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The cost-effectiveness of social distancing measures for mitigating the COVID-19 pandemic in a highly-populated country: A case study in Indonesia

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A R T I C L E I N F O

Keywords:
SEIR model
School closures
Workforce
Community contact reduction
Cost-saving

A B S T R A C T

Background: As one of the strategies to mitigate the COVID-19 pandemic, social distancing (SD) measures are recommended to control disease spread and reduce the attack rate. Therefore, this study aims to estimate the costs and effects of SD measures through school closures, workforce, and community contact reductions for mitigating the COVID-19 pandemic in Indonesia.

Methods: Two mitigation scenarios of SD for 1 month and continuous SD were compared with the baseline (no intervention). A modified Susceptible-Exposed-Infected-Recovered (SEIR) compartmental model accounting for disease spread during the latent period was applied by considering a 1-year time horizon. The costs of healthcare, school closures, and productivity loss due to disease as well as intervention were considered to estimate the total pandemic cost among all scenarios.

Results: In a comparison with the baseline, the result showed that total savings in scenarios of SD for 1 month and continuous SD was approximately $415 billion and $699 billion, respectively, while the averted deaths were 4.6 million and 8.5 million, respectively. Sensitivity analysis showed that basic reproduction number, infectious period, daily wage, incubation period, daily ICU admission cost, and case fatality rate were the most influential parameters affecting the savings and the number of averted deaths.

Conclusions: SD measures through school closures, workforce, and community contact reductions were concluded to be cost-saving. Increasing the duration of social distancing tends to increase both the savings and the number of averted deaths.

1. Introduction

The general occurrence of COVID-19 is a disruptive event that increases morbidity and mortality globally and causes severe economic, social, and political impacts. Since the World Health Organization (WHO) has declared the pandemic status of COVID-19 on March 11, 2020, the threat of this disease has been a major public health concern [1]. Learning from the experience of the last influenza pandemic, three major mitigation interventions were therefore provided. This includes curtailing interactions between infected and uninfected populations through social distancing (SD) measures, decreasing symptomatic patients' infectiousness by antiviral treatment, and reducing the susceptibility of infected individuals with vaccines [2]. Currently, there are no specific drugs for the treatment or prevention of COVID-19, hence SD is now being considered as part of the alternative mitigation measures, particularly when antiviral drugs are still being developed. Different

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with lockdown measures that entail the complete stoppage of public movement except essential services, SD measures aim to control the disease spread and reduce the attack rate through several approaches, such as school closures, workforce and community contact reductions [3].

Indonesia being highly populated, has reported significant numbers of 4.3 million confirmed cases and 0.1 million deaths due to COVID-19, where Java island (151.7 million population) is the epicenter of the pandemic's epicenter with approximately 82% of total confirmed cases and 70% of total deaths in the country [4,5]. Following the WHO's recommendations, SD measures have been practiced in Indonesia. Since March 15, 2020, the central government has prompted the local governments to close all schools. In the context of workforce and community contact reductions, all institutions and companies have been encouraged to implement work-from-home policies which are to be reviewed periodically, depending on the COVID-19 situation development. Nevertheless, the stakeholders hardly perform a comprehensive review of these policies as the impacts of SD measures remain unclear [6]. Even though SD tends to lower the peak of incidence and have less upfront costs, it is considered to have higher indirect costs, such as productivity loss due to interventions, compared with pharmacological interventions [7].

Therefore, this study aimed to estimate the costs and effects of SD measures for mitigating the COVID-19 pandemic in Indonesia. In a comparison with the baseline (no intervention), two mitigation scenarios of SD for 1 month and continuous SD were applied. A compartmental model was developed by obtaining the best available data and considering the potential impacts of school closures, workforce and community contact reductions [8].

2. Methods

2.1. Model

Applying a horizon analysis in 1-year time, *Goh* et al.'s methodology was broadened by adjusting a compartmental model that represented the spread of COVID-19 during the latent period [9]. Four compartments were applied for the number of susceptible (S), exposed (E), infected (I), and recovered (R) individuals. The model subdivides the total population size at time *t* denoted as *N(t)* into susceptible *S(t)*, exposed *E(t)*, infected *I(t)*, and recovered *R(t)*. The model also stated the exposed persons have made contact with a contaminated individual, yet they are not infectious. Moreover, its dynamics were described by a set of four equations correlating to the periods of the disease's progress:

$$N(t) = S(t) + E(t) + I(t) + R(t) \tag{1}$$

$$S(t) = -\frac{Rt}{Tinf} \cdot IS \tag{2}$$

$$E(t) = \frac{Rt}{Tinf} \cdot IS - \frac{E}{Tinc} \tag{3}$$

$$I(t) = \frac{E}{Tinc} - \frac{I}{Tinf} \tag{4}$$

$$R(t) = \frac{I}{Tinf} \tag{5}$$

In the equation above, R_t is the time-varying basic reproduction number, T_{inf} is the infectious period, and T_{inc} is the incubation period [9].

The baseline pandemic is believed to continue developing exponentially and then decline naturally until all susceptible people had contracted the disease. The transmission of infection was probabilistically implemented in the model between the infected and vulnerable individuals that had contact with the virus. In response to the growing distribution of the disease, births and natural deaths (*e.g.*, due to chronic diseases) were also believed to be steady. Therefore, selected parameters were drawn from the article, and up to this point, detailed information has been provided on the mitigation strategy in the model (see Fig. 1).

In the context of health economics, approximately 271.6 million of the total population in Indonesia was used to simulate the impact of SD for 1 month and continuous SD as alternative strategies for mitigating the COVID-19 pandemic [10]. By comparing two mitigation techniques to the baseline, overall savings on pandemic expense (in US Dollars according to 2020 price point) and the number of prevented deaths were estimated. Additionally, univariate sensitivity tests were performed to analyze various input variables' influence on the saving and the number of prevented deaths.

2.2. Epidemiological parameters

In this study, the reproduction number (R_0) was applied at 2.2 (95% CI; 1.4–3.9) as the indicator of infectiousness to calculate the number of secondary infections developed by each infected person [11]. T_{inc} and the T_{inf} were estimated to be 5.2 (95% CI; 4.1–7.0 days) and 2.3 days (95% CI; 0–14.9 days), respectively [11]. The rates of mortality and hospitalization were calculated to be 3.7% (95% CI; 3.6–3.8%) and 18.4% (95% CI; 11.0–37.6%), respectively [12]. We identified recovery time for minor symptoms, time to hospitalization, and time from the end of incubation to death at 24.7 (95% CI; 22.9–28.1 days) [12], 7 (95% CI; 4–9 days), and 21 days (95% CI; 17–25 days), respectively [13]. In addition, the length of hospital stay was projected to be 11 days (95% CI; 7–14 days) [13]. The proportions of non-ICU and ICU hospitalization were estimated as 32.9% and 67.1%, respectively, from the total cases recorded [14]. Furthermore, approximately 42% and 81% reductions in disease attack rates during SD for 1 month and continuous SD, respectively, were applied from two previous studies that considered the potential of SD measures on reducing the pandemic level [15,16]. To investigate the impact of SD measures, three major mitigation interventions through school closures, workforce and community contact reductions were considered. It was assumed that all school children needed to stay at home and prevent contact with outsiders. For workforce reduction, all workers were expected to have a 50% probability of staying at home and not make contact with their co-workers. Finally, all individuals were expected to have 50% less contacts in the community.

2.3. Cost parameters

The total number of the pandemic cost was specifically estimated from the societal perspective. This included direct healthcare costs, for example, outpatients, non-ICU & ICU hospitalizations, as well as indirect (*e.g.*, productivity loss due to disease and intervention) and school closures' costs. The cumulative costs of all health events were estimated in the baseline scenario by adding the overall cost for outpatients, as well as non-ICU and ICU hospitalizations. These were determined by multiplying the average daily cost by the average duration of stay for each age category. The average treatment costs per day of $24.20 (Min = $16.01, Max = $28.8), $162.11 (Min = $81.57, Max = $364.29), and $219.15 (Min = $110.27, Max = $492.46) were applied for outpatients, as well as non-ICU and ICU hospitalizations, respectively, from a previous result in Indonesia on measuring the unit cost of pulmonary patients [17].

Productivity loss due to death was estimated by considering age-specific death in each age group, life expectancy (72.7 years), and GDP per capita of Indonesia ($4016) [18,19]. Also, productivity loss due to disease was estimated using an average wage of $11 per day and work-days lost due to illness [19]. Furthermore, the numbers of work-days lost due to GP visits, hospitalization and ICU admission were estimated to be 25, 36, and 34 days, respectively [12,13]. To estimate the loss due to intervention, the working-age population (20–59 years old) was assumed to lose 50% of their productivity in both scenarios of SD for 1 month and continuous SD. The cost of missed school days due to SD was estimated using an average daily tuition fee of $0.23 per student

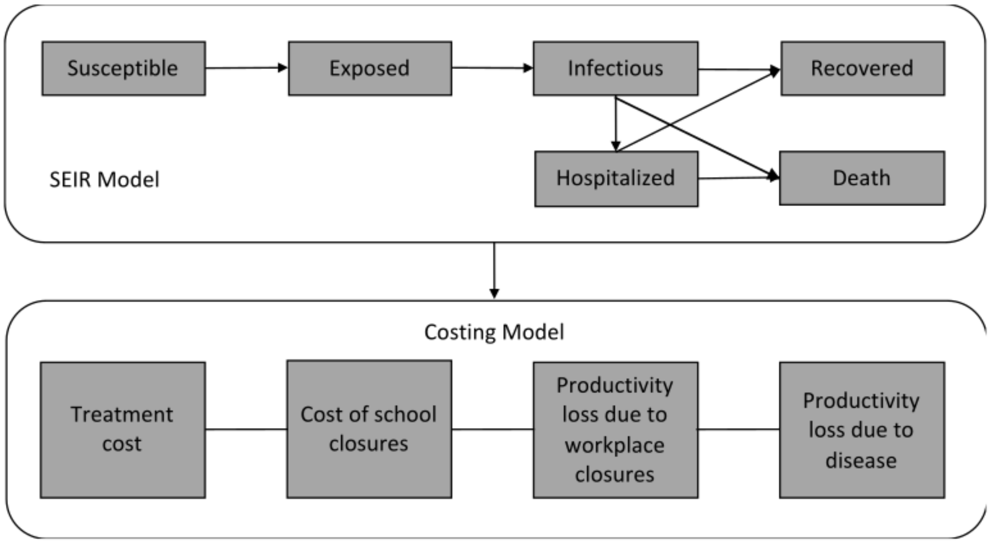

Fig. 1. Schematic presentation of SEIR and costing models.

for a public institution and the number of school days lost depending on the length of each mitigation circumstance [20]. Furthermore, the cost of childcare was not included in this study. All costs were measured in US Dollars using the Central Bank of Indonesia's most recent index changes from March 2020 [21]. The model's input parameters can be seen in Table 1.

3. Results

In a 1-year time horizon, the numbers of non-ICU and ICU hospitalizations, as well as outpatients and deaths in the baseline (no intervention) were estimated, which were 15,445,028, 4,252,172, 8,687,751, and 8,489,113 cases, each. The baseline scenario generated most of the expected cases. The SD's scenario consistently produced the fewest cases, thereby suggesting the number of outpatients, non-ICU and ICU hospitalizations as well as deaths to be 50,699, 11,294, 23,076, and 19,598 cases, respectively. More specific information on the cases number among mitigation scenarios by severity level can be seen in Table 2. To provide an idea about SD measures' effect on reducing the number of diseases, and deaths in the baseline, scenarios of SD for 1 month and continuous SD, these overviews were presented in Fig. 2a, 2b, and 2c respectively. These figures showed that the continuous SD had the greatest effect when compared to other scenarios.

Table 1
Input parameters in the model.

Parameters	Value	Ref.
Reproduction number (R_0)	2.2 (95% CI; 1.4–3.9)	[11]
Incubation time (T_{inc})	5.2 days (95% CI; 4.1–7.0 days)	[11]
Infectious time (T_{inf})	2.3 days (95% CI; 0–14.9 days)	[11]
Time to death from end of incubation	21 days (95% CI; 17–25 days)	[13]
Length of stay (hospitalization)	11 days (95% CI; 7–14 days)	[13]
Time to recover for mild cases	24.7 days (95% CI; 22.9–28.1 days)	[13]
Time to hospitalization	7 days (95% CI; 4–9 days)	[13]
Case fatality rate	3.7% (95% CI; 3.6%–3.8%)	[12]
Hospitalization rate	18.4% (95% CI; 11.0%–37.6%)	[12]
Disease attack rate reduction (SD for 1 month)	42%	[15]
Disease attack rate reduction (SD continuously)	81%	[16]
Average daily wage	$11.00 (95% CI; $8.02-$13.98)	[19]
Average daily tuition fee	$0.23 (95% CI; $0.17-$0.30)	[20]
Average daily cost of outpatient	Average tariff = $24.20 (Min = $16.01; Max = $28.80)	[17]
Average daily cost of hospitalization	Average tariff = $162.11 (Min = $81.57; Max = $364.29)	[17]
Average daily cost of ICU admission	Average tariff = $219.15 (Min = $110.27; Max = $492.46)	[17]
Work-days lost (outpatient)	25 (95% CI; 23–28)	[12,13]
Work-days lost (hospitalization)	36 (95% CI; 30–42)	[12,13]
Work-days lost (ICU admission)	44 (95% CI; 34–54)	[12,13]
Total population	271.6 million	[10]
Life expectancy years	72.67 years	[18]
Time horizon analysis	1 year	[9]

The results confirmed that the overall expenses of the pandemic was $777 billion, $362 billion, and $78 billion in the baseline, SD for 1 month and continuous SD, respectively. In addition, the cost of healthcare, school closures and productivity loss due to disease and intervention were considered to estimate the overall pandemic cost in all scenarios. Both mitigation scenarios were thought to be cost-saving since these approaches were more successful while still being less expensive. More specific information about the cost analysis can be seen in Table 3a.

When compared to other costs, the loss of productivity due to disease was expected to be reduced by 2% and 92% in scenarios of SD for 1 month and continuous SD, respectively. Productivity loss due to intervention tended to increase by 7% and 96% in both aforementioned scenarios, respectively. Furthermore, the cost of healthcare was expected to decline by 5–6% and that of school closures tended to increase by 1–2% in both mitigation scenarios. More specific information on the cost shift in a percentage as a result of intervention can be seen in Table 3b.

Sensitivity analysis showed that basic reproduction number, infectious period, daily wage, incubation period, daily ICU hospitalization cost and case mortality rate were the most essential parameters influencing the savings (see Fig. 3a). In addition, basic reproduction number, infectious period, incubation period, and case fatality rate affected the number of averted deaths (see Fig. 3b).

4. Discussion

Up to now, approximately 4.26 million confirmed cases and 0.14 million deaths due to COVID-19 have been reported by the government

Table 2
Number of outpatients, non-ICU hospitalizations, ICU admissions and deaths.

Intervention	Outpatient	Non-ICU hospitalization	ICU admission	Death
Baseline	15,445,028	4,252,172	8,687,751	8,489,113
SD for 1 month	2,155,612	779,318	1,592,249	3,889,206
SD continuously	50,699	11,294	23,076	19,598

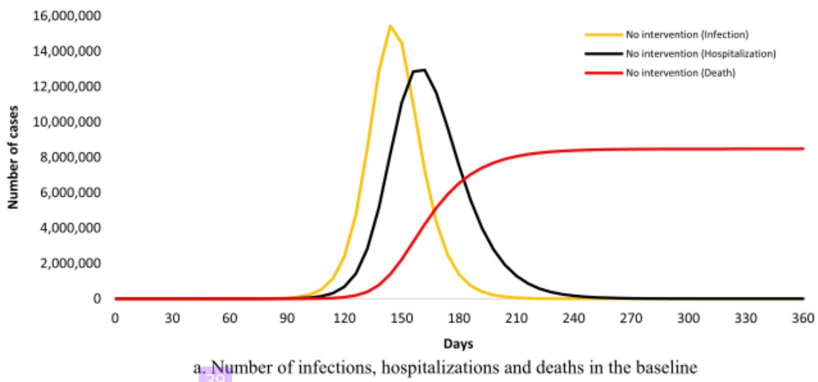

Fig. 2a. Number of infections, hospitalizations and deaths in the baseline.

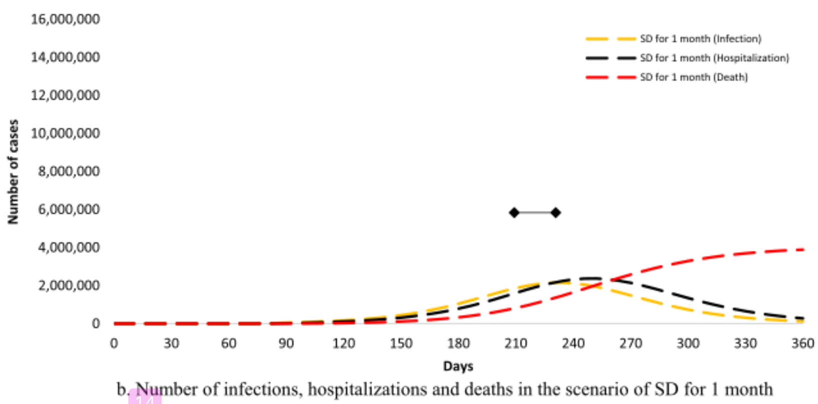

Fig. 2b. Number of infections, hospitalizations and deaths in the scenario of SD for 1 month.

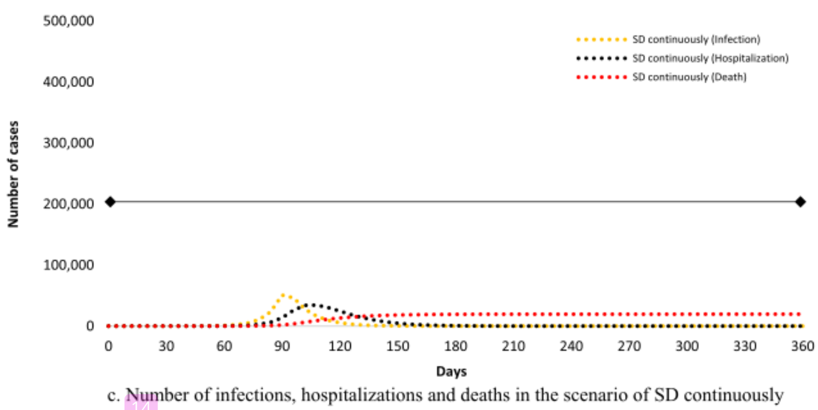

Fig. 2c. Number of infections, hospitalizations and deaths in the scenario of SD continuously.

Table 3a
Total pandemic costs, potential savings and averted deaths.

Intervention	Costs (million $)					Savings (million $)	Averted deaths
	Direct medical cost	Cost of school closures	Productivity loss due to intervention	Productivity loss due to disease	Total pandemic cost		
Baseline	$44,130.82	–	–	$732,921.85	$777,052.67	–	–
SD for 1 month	$4016.85	$489.99	$24,898.47	$332,836.87	$362,242.18	$414,810.49	4,599,907
SD continuously	$51.51	$1469.96	$74,695.41	$1698.15	$77,915.02	$699,137.65	8,469,515

of Indonesia [4]. Applying the baseline scenario (no intervention), our study estimated there would be 28.38 million confirmed cases (outpatients, non-ICU, and ICU hospitalizations) and 8.49 million deaths. For mitigating pandemic, SD has been widely considered as alternative measures, particularly when vaccines and antiviral drugs remain under development. This study confirmed that SD measures through school closures, workforce, and community contact reductions potentially decrease the total number of outpatients, non-ICU and ICU hospitalizations, as well as deaths due to COVID-19 in Indonesia. In a 1-year time horizon, the continuous SD scenario tended to reduce the number of COVID-19 cases by >90%. The result is similar to a previous study by Jackson et al., which estimated the effects of weather-related SD on the city-scale transmission of coronavirus. Furthermore, these scholars stated the school closure reduced coronavirus infection at 5.6% (95% CI; 4.1–6.9%), which was similar to influenza H1N1 at 7.6% (95% CI; 5.2–9.7%) and higher than influenza H3N2 at 3.1% (95% CI; 2.5–3.2%) [22]. In addition, two previous studies in mainland China concluded the overall package of SD measures was effective in reducing the COVID-19 pandemic [23,24]. Learning from the experience of the influenza pandemic, several sources also illustrated that school closures tended to cause a significant reduction in the number of cases [25–27]. Based on the inherent reduction in contact, the benefit of implementing SD measures in a pandemic situation is assumed to be favourable. In general, a long period of SD measures can be predicted to lead to the greatest reductions in terms of peak and cumulative attack rates [28,29].

The scale and speed of SD measures are unprecedented globally. Nevertheless, the length of maintaining tight suppression measures by a country before behavioural fatigue occurs in the population remains unclear. Based on predictions that SD measures have to be in place for several months, there is an urgent need to identify the possible means by which a country effectively reopens schools and workplaces [30]. This study estimated the total pandemic cost to be $777 billion, $362 billion and $78 billion in the baseline, as well as scenarios of SD for 1 month and continuous SD, respectively. The largest contribution to the total cost in all scenarios was productivity loss due to disease and intervention (92–96%). The current result has a similarity with two previous studies on the cost-effectiveness of strategies for mitigating an influenza pandemic in Australia [15,16]. Even though the fact that SD seems to significantly reduce the incidence rate and the peak of mortality rate, this intervention provides a really huge impact on the non-medical cost.

In general, the results showed all mitigation scenarios were considered to be cost-saving since the interventions were more effective and less costly, which are also linear with some previous studies. In a comparison with the baseline, total savings in SD for 1 month and continuous SD were liable to be approximately $415 billion and $699 billion, respectively. In addition, increasing the SD duration could increase the intervention's effectiveness. The SD for 1 month and continuous SD scenarios tended to cause approximately 4.6 and 8.5 million averted deaths, respectively [16,31,32]. A systematic review on economic evaluations of interventions against influenza pandemics highlighted SD had the potential to be cost-saving [31]. Measures, such as the SD that decreased person-to-person contact, had the highest cost per averted death because of the economic disruption caused by the measures [32]. Milne et al. also stated a rigorous and sustained SD intervention is cost-effective for mitigating the pandemic [16]. Sensitivity analysis results also had similarity with several previous studies, which showed basic reproduction number, infectious period, daily wage, incubation period, daily ICU admission cost, and case fatality rate were the most influential parameters affecting the savings and the number of averted deaths for mitigating a pandemic situation [6,33]. Basic reproduction number, infectious period, incubation period and case fatality rate significantly affect the peak time, peak infected proportion and total attack rate [33]. Additionally, daily wage and ICU hospitalization cost are strongly associated with productivity loss and treatment cost due to COVID-19, respectively [8].

This is the first economic evaluation study for mitigating the COVID-

Table 3b
Potential changes in the pandemic cost due to intervention (%).

Intervention	Direct medical cost		Cost of school closures		Productivity loss due to intervention		Productivity loss due to disease	
	%	↓	%	↑	%	↑	%	↓
Baseline	5.68%	–	0.00%	–	0.00%	–	94.32%	–
SD for 1 month	1.11%	4.57%	0.14%	0.14%	6.87%	6.87%	91.88%	2.44%
SD continuously	0.07%	5.61%	1.89%	1.89%	95.87%	95.87%	2.18%	92.14%

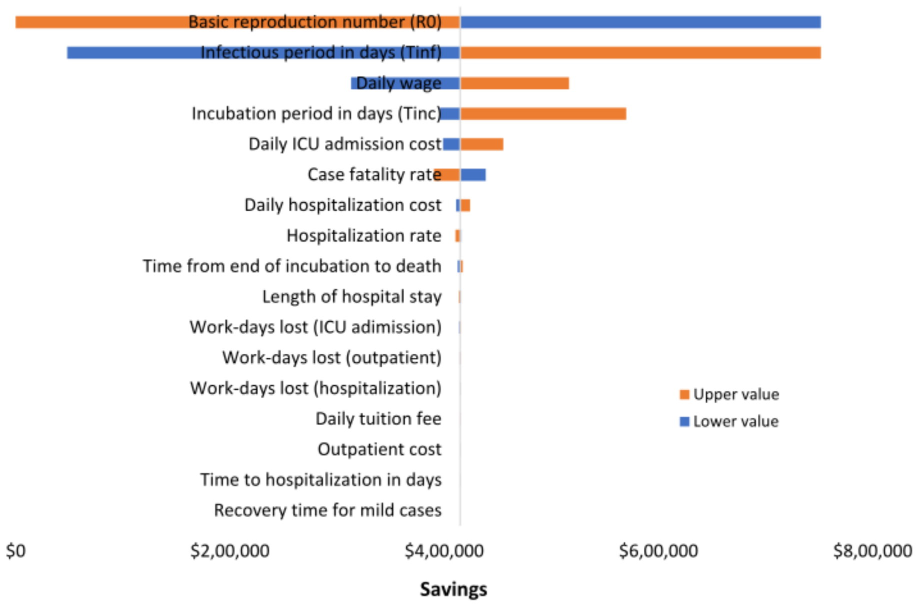

Fig. 3a. Effects of different input parameters on savings (SD for 1 month).

19 pandemic in Indonesia, therefore, it has several major innovative aspects. Firstly, the setting used was specifically focused to be in the country. An SEIR compartmental model accounting for the spread of COVID-19 during the latent period was also developed, while input parameters were mostly derived from the best available data. Secondly, this study was conducted from the societal perspective, which is relevant for evaluating SD measures that are considered to have higher non-medical costs than pharmacological interventions. Thirdly, two mitigation scenarios were developed within a hypothetical model of disease spread on the duration of SD measures. This is crucial since the government has the policy to review the decision periodically, and cost-effectiveness is an important criterion for prioritizing mitigation strategies in a pandemic situation. The lack of reliable local data on epidemiological parameters (*e.g.,* basic reproduction number; incubation and infectious period; time to recover, hospitalization and death; case fatality & hospitalization rates; and disease attack reduction) was discovered to be the study's main limitation. To deal with this, data were extrapolated from several published studies in China [9], [-11] and the issue in question was examined in the sensitivity analysis, while another limitation was not considering possible recurrent peaks of the virus.

The results can be used to assist stakeholders in estimating the best strategies related to SD measures for mitigating the COVID-19 pandemic in Indonesia. Even though the two scenarios applied were considered to be cost-saving, increasing the duration of SD tends to increase both the savings and the number of averted deaths. Meaning that, these non-pharmacological interventions are an appropriate alternative for mitigating the pandemic from the economic perspective, particularly when vaccines and antiviral drugs are still under development. However, the described short-term measures require constant re-evaluation, which is in line with the rapid development of COVID-19 transmissions.

5. Conclusion

Overall, SD for 1 month and continuous SD were considered to be cost-saving, hence increasing the duration of SD measures tended to increase the savings and the number of averted deaths. In addition, basic reproduction number, infectious period, daily wage, incubation period, daily ICU hospitalization cost, and case fatality rate were discovered to be the most influential parameters affecting the savings and the number of averted deaths in both mitigation scenarios.

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CRediT authorship contribution statement

Auliya A. Suwantika: conceptualization, methodology, software, investigation, and writing – original draft preparation. **Inge Dhamanti:** conceptualization, validation, formal analysis, writing – original draft preparation, and project administration. **Yulianto Suharto:** conceptualization, validation, formal analysis, writing – original draft

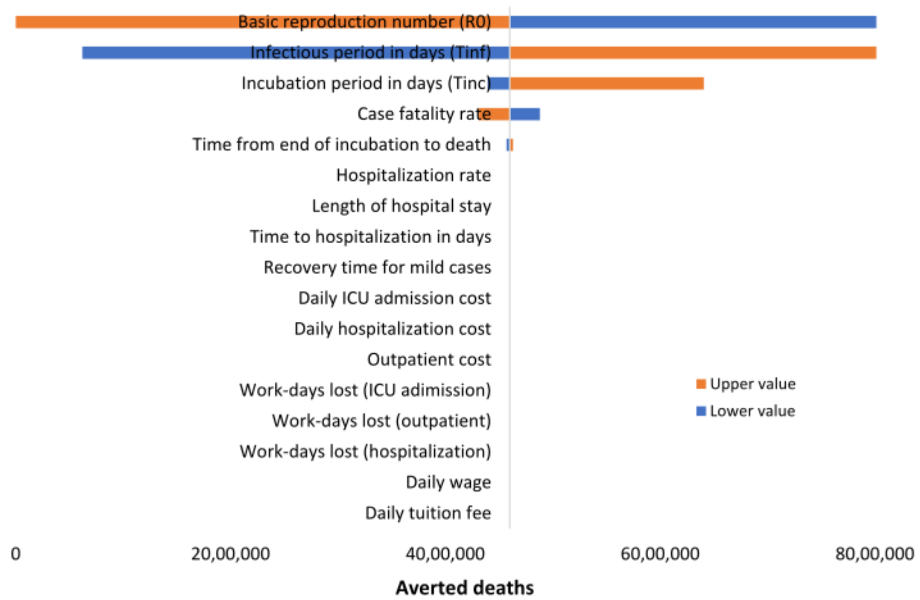

Fig. 3b. Effects of different input parameters on averted deaths (SD for 1 month).

preparation, and writing – review & editing. **Fredrick D. Purba:** methodology, software, resources, and writing - review & editing. **Rizky Abdulah:** methodology, investigation, and writing - review & editing.

Declaration of competing interest

No competing interests were disclosed.

References

[1] WHO. Coronavirus disease 2019 (COVID-19) situation report – 51. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10. [Accessed 10 September 2020].

[2] Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, Mock CN, Nugent R. Disease control priorities: improving health and reducing poverty. Disease control priorities. third ed., 9. Washington, DC: World Bank; 2018. https://doi.org/10.1596/978-1-4648-0527-1.

[3] WHO. Critical preparedness, readiness and response actions for COVID-19. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/critical-preparedness-readiness-and-response-actions-for-covid-19. [Accessed 10 September 2020].

[4] Committee of COVID-19 Handling and National Economic Recovery. COVID-19 monitoring data. https://covid19.go.id/peta-sebaran-covid19. [Accessed 9 December 2021].

[5] Statistics of Jakarta. Population by age and sex. 2018-2020. https://jakarta.bps.go.id/dynamictable/2019/09/16/58/jumlah-penduduk-provinsi-dki-jakarta-menurut-kelompok-umur-dan-jenis-kelamin-2018-.html. [Accessed 9 December 2020].

[6] Jackson C, Vynnycky E, Hawker J, Olowokure B, Mangtani P. School closures and influenza: systematic review of epidemiological studies. BMJ Open 2013;3:e002149.

[7] Perlroth DJ, Glass RJ, Davey VJ, Cannon D, Garber AM, Owens DK. Health outcomes and costs of community mitigation strategies for an influenza pandemic in the United States. Clin Infect Dis 2010;50(2):165–74.

[8] Halder N, Kelso JK, Milne GJ. Cost-effective strategies for mitigating a future influenza pandemic with H1N1 2009 characteristics. PLoS One 2011;6(7):e22087.

[9] Goh G. Epidemic calculator. 2020. http://gabgoh.github.io/COVID/index.html. [Accessed 10 September 2020].

[10] Statistics of Indonesia. Population by age and sex. 2018-2020. https://www.bps.go.id/indicator/12/1886/1/jumlah-penduduk-hasil-proyeksi-menurut-provinsi-dan-jenis-kelamin.html. [Accessed 10 September 2020].

[11] Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. N Engl J Med 2020;382(13):1199–207.

[12] Verity R, Okell LC, Dorigatti I, Winskill P, Whittaker C, Imai N, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. Lancet Infect Dis 2020;S1473–3099(20):30243–7.

[13] Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020;S0140–6736(20). https://doi.org/10.1016/S0140-6736(20)30566-3. 30566-3.

[14] Imperial College COVID-19 Response Team. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID- 19 mortality and healthcare demand. https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf. [Accessed 10 September 2020].

[15] Halder N, Kelso JK, Milne GJ. Cost-effective strategies for mitigating a future influenza pandemic with H1N1 2009 characteristics. PLoS One 2011;6(7):e22087.

[16] Milne GJ, Halder N, Kelso JK. The cost effectiveness of pandemic influenza interventions: a pandemic severity based analysis. PLoS One 2013;8(4):e61504.

[17] Hilfi L, Setiawati EP, Djuhaeni H, Paramita SA, Komara R. The differences of unit cost calculation by activity based costing (ABC) method and double distribution (DD) method for category 2 of pulmonary TB patients in outpatient and inpatient of lung hospital. JKKI 2015;1(2):63–70.

[18] Statistics of Jakarta. Life expectancy years. https://ipm.bps.go.id/data/provinsi/metode/baru/3100. [Accessed 10 September 2020].

[19] Statistics of Indonesia. GDP per capita. https://www.bps.go.id/dynamictable/2015/10/07/957/-seri-2010-produk-domestik-regional-bruto-per-kapita-atas-dasar-harga-berlaku-menurut-provinsi-2010-2018-ribu-rupiah-.html. [Accessed 10 September 2020].

[20] Ministry of Finance. Dana BOS tahun 2020 naik dan sudah bisac air di Januari. https://www.kemenkeu.go.id/publikasi/berita/dana-bos-tahun-2020-naik-dan-sudah-bisa-cair-di-januari/. [Accessed 10 September 2020].

[21] The Central Bank of Indonesia. Exchange rate information. https://www.bi.go.id/id/moneter/informasi-kurs/transaksi-bi/Default.aspx. [Accessed 10 September 2020].

[22] Jackson ML, Hart GR, McCulloch DJ, et al. Effects of weather-related social distancing on city-scale transmission of respiratory viruses. medRxiv 2020. https://doi.org/10.1101/2020.03.02.20027599. published online March 3.

[23] Tian H, Liu Y, Li Y, et al. The impact of transmission control measures during the first 50 days of the COVID-19 epidemic in China. medRxiv 2020. https://doi.org/10.1101/2020.01.30.20019844. published online March 10.

[24] Lai S, Ruktanonchai NW, Zhou L, et al. Effect of non-pharmaceutical interventions for containing the COVID-19 outbreak. medRxiv 2020. https://doi.org/10.1101/2020.03.03.20029843. published online March 13.

[25] Earn DJ, He D, Loeb MB, Fonseca K, Lee BE, et al. Effects of school closure on incidence of pandemic influenza in Alberta, Canada. Ann Intern Med 2012;156(3):173–81.

[26] Wong ZS-Y, Goldsman D, Tsui K-L. Economic evaluation of individual school closure strategies: the Hong Kong 2009 H1N1 pandemic. PLoS One 2016;11(1):e0147052.

[27] Eames KT, Tilston NL, Brooks-Pollock E, Edmunds WJ. Measured dynamic social contact patterns explain the spread of H1N1v influenza. PLoS Comput Biol 2012;8:e1002425.
[28] Jackson C, Mangtani P, Hawker J, Olowokure B, Vynnycky E. The effects of school closures on influenza outbreaks and pandemics: systematic review of simulation 23 studies. PLoS One 2014;9(5):e97297.
[29] Sadique MS, Adams EJ, Edmunds WJ. Estimating the costs of school closure for mitigating an influenza pandemic. BMC Publ Health 2008;8:135.
[30] Viner RM, Russell SJ, Croker H, Packer J, Ward J, Stansfield C, Mytton O, Bonell C, Booy R. School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. Lancet Child Adolesc Health 2020;4(5):397–404.
[31] Pe rez Velasco R, Praditsitthikorn N, Wichmann K, Mohara A, Kotirum S, et al. Systematic review of economic evaluations of preparedness strategies and interventions against influenza pandemics. PLoS One 2012;7(2):e30333.
[32] Smith RD, Keogh-Brown MR, Barnett T, Tait J. The economy-wide impact of pandemic influenza on the UK: a computable general equilibrium modelling experiment. BMJ 2009;339:b4571.
[33] Nsoesie EO, Beckman RJ, Marathe MV. Sensitivity analysis of an individual-based model for simulation of influenza epidemics. PLoS One 2012;7(10):e45414.

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PAGE 2

PAGE 3

PAGE 4

PAGE 5

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PAGE 7

PAGE 8