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Why Does Indonesia Have a High Covid-19 Case-Fatality Rate?

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Abstract

The COVID-19 pandemic has taken the world by storm, but the magnitude of its impact differs from country to country. As of August 2020, Indonesia's COVID-19 case-fatality rate is higher than the world average. The aim of our research is to find out why Indonesia has a high COVID-19 case-fatality rate. Using OLS regression models, we found the number of COVID-19 related deaths, the number of COVID-19 tests performed, population age, population, voice and accountability index, and control of corruption index are significant predictors of a country's COVID-19 case-fatality rate. Based on our results, we conclude that Indonesia's COVID-19 case-fatality rate is higher than it is supposed to be, mainly because of a lack of COVID-19 testing and accurate public information.

Key words : COVID-19, Coronavirus, Case-fatality, Indonesia, Regression

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INTRODUCTION

On March 11, 2020, the coronavirus, formally known as COVID-19, has been declared as a pandemic by the World Health Organization (World Health Organization, 2020). Since then, the virus has infected more than 40 million people and has taken more than 1 million lives. As of August 31, 2020, the world's COVID-19 case-fatality rate is 2.68% (Our World in Data, 2020). In Indonesia, the COVID-19 case-fatality rate as of October 20, 2020, is 4.27%. While this has decreased dramatically from 8.73% (April 20, 2020), Indonesia's COVID-19 case-fatality remains above the world average.

The COVID-19 pandemic has hit each country differently. Compared to Indonesia, Italy's COVID-19 case-fatality rate is much higher (13.23% as of August 31, 2020). In contrast, Singapore's COVID-19 case-fatality rate is much lower than Indonesia (0.05% as of August 31, 2020). Therefore, we are interested in analyzing the economic factors of COVID-19 cases, COVID-19-related deaths, and COVID-19 case-fatality rate. We are also interested in understanding why Indonesia's COVID-19 case-fatality rate is higher than the world average.

The hypotheses of our research are as follows.

Table 1. Research Hypotheses

H_1	A country's number of COVID-19 tests has a significant impact on the country's number of COVID-19 cases.
H_2	A country's number of COVID-19 tests has a significant impact on the country's number of COVID-19 related deaths.
H_3	A country's number of COVID-19 tests has a significant impact on the country's COVID-19 case-fatality rate.
H_4	A country's strictness in applying COVID-19 related protocols has a significant impact on the country's number of COVID-19 cases.
H_5	A country's strictness in applying COVID-19 related protocols has a significant impact on the country's number of COVID-19 related deaths.
H_6	A country's strictness in applying COVID-19 related protocols has a significant impact on the country's number of COVID-19 case-fatality rate.
H_7	A country's COVID-19 testing policy has a significant impact on the country's number of COVID-19 cases.
H_8	A country's COVID-19 testing policy has a significant impact on the country's number of COVID-19 related deaths.
H_9	A country's COVID-19 testing policy has a significant impact on the country's number of COVID-19 case-fatality rate.
H_{10}	A country's population average age has a significant impact on the country's number of COVID-19 cases.
H_{11}	A country's population average age has a significant impact on the country's number of COVID-19 related deaths.
H_{12}	A country's population average age has a significant impact on the country's number of COVID-19 case-fatality rate.
H_{13}	A country's human quality has a significant impact on the country's number of COVID-19 cases.
H_{14}	A country's human quality has a significant impact on the country's number of COVID-19 related deaths.
H_{15}	A country's human quality has a significant impact on the country's number of COVID-19 case-fatality rate.
H_{16}	A country's quality of health system has a significant impact on the country's number of COVID-19 cases.
H_{17}	A country's quality of health system has a significant impact on the country's number of COVID-19 related deaths.
H_{18}	A country's quality of health system has a significant impact on the country's number of COVID-19 case-fatality rate.

H_{19}	A country's number of population has a significant impact on the country's number of COVID-19 cases.
H_{20}	A country's number of population has a significant impact on the country's number of COVID-19 related deaths.
H_{21}	A country's number of population has a significant impact on the country's number of COVID-19 case-fatality rate.
H_{22}	A country's level of freedom of speech has a significant impact on the country's number of COVID-19 cases.
H_{23}	A country's level of freedom of speech has a significant impact on the country's number of COVID-19 related deaths.
H_{24}	A country's level of freedom of speech has a significant impact on the country's number of COVID-19 case-fatality rate.
H_{25}	A country's level of corruption has a significant impact on the country's number of COVID-19 cases.
H_{26}	A country's level of corruption has a significant impact on the country's number of COVID-19 related deaths.
H_{27}	A country's level of corruption has a significant impact on the country's number of COVID-19 case-fatality rate.

The first human case of COVID-19 is currently presumed to be initiated by animal-to-human transmission (Stratton, 2020). However, there has been no confirmation of where the virus comes from or who patient zero is at this writing time. Not to mention, the nature of the coronavirus itself is still unclear. Since the pandemic is still happening at the time of this writing, the number of extensive and in-depth research around COVID-19 is still limited. However, in this short time, there have been many academic papers published on the subject already.

One country that has a very high COVID-19 death rate is Italy. Why is Italy's COVID-19 death rate so high compared to other countries such as China? Several factors have been suggested as reasons why countries have different COVID-19 death rates, such as population age, the definition of COVID-19 related deaths, and testing strategies (Onder, Rezza, & Brusaferro, 2020). Using direct standardization, it was found that differences in testing strategies could be the most important factor in the difference in the COVID-19 death rate between Italy and China, as Italy tends to test only those who have shown severe symptoms (Barone-Adesi, Ragazzoni, & Schmid, 2020).

Boccia, Ricciardi, & Ioannidis also noted some factors as the reason for Italy's high death rate. The factors include the high number of elderly populations, a high proportion of patients with a history of smoking, and a high rate of chronic obstructive pulmonary disease and ischemic heart disease (Boccia, Ricciardi, & Ioannidis, 2020). Besides that, the lack of health care systems, such as ICU beds and sub intensive care beds, can also cause a high death rate in Italy. The hospital overcrowding may also explain the high infection rate in Italy, which, in the end, can create a high death rate.

The health care system and testing strategies also affect the death rate differences between countries (Gaye, Fanidi, & Jouven, 2020). The health care system includes the clinical management and care of COVID-19 patients, which can vary across countries. The heterogeneity in testing strategies, such as the kits used to detect COVID-19 and the number of tests per day, can also cause the death rate difference. The variability in assessing the number of deaths per day is also an essential factor for the death rate. For example, the number of deaths mentioned in one country corresponds to the number of deaths in the

hospital, while it did not count the one who died at home.

In contrast, Japan and Germany have a low death rate. In Japan, the main factors are its culture and health history (Iwasaki & Grubaugh, 2020). It is well known that Japanese culture does not involve handshaking, hugging, or kissing when greeting. Japanese also seems to wear face masks long before COVID-19 to avoid transmission of respiratory infection. Besides that, Japan has mandatory childhood BCG vaccines against tuberculosis (Iwasaki & Grubaugh, 2020). Countries with compulsory BCG vaccines show a relatively low death rate from COVID-19 compared to countries with no mandatory BCG vaccines, such as the USA, Spain, France, Italy, and the Netherlands.

In Germany, the low death rate can be associated with an early and high level of testing among a broad sample of the German population (Stafford, 2020). Since they perform many tests, it is more likely that a new case can be found, which leads to a higher total COVID-19 case compared to the number of deaths. Germany also took action to prevent the spread of COVID-19, such as closing school and retail business; banning gathering of people; mandating the isolation of people who had COVID-19.

However, the death rate's accurate estimation depends on the other factors; one is the testing strategy (Pearce, Vandenbroucke, VanderWeele, & Greenland, 2020). In some countries, the tests were conducted only for people with symptoms. Using this approach, the asymptomatic will remain untested. Instead of using the actual number of infected who have died, the estimation of death rate uses the number of infected who have tested positive and have died, resulting in overestimating or underestimating the death rate. Moreover, test performance also affects the death rate's accurate estimation since no test provides 100% accurate results, leading to the overestimation or underestimation of the death rate.

METHOD

A country's COVID-19 case-fatality rate is defined as:

$$casefatality_i = \frac{deaths_i}{cases_i} \quad (1)$$

Where $casefatality_i$ represent the COVID-19 case-fatality rate *of country i* (measured as a ratio), $deaths_i$ represents the number of deaths caused by COVID-19 in country *i*, and $cases_i$ represents the number of recorded COVID-19 cases in country. This means other variables can affect a country's COVID-19 case-fatality rate directly or through variations in the number of COVID-19 related deaths or in the number of COVID-19 cases.

One way to estimate the relationship between COVID-19 case-fatality rate, number of deaths, number of cases, and other variables is to use Ordinary Least Squares (OLS). Consider the following equations.

$$cases = \beta X + u \quad (2)$$
$$deaths = \beta X + u \quad (3)$$
$$casefatality = \beta X + u \quad (4)$$

Where X represents observed variables that can affect their respective independent variables, β represents the regression parameters, and u represents the error term. We considered using panel data regression models, but we decided against it due to a lack of data.

The main data set we used is obtained from Our World in Data (Our World in Data, 2020). The data set consists of daily COVID-19-related data from 210 countries from December 31, 2019, and it is being updated daily by adding the newest data. It consists of variables such as the total number of COVID-19 cases, the number of deaths caused by COVID-19, the number of COVID-19 tests performed, a

country's COVID-19 stringency index, population, population density, the population proportion for 65 years old and older, real GDP per capita, the death rate from cardiovascular disease, the proportion of women who smoke, the proportion of men who smoke, the number of hospital beds per 1000 people and the human development index.

Our World in Data collected the data from several different sources. The COVID-19 number of cases and deaths data are collected from the European Centre for Disease Prevention and Control (European Centre for Disease Prevention and Control, 2020). The number of tests performed by each country is collected by the Our World in Data team from national government reports. The other variables such as population (United Nations, 2020), population density (The World Bank, 2020), real GDP per capita (The World Bank, 2020), population ages 65 or above (The World Bank, 2020), the death rate from cardiovascular disease (Institute for Health Metrics and Evaluation, 2018), smoking prevalence for women (The World Bank, 2020), smoking prevalence for men (The World Bank, 2020), hospital beds per 1000 people (The World Bank, 2020), and human development index (United Nations Development Programme, 2020) are obtained from various sources such as The World Bank and The United Nations. We also added smoking prevalence for all (The World Bank, 2020) to our data set.

The stringency index is an index (from 0 to 100) that measures a country's strictness of government policies as a response to COVID-19, based on school closures, workplace closures, cancellation of public events, restriction of public gatherings, closures of public transport, stay-at-home requirements, public information campaigns, restrictions on interval movements, and international travel controls. The index is published by Blavatnik School of Government and University of Oxford (Hale, Webster, Petherick, Phillips, & Kira, 2020).

We also added a country's testing policy as a variable. The testing policy is a categorical variable that described a country's testing policy regarding COVID-19. The categories are represented with the number 0 to 3, and the testing policy categories are no testing policy (0), testing those who show symptoms and are in key groups (1), testing those with symptoms (2), and open public testing (3). Testing policy data is also published by Blavatnik School of Government and University of Oxford (Hale, Webster, Petherick, Phillips, & Kira, 2020).

Finally, we decided to add World Governance Indicators (WGI) data, including voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. The WGI data is downloaded from The World Bank and initially published by Kaufmann, Kraay, and Mastruzzi (Kaufmann, Kraay, & Mastruzzi, 2010). The WGI variables are measured as separate indices that range from -2.5 to 2.5.

The research framework for this research is as follows.

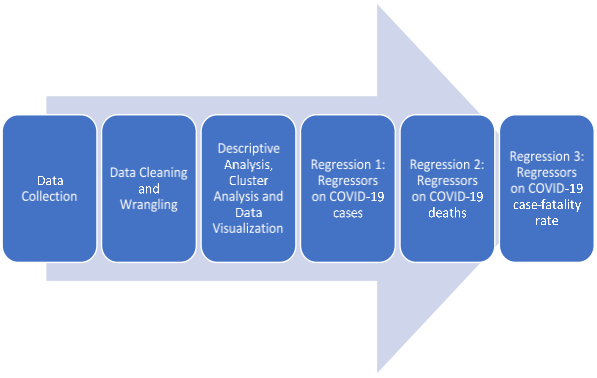

Figure 1. Research Frmework

RESULTS AND DISCUSSION

We decided to choose August 31, 2020, as the date used for our analysis. We calculated the number of days between August 31, 2020, and the first day a country has a recorded COVID-19 case for all countries and find the average number of days to be 178 days. The minimum number of days is 109 days, and the maximum number of days is 245 days. We check this so that we do not include countries that have only experienced COVID-19 for just a couple of days.

The following tables show the descriptive summary statistics for the variables on August 31, 2020, used in this manuscript.

Table 2. Descriptive Summary Statistics COVID-19 Variables

	TOTAL CASES	TOTAL DEATHS	CASE FATALITY RATE	TOTAL TESTS	STRINGENCY INDEX	TESTING POLICY
Mean	120933.3	4052.378	0.026775	3279289	55.74395	1.9375
Median	5961	109	0.019603	663871.5	57.41	2
Maximum	5997163	183069	0.288786	89489959	96.3	3
Minimum	3	0	0	8408	8.33	0
Std. Dev.	559882	17101.3	0.030356	11166872	20.39261	0.801115
Observations	209	209	209	88	177	176

Table 3. Descriptive Summary Statistics Other Variables

	AGED 65 OLDER	HUMAN DEVELOPMENT INDEX	HOSPITAL BEDS PER THOUSAND	POPULATION	VOICE	CORRUPTION
Mean	8.80783	0.709994	3.012671	37083651	-0.027495	-0.015416
Median	6.659	0.741	2.3585	6871287	0.029661	-0.188656
Maximum	27.049	0.953	13.8	1.44E+09	1.686955	2.170071
Minimum	1.144	0.354	0.1	809	-2.193209	-1.773724
Std. Dev.	6.205392	0.155006	2.464917	1.43E+08	0.98057	1.00373
Observations	182	179	164	209	187	187

It can be seen from Table 2 and Table 3 that the number of observations for each variable differs from one another. The difference is caused by the fact that there are missing data. One country in particular (Hong Kong) has too many missing data, and we decided to exclude it from our analysis altogether.

Based on Table 2 and Table 3, we can see that the average number of COVID-19 cases and deaths are 120933 cases and 4052 deaths, respectively. The case-fatality rate is calculated as total cases divided by total deaths, and the average case-fatality rate is 2.68%. The standard deviation for total tests is high, and we only have 88 observations for total tests. However, we decided to keep the variable as it is of interest to us. The average stringency index is 55.74 out of 100, which means that the government policies response to COVID-19 in all countries is not very strict. The statistics for testing policy show that 50% of the world has implemented a testing policy that tests all who show symptoms. We also see that roughly 8.81% of the world population is aged 65 or older.

Since we use total cases as our denominator for the case-fatality rate, we cannot use countries with 0 cases. Furthermore, to satisfy OLS's normality assumption, we decided to transform several variables into their logarithmic form. These variables include

COVID-19 cases, deaths, and case-fatality rate and thus, we are also excluding countries that show 0 deaths and 0 case-fatality rate from our regression analyses.

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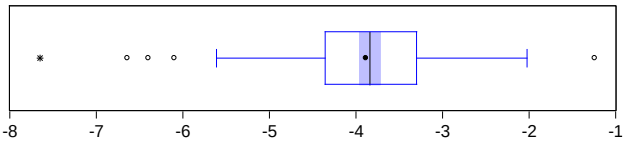

Source: Data processed

Figure 2. Box Plot of ln (Case-Fatality)

Even after transforming case-fatality rate into its logarithmic form, we still find an outlier, which is Singapore (see Figure 2). Thus, we decided to exclude Singapore from our regression analyses as well.

The next thing we want to see is the correlation between the logarithmic form of total cases, total deaths, and case-fatality rate. The following table shows a correlation analysis between the three variables.

Table 4. Correlation Matrix of ln(cases), ln(deaths) and ln(case-fatality), with its p-values in brackets

	ln(cases)	ln(deaths)	ln(case-fatality)
ln(cases)	1		
	---		
ln(deaths)	0.9495	1	
	(0.0000)	---	
ln(case-fatality)	0.0925	0.4117	1
	(0.2081)	(0.0000)	---

Source: Data processed

Based on both magnitude and statistical significance, we can see from Table 4 that case-fatality rate is more correlated with deaths than with cases. There is a significant positive correlation between ln(cases) and ln(deaths); a significant positive correlation between ln(deaths) and ln(case-fatality); but there is no significant correlation between ln(cases) and ln(case-fatality). Nevertheless, we are still interested in all three variables.

Next, we used an OLS regression analysis to determine what factors affect a country's number of COVID-19 cases. We used backward stepwise selection to obtain the following output. We will refer to this model as model (2).

Table 5. Regression Output of ln(cases) on regressors, with p-values in brackets Model (2)

Variable (Dependent Variable = ln(cases))	Estimate
Constant	-5.2259 (0.0000)***
ln(tests)	1.1387 (0.0000)***
Stringency Index	0.0200 (0.0092)***
Age 65 or Older	-0.0953 (0.0011)***
Voice	0.819 (0.0002)***
Corruption	-0.6462 (0.0005)***
F Statistic	55.1307 (0.0000)***
R-Squared	0.7794
Akaike Info Criterion	2.9982
Jarque-Bera Statistic	5.2815 (0.0713)*
White Statistic	20.7721 (0.4107)
RESET Statistic	0.7343 (0.3941)
Included Observations	84

* = significant at 10%; *** = significant at 1%

Source: Data processed

Based on Table 5, we can see that the number of tests performed has a significant positive impact on the number of COVID-19 cases. An increase in the number of tests by 1% is expected to increase COVID-19 cases by 1.14%, ceteris paribus. The increment is expected, as we can find more infected patients by doing more tests. However, using the number of tests as one of our regressors reduces our included observations to 84.

The other results are interesting. Based on our estimation, an increase in stringency index by 1 point is expected to increase the number of COVID-19 cases by 2%, ceteris paribus. The empirical result is interesting as we expect a higher stringency index would reduce the number of cases, but as we are using the cumulative number of cases as at August 31, 2020, perhaps a high stringency index is a response to high number of COVID-19 cases. Moreover, an increase in a country's population share of 65 years or older by 1% point is expected to reduce COVID-19 cases by 9.53%, ceteris paribus. Common sense suggests that COVID-19 would be able to infect older residents more easily. Still, our estimates indicate that the relationship between COVID-19 cases and the more aging population in a country is negative. One possible explanation why this is the case is that perhaps older residents tend to be more risk-averse and spend less time in public gatherings, and hence reducing the spread of COVID-19.

The coefficient estimates of the WGI indicators show interesting results as well. An increase in the voice and accountability index by 1 point is expected to increase COVID-19 cases by 81.9%, ceteris paribus. In contrast, an increase in the control of corruption index by 1 point is expected to reduce COVID-19 cases by 64.62%, ceteris paribus. It is important to remember that the WGI indices represent views of experts and many citizens regarding the quality of governance in a country, not the direct measures of the quality itself. For example, the control of corruption index represents how experts and citizens view a country's ability to control corruption and is not an official measurement of a country's corruption level. However, these two estimated coefficients together may tell that a country that is willing to use public power for private gains may perhaps willingly or unwillingly misinform the public by providing inaccurate information. We will discuss this more in a later section. Note that the WGI indices range from -2.5 to 2.5, so an increase by 1 point is huge in terms of magnitude.

In addition, we found no evidence of heteroskedasticity, specification bias, or multicollinearity in model (2). The errors are still normally distributed at a 5% level of significance.

We used backward stepwise selection in OLS to observe what factors affect a country's number of COVID-19 related deaths. The following table summarizes the regression output, and we will refer to this model as model (3).

Table 6. Regression output of ln(deaths) on regressors, with p-values in brackets (calculated based on White heteroskedasticity-consistent standard errors) Model (3)

Variable (Dependent Variable = ln(deaths))	Estimate
Constant	-0.7319
	(0.6228)
ln(cases)	0.6466
	(0.0188)**
ln(cases)^2	0.0222
	(0.0984)*
Age 65 or older	0.1050
	(0.0000)***
Human Development	-1.8725
Index	(0.0268)**
Hospital Beds per	-0.0824
1000 People	(0.0045)***
Testing Policy -	-1.1964
Specific	(0.0861)*
Testing Policy -	-1.2659
Symptom	(0.0702)*
Testing Policy - Open	-1.3869
	(0.0501)*
F Statistic	186.4622
	(0.0000)***
R Squared	0.9210
Akaike Info Criterion	2.2398
Jarque-Bera Statistic	1.6275
	(0.4432)
White Statistic	57.6125
	(0.0069)***
RESET Statistic	0.2043
	(0.6520)
Included Observations	137

* = significant at 10%; ** = significant at 5%; *** = significant at 1%

Source: Data processed

We can see from Table 6 that there is a quadratic logarithmic positive significant relationship between the number of COVID-19 cases and COVID-19 deaths.

The coefficient estimates from model (3) show reasonable results. An increase in the population share of 65-year-old or older by 1% point is expected to increase COVID-19 deaths by 10.5%, ceteris paribus. The result is expected, as we expect older residents to have weaker resistance against COVID-19, leading to the increment of deaths. On the other hand, an increase in the human development index (HDI) by 1 point is expected to reduce COVID-19 deaths by 187.25%, ceteris paribus. HDI is calculated based on three dimensions: long and healthy life, knowledge, and a decent standard of living. Thus, the negative relationship between HDI and COVID-19 deaths may represent how increasing human quality can lead to more preparedness in facing a pandemic such as COVID-19. In addition, an increase in the number of hospital beds per 1000 people by 1 bed per 1000 people is expected to decrease COVID-19 deaths 8.24%, ceteris paribus. The result shows how having more medical equipment can save more lives from COVID-19.

The testing policy dummies show that a more open testing policy tends to lead to less COVID-19 deaths. Compared to having no testing policy, a country with open public testing is expected to have less COVID-19 deaths, on average, by 138.69%, ceteris paribus.

Our results are reasonable as a more open testing policy provides more opportunities for residents to get tested. By detecting the infection early, a COVID-19 patient is more likely to survive.

There is evidence of heteroskedasticity in model (3), so we used White-heteroskedasticity standard errors. The errors are normally distributed, and there is no evidence of specification bias nor multicollinearity.

The following table shows the OLS regression output that shows the estimators of a country's COVID-19 case-fatality rate. The regressors are chosen using backward stepwise selection, and we will refer to this model as model (4).

Table 7. Regression output of ln(case-fatality) on regressors, with p-values in brackets (calculated based on White heteroskedasticity-consistent standard errors) Model (4)

Variable (Dependent Variable = ln(case-fatality))	Estimate
Constant	-3.5633 (0.0003)***
ln(deaths)	0.3507 (0.0000)***
Aged 65 or Older	0.0906 (0.0000)***
ln(tests)	-0.5307 (0.0000)***
ln(population)	0.2180 (0.0002)***
Corruption	0.3069 (0.0284)**
Voice	-0.2408 (0.0831)*
F Statistic	23.6927 (0.0000)***
R Squared	0.6457
Akaike Info Criterion	1.5942
Jarque-Bera Statistic	6.7395 (0.0344)**
White Statistic	56.5433 (0.0007)***
RESET Statistic	0.0447 (0.8332)
Included Observations	85

* = significant at 10%; ** = significant at 5%; *** = significant at 1%

Source: Data processed

We can see from Table 7 that there is a significant positive relationship between the number of COVID-19-related deaths and the COVID-19 case-fatality rate, where an increase in COVID-19 deaths by 1% is expected to increase the COVID-19 case-fatality rate by 0.35%, ceteris paribus. Moreover, like its impact on COVID-19 deaths, model (4) shows that an increase in the population share of 65-year-old or older is expected to increase COVID-19 case-fatality rate by 9.06%, ceteris paribus.

An increase in the number of COVID-19 tests performed by 1% is expected to decrease COVID-19 case-fatality rate by 0.53%, ceteris paribus. Like the testing policy, by performing more tests, those infected by COVID-19 can be detected earlier. Hence, they will get professional treatment before the disease becomes much worse. Furthermore, an increase in population by 1% is expected to increase the case-fatality rate by 0.22%, ceteris paribus.

Interestingly, the WGI indices have a significant impact not only on the number of COVID-19 cases but also on COVID-19 case-fatality rate. An increase in the control of corruption index by 1 point is expected to increase COVID-19 case-fatality rate by 30.69%, ceteris paribus. In contrast, an increase in the voice and accountability index by 1 point is expected to reduce COVID-19 cases by 24.08%, ceteris paribus. Perhaps, these two estimates show how the level of control a country has on

the accuracy of public data may play a part in how a country's number of COVID-19 cases and case-fatality rate are reported.

Similar to the previous model, model (4) also exhibits heteroskedasticity, so we decided to use White-heteroskedasticity standard errors here as well. It has non-normality problems in the error terms, but not at a 1% level of significance. Furthermore, it shows no sign of specification bias nor multicollinearity.

Out of all three models we have estimated, model (3) has the highest coefficient of determination. When we use model (3) to calculate Indonesia's estimated number of COVID-19 deaths, we expected Indonesia to have 4319,16 COVID-19 deaths as of August 31, 2020, or a case-fatality rate of 2.51%. This means there is a 1.76% points difference between our estimate and Indonesia actual case-fatality rate of 4.27% as of August 31, 2020. While this may look like a small difference, one way to take this is that we estimate Indonesia's case-fatality rate to be below the world case-fatality rate of 2.68%, and yet Indonesia's actual case-fatality rate is higher than the world average.

A glance in Indonesia's macroeconomic variables shows that one specific statistic makes Indonesia stand out: the proportion of male smokers. In terms of the proportion of male smokers, Indonesia has the second-highest number of 76.1%, which is only preceded by Timor (78.1%). Timor used to be a part of Indonesia and has a much smaller population compared to Indonesia. However, we found the proportion of male smokers to have no significant impact on the number of COVID-19 cases, the number of COVID-19 deaths, nor the COVID-19 case-fatality rate. The finding is inconsistent with the research done by Boccia, Ricciardi & Ioannidis (Boccia, Ricciardi, & Ioannidis, 2020), who stated that the population proportion of smokers has a significant impact on a country's COVID-19 case-fatality rate. We argue that more data is needed to draw a more convincing conclusion on the relationship between smokers' proportion and the COVID-19 case-fatality rate.

Consistent with the researches that had been done on COVID-19 case-fatality rate in other countries (Onder, Rezza, & Brusaferro, 2020; Boccia, Ricciardi, & Ioannidis, 2020; Barone-Adesi, Ragazzoni, & Schmid, 2020; Gaye, Fanidi, & Jouven, 2020; Pearce, Vandenbroucke, VanderWeele, & Greenland, 2020), we found population share of 65 years old or older (as a proxy to population age) and testing policies to have a significant impact on COVID-19 case-fatality rate, whether directly or indirectly through the number of COVID-19 deaths. We also found the number of hospital beds per 1000 people to be a significant estimator of COVID-19 deaths. This conclusion was also stated in previous research (Boccia, Ricciardi, & Ioannidis, 2020) regarding how hospital overcrowding may impact the COVID-19 death rate.

The number of tests performed has also been proven to be a significant predictor of the number of COVID-19 cases and the COVID-19 case-fatality rate; this conclusion also supports previous research (Stafford, 2020). As of August 31, 2020, Indonesia has done 1282618 COVID-19 tests. The test number was much smaller compared to the world average, which was at 3279289 tests. Many different variables could cause a lack of COVID-19 test but one factor could be the fact that coronavirus stigma runs deep and dangerous in Indonesia (Lamb & Widianto, 2020). People are afraid of being shunned as a response to being infected by COVID-19.

Before we ran our regression analyses above, we decided to do some cluster analyses to see where Indonesia falls when we divide world countries based on COVID-19 case-fatality rate, stringency index, population density, the proportion of age 65 or older, cardiovascular death rate, human development index, and testing policy. The variables were chosen based on variables that were mentioned in previous researches. Still, we also want to keep each variable's level of independence while keeping the sample size high enough. We ended up using 158 countries for our cluster analysis. Our elbow plot shows k = 2 to be ideal, but we decided to run k-means clustering using k = 2, 4, 6, and 8. When we used k = 2, k = 4, and k = 8, Indonesia is always in a cluster with a case-fatality rate of around 2-3%, and yet its actual case-fatality rate is at 4.27%. Perhaps, this indicates that Indonesia, given its level of stringency index, HDI, and other variables used in the cluster analysis, should have a lower COVID-19 case-fatality rate.

When we used k = 6, the result was more interesting. We found Indonesia to be in a group with 14 other countries: Albania, Azerbaijan, Bulgaria, Egypt, Georgia, Guyana, Kyrgyzstan, Moldova, Papua New Guinea, Serbia, Sudan, Ukraine, Uzbekistan, and Yemen. The average COVID-19 case-fatality rate for these 15 countries is 4.58%, which is close to Indonesia 4.27% COVID-19 case-fatality rate. Interestingly, except for Georgia, each country in this cluster has a negative WGI control of corruption index. The world average of WGI control of corruption index is 0, and hence 14 out of 15 countries that are in this cluster is in the bottom 50% of the world in terms of control of corruption.

Based on model (2) and (4), we found control of corruption index to have a negative significant impact on the number of COVID-19 cases; and we also found control of corruption index to have a positive significant impact on COVID-19 case-fatality rate. In our introduction, we mentioned that all COVID-19 researches would not give any meaningful conclusions if the countries' data are inaccurate. At the end of the day, it is very important for countries to provide accurate, honest data available to the public, specifically for researchers and academics. While the WGI control of corruption index may or may not fully represent a country's actual level of corruption, the fact that our findings suggest how the control of corruption may affect a country's COVID-19 numbers cannot be ignored.

The WGI control of corruption index reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption and capture of the state by elites and private interests (Kaufmann, Kraay, & Mastruzzi, 2010). Indonesia has a legacy of controlling public information to obtain private gain (Baskoro, 2018). While Indonesia has moved far away from The New Order (1966-1998), controlling public COVID-19 information to regulate the masses would not be difficult to imagine, whether or not the reasoning behind it is good or bad.

The lack of accuracy in Indonesia's COVID-19 data was mentioned in April 2020 by Reuters (Reuters, 2020), who suggested Indonesia has a higher COVID-19 death rate than the official reported number. Furthermore, Financial Times also reported in April 2020 that there was an increase of 1400 in the number of burials compared to the historical average in the same period, and the number is 15 times higher than the reported number of COVID-19 deaths in the same period (Burn-Murdoch, Romei, & Giles, 2020). A former study conducted by Martinez de Salazar Munoz et al. (Martinez de Salazar Munoz, Niehus, Taylor, Buckee, & Lipsitch, 2020) was also found that Indonesia may have undetected cases. Therefore, it is important to note that we are not for or against

censoring public information for the greater good.

The government's response to research and academic finding related to COVID-19 is also important since the policy should be made based on the empirical finding. However, many events show that the government might not accept all the findings, as elaborated in The Jakarta Post (The Jakarta Post, 2020). The blindfold of empirical findings may lead the policymakers to have an incorrect decision to handle COVID-19, and it may lead to the lack of accuracy in COVID-19's data as well.

One variable that has not been mentioned in our results and discussions is the "definition of COVID-19 deaths" variable that was considered important in previous research (Onder, Rezza, & Brusaferro, 2020). We did not include this variable in our research because we simply do not have enough data on the definition of COVID-19 deaths that is used for each country. Similar to our point regarding the importance of public data accuracy, the differences in the definition of COVID-19 deaths between countries can affect our analysis significantly. On September 17, 2020, Indonesia's Ministry of Health stated that they plan to narrow the definition of COVID-19 related deaths (Wibowo, 2020). Therefore, more research can be done in the future to observe the impact of the change in the definition COVID-19 death, although a decrease in COVID-19 case-fatality rate that is caused by a simple change in definition does not necessarily mean things are getting better.

CONCLUSION

In conclusion, we found the number of COVID-19 related deaths, population proportion of aged 65 or older, the number of COVID-19 tests done, population, control of corruption index, and voice and accountability index to be significant predictors of COVID-19 case-fatality rate. We argue that more COVID-19 cases will be detected by doing more tests, but it will reduce the case-fatality rate as those who are detected early are more likely to survive. Furthermore, we found that a country with a lower control of corruption index, i.e., a country that is perceived as more corrupt by residents and experts, tend to have a lower number of COVID-19 cases and a higher COVID-19 case-fatality rate. We argue that this could show how a country that is more willing to control public information for private gains are more likely to report inaccurate COVID-19 numbers. Hence, when it comes to Indonesia, we argue that Indonesia's COVID-19 case-fatality rate is higher than it is supposed to be because Indonesia's actual number of COVID-19 cases might be higher than what is reported. This is supported by the fact that Indonesia has done significantly fewer tests compared to the world average.

Thus, our recommendation for policymakers is to focus more on removing the very negative stigma of the infected, as the fear of being shunned is very likely to be why the number of tests performed is very low. We also recommend policymakers put more effort on providing accurate information to the public since the accuracy of information itself can be used to a better policy formulation in fighting the COVID-19.

The novelty our research is finding the connection between corruption and the number COVID-19 cases and hence, COVID-19 case-fatality rate. For future researches, we recommmend researchers to dig a little deeper on information inaccuracy, and try to observe it's psychological impact on a country's residents, especially on their COVID-19 related

actions. Note that our research is not without limitations; in this case, the lack of available data and the fast-paced real-world changes can weaken our findings.

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