite distressing. As analyzed and with the support of literature reviews and triangulations, countries with low CFR more or less tend to have strong political interventions in terms of control measures implementation such as rapid mass testing, contact tracing of infections, local and international mobility restrictions, effective quarantine measures and effective information dissemination. This paper also noted that the national economic capability and per capita tend to be associated with the low or nil CFR. This paper pointed out that population density is also closely associated with the spread of infection in Singapore. Furthermore, comparisons of testing data across countries are affected by differences in the way the data are reported. For the period covered, the data of COVID-19 in the SEA countries offer an avenue for a CFR preliminary analysis where mathematical models like simple linear regression can be adequately applied. However, it is still very premature to draw a conclusive statement due to data limitations and other factors like comorbidities which may affect the overall analysis. Nevertheless, this paper provides a preliminary estimate of CFR useful for advanced action planning and responses against the COVID-19 pandemic in the SEA countries.

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