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ЭПИДЕМИОЛОГИЯ

Correlation between Completeness Status of COVID-19 Vaccination and Death of Confirmed COVID-19 Cases in Jakarta, July – December 2021

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Summary

Introduction: According to data from the Jakarta Health Office, infectious diseases are among the top causes of death in the city, ranking third from 2016 to 2019 and rising to first place in 2021. The ratio of COVID-19-related deaths to all reported deaths also increased in 2021 compared to 2020. Despite the importance of vaccination, the coverage in DKI Jakarta were below the target up until the last day of vaccination program.

Objective: To determine the correlation between the completeness of the COVID-19 vaccination status and the death of confirmed COVID-19 cases.

Materials and methods: This is a retrospective cohort study with 1,881 samples from Jakarta Health Office COVID-19 surveillance data from July to December 2021, analyzed using Cox regression.

Results: The crude-hazard ratio correlation between the completeness of COVID-19 vaccination status and death in confirmed cases was 3.19 (95 % CI: 2.06 to 4.94), and the hazard ratio after adjusting for age group, symptom criteria, concomitant heart disease and hypertension covariates was 3.47 (95 % CI: 2.13 to 5.67).

Conclusion: Our findings suggest that, to reduce the mortality rate in confirmed COVID-19 cases, complete and evenly distributed vaccination among all target groups is necessary.

Keywords: COVID-19 death, COVID-19 vaccination, age, symptoms, heart, hypertension.

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Корреляция между степенью полноты вакцинации от COVID-19 и смертью подтвержденных случаев заболевания в Джакарте, июль – декабрь 2021 г.

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Резюме

Введение. По данным Управления здравоохранения Джакарты, инфекционные заболевания неизменно значились среди основных причин смерти в Джакарте, занимая третье место с 2016 по 2019 год и поднявшись на первое место в 2021 году. Соотношение смертей, связанных с COVID-19, ко всем зарегистрированным случаям смерти также увеличилось в 2021 году по сравнению с предыдущим годом. Несмотря на всю важность вакцинации, порядка 16 % жителей Джакарты не прошли её по разным причинам.

Цель исследования: установить корреляцию между полнотой вакцинации от COVID-19 и смертью подтвержденных случаев COVID-19.

Материалы и методы: это ретроспективное когортное исследование, основанное на данных наблюдения 1881 случай COVID-19 с июля по декабрь 2021 года, полученных от Управления здравоохранения Джакарты и проанализированных с использованием регрессии Кокса.

Результаты: значения отношения рисков между полнотой статуса вакцинации от COVID-19 и смертью подтвержденных случаев до и после поправки на такие ковариаты, как возрастная группа, наличие/отсутствие симптомов, сопутствующих болезней сердца и гипертонию, составляли 3,19 (95 % ДИ: 2,06–4,94) и 3,47 (95 % ДИ: 2,13–5,67) соответственно.

Заключение: полученные результаты свидетельствуют о том, что для снижения уровня смертности подтвержденных случаев COVID-19 необходима полная и равномерно распределенная вакцинация всех целевых групп.

Ключевые слова: смерть от COVID-19, вакцинация против COVID-19, возраст, симптомы, сердце, гипертония.

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Introduction

The COVID-19 pandemic lasted for almost two years and impacted all regions. On December 12, 2021, global cumulative COVID-19 cases reached 268,934,575, with 5,297,850 deaths, resulting in a case fatality rate (CFR) of 1.97 %. At that time, there was a global decrease of 5 % in the number of cases and a 10 % decrease in deaths compared to the previous week. However, cases were still increasing in Africa, where the number of cases had more than doubled that week, and in the Western Pacific, which saw a 7 % increase in cases compared to the previous week. Meanwhile, the number of deaths decreased in all regions except the Western Pacific, which experienced a 4 % increase [1]. In Jakarta, as of December 12, 2021, the COVID-19 surveillance data from the Jakarta Health Office recorded a national total of 4,259,143 confirmed cases with 143,936 deaths, resulting in a CFR of 3.4 %. At the provincial level, Jakarta had reported 864,390 confirmed cases with 13,583 deaths, corresponding to a CFR of 1.6 % [2]. Throughout the pandemic, Jakarta's CFR has been consistently lower than the national rate due to improved health facilities and collaborative efforts within the Government.

At that time, the trend in COVID-19 cases had been consistently declining over the preceding two months. The peak of national cases occurred between July 12 and 18, 2021, while Jakarta experienced its peak from July 5 to 11, 2021. Additionally, the peak in deaths nationally was recorded from July 26 to August 1, 2021, and in Jakarta from July 19 to 25, 2021. Both national and Jakarta trends showed a decrease in cases and deaths, although there were some fluctuations in Jakarta's trend compared to the national one [3].

According to the Jakarta Health Office surveillance data from 2016 to 2019, circulatory system disorders (ICD-X codes: I00–I99) were the leading cause of death in Jakarta. In 2020, they remained the top cause of death along with specific infectious and parasitic diseases (ICD-X codes: A00–B99). By 2021, COVID-19 had become the leading cause of death due to its widespread transmission, leading to a significant increase in the death rate. Figure shows the number of deaths from COVID-19 compared to total deaths in Jakarta in 2020 and 2021.

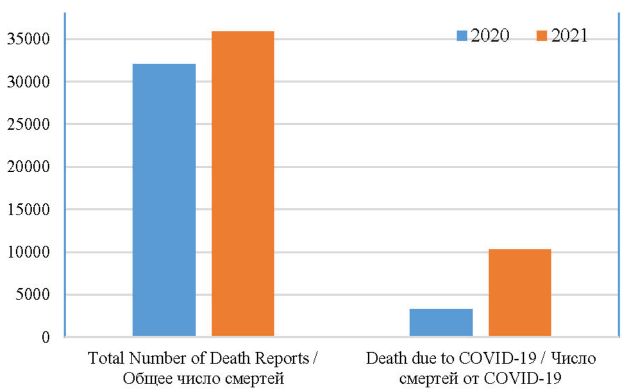

Figure. Comparison of COVID-19 deaths with total deaths in Jakarta, 2020–2021

Рисунок. Число случаев смерти от COVID-19 относительно общего числа смертей в Джакарте в 2020–2021 гг.

This figure demonstrates the increase in total death reports by 11.9 %, while death reports due to COVID-19 increased by 213.3 %. The ratio of deaths from COVID-19 compared to the total number of deaths also increased almost three times, from 1:10 in 2020 to 1:3.5 in 2021. Based on this data, COVID-19 deaths were a problem in Jakarta, Indonesia, both regionally and globally, even though the CFR was low compared to other diseases.

According to data from Johns Hopkins University, as quoted by the Ministry of Health (MoH), the COVID-19 control program in Indonesia was considered one of the best in the world [4]. The program consisted of three main activities, namely six preventive measures or 6 PM (wearing a mask, washing hands using soap and running water, maintaining social distance, limiting mobility, staying away from crowds and avoiding eating together); TTI (Testing, Tracing and Isolation), and Vaccination [5]. Six PMs and vaccination were mandatory activities for the citizens, while the Government was obliged to ensure the availability of vaccination services and TTI activities. The MoH set the minimum testing target of 1 per 1,000 people per week, the maximum positivity rate of 5 %, contact tracing conducted in at least 80 % of cases, PCR tests conducted in at least 80 % of close contacts, and monitoring until completion of the quarantine period in at least 80 % [6].

Indonesia's COVID-19 vaccination program was officially launched on January 13, 2021. In accordance with the Minister of Health Regulation, the implementation was carried out in phases, beginning with healthcare workers (phase 1), followed by older adults and public service officers (phase 2), and subsequently expanded to include vulnerable populations, the general public, and children aged 12–17 years. The decision to include children, effective from July 1, 2021, was based on epidemiological data at the time, which showed a significant increase in COVID-19 incidence across all age groups, including pediatric populations [7].

As of late 2021, the COVID-19 vaccination program in Indonesia had been in place for nearly a year. However, peer-reviewed publications evaluating the program—particularly regarding vaccine effectiveness in preventing transmission, severe illness, and mortality—remained limited. Such evidence was critical for both public accountability and health promotion, especially in light of prevailing public skepticism. At the time, there were widespread perceptions that the vaccination campaign served governmental or commercial interests rather than public health. Studies exploring public perceptions revealed that vaccine hesitancy was often rooted in doubts about vaccine efficacy. Those doubts were reinforced by limited public understanding and a lack of consistent, evidence-based communication from authorities and healthcare professionals [8, 9].

This study seeks to contribute to the growing body of evidence regarding the role of COVID-19 vaccines in reducing mortality. Vaccination represents a crucial tool in the global effort to control the pandemic.

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Determining the level of protection conferred by vaccines—whether 100 %, 70 %, or 50 %—has direct implications for vaccination coverage targets and public health strategies. For instance, if a vaccine has 60% effectiveness, achieving herd immunity would require full (100 %) population coverage. In such scenarios, continued adherence to health protocols remains essential to augment community protection [10].

A number of literature reviews have affirmed the safety and immunogenicity of COVID-19 vaccines. Double-dose regimens, in particular, have been shown to elicit strong immune responses across age groups. As of that period, all vaccines undergoing phase 3 clinical trials demonstrated favorable safety profiles and varying degrees of efficacy in preventing COVID-19 infection [11].

According to official data from the corona.jakarta.go.id portal, as of December 12, 2021, COVID-19 vaccine coverage in Jakarta had reached 83.89 % for the first dose and 72.22 % for the second dose [6]. This indicated that approximately 28% of the population had not yet completed the full vaccination schedule. Sub-district-level data showed an average second-dose coverage of 70.88 %, with the highest in Pari Island, Kepulauan Seribu (88.32 %), and the lowest in Kalibaru, Cilincing, North Jakarta (55.67 %). The Jakarta Health Agency had set a target of ≥ 80 % coverage for the second dose, yet by that date, 260 out of 267 sub-districts (97.38 %) had not reached the target. For the first dose, 51 sub-districts (19.1 %) remained below the 80% threshold.

Based on a literature study conducted by Alkautsar [12], comorbid obesity, hypertension, and diabetes mellitus (DM) increase ACE-2 and SARS-CoV-2 receptor binding, causing receptor expression to increase so that individuals are susceptible to COVID-19 infection and increase patient severity. Abnormalities in cytokine production, endothelial dysfunction, and cytokine storms play a role in determining the severity of the condition of COVID-19 patients, so it can be concluded that comorbid obesity, hypertension, and DM increase the risk of disease severity in patients [13].

In 2019, the prevalence of diabetes among people aged 20 to 79 in Indonesia was 8.3 % ranking 7th in the world. The national prevalence of diabetes, based on the 2018 national basic health survey, was 2 %. Jakarta had the highest prevalence nationally, with 3.4 % compared to 2.5 % in 2013 [14]. Additionally, based on the 2018 national basic health survey data, the prevalence of hypertension in the ≥18 age group of DKI Jakarta was 34.1 %, ranking 5th, an increase from 25 % in 2013 [15]. These statistics suggest a relatively high risk of COVID-19 severity and mortality in Jakarta.

Method

This is an analytical observational study with a retrospective cohort design because all independent variables examined in this study were confirmed to have occurred before being infected with COVID-19. This study aims to examine the completeness of COVID-19 vaccination status as the main independent variable and its correlation with death due to COVID-19, which is influenced by covariate variables including sex, age group, symptomatic or asymptomatic case criteria, and comorbid conditions (diabetes mellitus, heart disease, hypertension, malignancy, immunological disorders, chronic kidney failure, chronic obstructive pulmonary disease (COPD), and obesity). The sample used is data on COVID-19 cases that are thoroughly filled on individual variables, including comorbid variables, symptom criteria and vaccine status from July to December 2021. A total of 1,881 data points that met the criteria were collected, with the sample size based on the sample calculation for cohort research as follows [16]:

$$n = \frac{\{z_{1-\alpha/2}\sqrt{2p(1-p)}+z_{1-\beta}\sqrt{p_1(1-p_1)+p_2(1-p_2)}\}^2}{(p_1-p_2)^2}$$

P_1 = Prevalence of outcome in the unexposed group

P_2 = Prevalence of outcome in the exposed group

$$P = \frac{P_1 + P_2}{2}$$

α = Level of significance

β = 1-power of test

Z = The z-score corresponding to the degree of confidence

n = Calculated sample size

Furthermore, the calculation of the minimum sample size uses Lemeshow's sample calculation formula software. The strength of the study (confidence level) was determined at 95 % with a relative precision of 0.5. Meanwhile, the values of P1, P2 and RR are based on several previous studies with several comorbid independent variables (Table 1).

Based on the table above, the minimum sample size of 1,527 samples was determined. Meanwhile, COVID-19 surveillance data that met the inclusion criteria, namely complete filling of all individual characteristic variables, comorbid data, symptomatic or not, and the existence of vaccination history data, amounted to 1,881 data points and was decided to be used entirely.

The study examined the eventual outcomes of COVID-19 patients, categorizing them as either recovering/completing isolation or deceased. The primary independent variable was the completeness of vaccination status, which was split into complete vaccination (2 or 3 doses received before COVID-19 diagnosis) and incomplete vaccination (no vaccination or just one dose before diagnosis). Covariate variables included sex, age group (≤ 50 years and > 50 years), symptomatic/asymptomatic status, number of comorbidities, and specific conditions such as diabetes mellitus, heart disease, hypertension, malignancy, immunological disorders, chronic kidney failure, COPD, and obesity.

This study aims to find the relationship between the completeness of COVID-19 vaccination status and death in confirmed cases of COVID-19 after adjusting for covariates. Data was analyzed using Cox regression with STATA 16 software.

Results

The analysis was performed by correlating the main independent variables and all covariate variables with the dependent variable, namely death, in confirmed

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***Table 1.* Minimum sample calculation**

***Таблица 1.* Расчет минимального размера выборки**

Studies / Исследования	P1	P2	RR / OP	95% CI / 95% ДИ	Minimum sample / Минимальный размер выборки
Wulandari et al. Correlation between diabetes mellitus and deaths in COVID-19 confirmed cases DKI Jakarta March – August 2020 [17] / Вуландари и соавт. Корреляция между сахарным диабетом и смертью подтвержденных случаев COVID-19 в Особом столичном округе Джакарта с марта по август 2020 г.[17]	0.20	0.02	3.9	(2.2–6.8)	1527
Drew et al. Symptoms and comorbidities that predict mortality in COVID-19 positive patients in five regions of DKI Jakarta and qualitative explora-tion of public obedience to large-scale social restrictions, September 2020 [13] / Дрю и соавт. Симптомы и сопутствующие заболевания, предсказывающие смертность у пациентов с положительным результатом теста на COVID-19 в пяти регионах Особого столичного округа Джакарты, и качественное исследование общественного соблюдения масштабных социальных ограничений, сентябрь 2020 г. [13]	0.17	0.02	9.3	(8.0–10.8)	1056

Abbreviations: RR, relative risk; CI, confidence interval.
Аббревиатуры: ОР, относительный риск; ДИ, доверительный интервал.

cases of COVID-19. The strength of the correlation was calculated using the Relative Risk (RR) number. Table 2 shows the results of each variable's calculation.

The main independent variables and all covariates correlated significantly with the deaths of confirmed COVID-19 cases. The highest RRs in order were the presence of symptoms, immunological disorders, obesity, hypertension, number of comorbidities, diabetes, heart disease, malignancy, age group, COPD, chronic renal failure, vaccination completeness status and sex.

Stratification Analysis

The stratification analysis is used to determine the hazard ratio of the main independent variables in relation to the dependent variable within each covariate stratum. These strata consist of sex, age group, symptoms, diabetes, heart disease, hypertension, malignancy, immunological disorders, chronic renal failure, COPD, obesity, and the number of comorbidities. This helps to identify potential confounding and interactions within each covariate.

In addition, interaction analysis was conducted to determine any modifying effects that may be present due to differences in the strength or direction of the correlation between exposure and outcome among strata groups influenced by the covariates. Potential interactions were identified using the Log Likelihood Ratio (LR) test. The LR test calculates the difference between –2LL of the model that does not contain interactions and –2LL of the complete model that contains interactions. If the p-value of the LR test is greater than 0.05, it proves that there is no potential interaction between the vaccination completeness status variable and the covariate [18]. Potential confounding can be identified by calculating the difference between crude hazard ratio (CHR) and adjusted hazard ratio; if the difference between crude and adjusted HR is significant, it is a potential confounder. Hansel Mantel calculation formula: (HRcrude – HRadjusted)/HRadjusted x 100 %; if the result is > 10 %, then the variable is a confounding variable, and if the result is < 10 %, then the variable is not a confounding variable [19].

Confounding variables are covariates that are related to the main independent variable, namely vaccination completeness status, and are related to the outcome, namely the death of COVID-19 confirmed cases. This variable is not an intermediate variable between the COVID-19 vaccination completeness status, and the death of COVID-19 confirmed cases. Stratification analysis and evaluation of covariates that can potentially be confounding and interactions that affect the correlation between the completeness of COVID-19 vaccination status and death in COVID-19 confirmed cases is presented in Table 3.

These findings show that the potential confounding variables include age group, diabetes mellitus, heart, hypertension and the number of comorbidities, while the variables that interact with the correlation between vaccination completeness status and mortality due to COVID-19 include heart disease and COPD.

Multivariate Analysis

Multivariate analysis was conducted for all main independent variables and covariates with a p-value < 0.25. All covariates and the main independent variables were eligible to be multivariate candidates (Table 4).

Based on the table above, it is known that several variables have a p-value of > 0.05. These variables are (from largest to smallest) chronic renal failure, number of comorbidities, COPD, obesity, sex, immunological disorders, malignancy, diabetes, and heart disease. Moreover, the variables that had the highest *p*-value were gradually excluded. However, variables suspected of confounding or having interactions were maintained despite having a high p-value. Below is the analysis after excluding the suspected variables.

Confounding Analysis

Analysis of confounding was necessary because confounding interferes with the correlation between the main independent variable, namely vaccination completeness status, and the dependent variable, namely the outcome in confirmed cases. This was assessed using the hazard ratio (HR) difference value. Covariates were excluded one by one from the model. If the difference between the crude hazard ratio and the adjusted hazard ratio was higher than 10 %, the variable was specified as confounding and retained

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Table 2. **Bivariate analysis of main independent variables and covariates with COVID-19 end status**

Таблица 2. **Двумерный анализ основных независимых переменных и ковариатов для подтверждённых случаев COVID-19**

Variable / Переменная	Disease outcome / Исход болезни				*p*	RR (95% CI) / Относительный риск (95% ДИ)
	Death / Смерть		Recovery / Выздоровление			
	n	%	*n*	%		
Sex / Пол						
Male / Мужской	71	8.1	809	91.9	0.004	1.68 (1.18 – 2.40)
Female / Женский	48	4.8	953	95.2		
Age group, years / Возрастная группа, лет						
> 50	93	17.7	432	82.3	0.000	9.24 (6.05 – 14.10)
≤ 50	26	1.9	1330	98.1		
Vaccination status / Статус вакцинации						
Incomplete / Неполный	95	9.1	947	90.9	0.000	3.19 (2.06 – 4.94)
Complete / Полный	24	2.9	815	97.1		
Symptoms / Симтомы						
Symptomatic / Имеются	111	18.8	481	81.3	0.000	33.21 (15.57 – 70.84)
Asymptomatic / Отсутствуют	7	0.6	1233	99.4		
Comorbidity / Сопутствующие заболевания						
≥ 2	30	65.2	16	34.8	0.000	13.44 (10.04 – 18.02)
0–1	89	4.9	1746	95.1		
Diabetes / Диабет						
Yes / Да	29	65.9	15	34.1	0.000	13.43 (10.02 – 18.00)
No / Нет	90	4.9	1744	95.1		
Heart disease / Болезнь сердца						
Yes / Да	22	66.7	11	33.3	0.000	12.69 (9.31 – 17.29)
No / Нет	97	5.3	1749	94.7		
Hypertension / Гипертония						
Yes / Да	41	58.6	29	41.4	0.000	13.58 (10.13 – 18.21)
No / Нет	78	4.3	1731	95.7		
Malignancy / Злокачественное новообразование						
Yes / Да	3	75.0	1	25.0	0.000	12.12 (6.70 – 21.93)
No / Нет	116	6.2	1759	93.8		
Immunological disorders / Болезни иммунной системы						
Yes / Да	2	100.0	0	0.0	0.000	16.05 (13.47 – 19.13)
No / Нет	117	6.2	1761	93.8		
Chronic renal failure / Хроническая почечная недостаточность						
Yes / Да	5	45.5	6	54.5	0.000	7.45 (3.81 – 14.58)
No / Нет	114	6.1	1755	93.9		
COPD / ХОБЛ						
Yes / Да	8	50.0	8	50.0	0.000	8.39 (4.98 – 14.14)
No / Нет	111	6.0	1751	94.0		
Obesity / Ожирение						
Yes / Да	1	100.0	0	0.0	0.000	15.91 (13.36 – 18.94)
No / Нет	118	6.3	1759	93.7		

in the model. Table 6 presents the results of the assessment after excluding the covariate variable.

Interaction/Modification Effect Analysis

The interaction effect between the main independent variables and covariate variables is evaluated to determine if there is a correlation that affects the dependent variable when these variables appears together.In this study, eight covariates were suspected to interact with the main independent variable. Furthermore, the analysis was carried out by comparing the –2LL (log-likelihood) value in the complete model with interaction and the complete model without interaction. If the chi-square *p*-value is < 0.05 at df =1, this means a significant interaction. Table 7 shows the results of the modification effect test.

The analysis above reveals a modification effect between the vaccination variable with sex and the vaccination variable with heart disease.

Final Model of Multivariate Analysis

Based on the analysis of confounding, interaction, and modification effects, the following final model best describes the relationship between vaccination

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Table 3. **Stratification analysis of vaccination completeness status with disease outcome based on covariate variables**

Таблица 3. **Стратифицированный анализ связи полноты вакцинации с исходом заболевания на основе ковариат**

Covariate / Ковариата		Outcome / Исход	Vaccination / Вакцинация				HR of each stratum / ОР в страте (95% CI / ДИ)	HR adjusted / ОР корр. (95% CI/ ДИ)	Δ HR / ОР (%)	LR test Chi² (*p*-value) / Тест ОП Χ² (*p*-значение)
			Incomplete / Неполная		Complete / Полная					
			n	%	*n*	%				
Sex / Пол	Male / Мужской = 1	Death / Смерть	53	11.2%	422	88.8%	2.51 (1.50–4.21)	3.25 (2.09–5.04)	1.85	2.29 (0.13)
		Recovery / Выздоровление	18	4.4%	387	95.6%				
	Female / Женский = 0	Death / Смерть	42	7.4%	525	92.6%	5.36 (2.30–12.49)			
		Recovery / Выздоровление	6	1.4%	428	98.6%				
Age group, years / Возрастная группа, лет	1 (> 50)	Death / Смерть	73	29.1%	178	70.9%	3.98 (2.51–6.34)	3.97 (2.59–6.09)	19.65	0.001 (0.98)
		Recovery / Выздоровление	20	7.3%	254	92.7%				
	0 (≤ 50)	Death / Смерть	22	2.8%	769	97.2%	3.93 (1.36–11.34)			
		Recovery / Выздоровление	4	0.7%	561	99.3%				
Symptoms / Симптомы	Yes / Да	Death / Смерть	90	27.8%	234	72.2%	3.54 (2.27–5.54)	3.22 (2.11–4.91)	0.93	2.436 (0.12)
		Recovery / Выздоровление	21	7.8%	247	92.2%				
	No / Нет	Death / Смерть	4	0.6%	697	99.4%	1.03 (0.23–4.56)			
		Recovery / Выздоровление	3	0.6%	536	99.4%				
Diabetes mellitus / Сахарный диабет	Yes / Да	Death / Смерть	26	81.3%	6	18.8%	3.25 (1.20–8.78)	2.77 (1.80–4.28)	14.75	0.115 (0.74)
		Recovery / Выздоровление	3	25.0%	9	75.0%				
	No / Нет	Death / Смерть	69	6.8%	940	93.2%	2.69 (1.66–4.34)			
		Recovery / Выздоровление	21	2.5%	804	97.5%				
Heart disease / Болезнь сердца	Yes / Да	Death / Смерть	16	69.6%	7	30.4%	1.16 (0.65–2.06)	2.85 (1.89–4.30)	11.93	10.195 (0.001)
		Recovery / Выздоровление	6	60.0%	4	40.0%				
	No / Нет	Death / Смерть	79	7.8%	940	92.2%	3.56 (2.15–5.89)			
		Recovery / Выздоровление	18	2.2%	809	97.8%				
Hypertension / Гипертония	Yes / Да	Death / Смерть	36	80.0%	9	20.0%	4.00 (1.80–8.88)	2.87 (1.88–4.40)	11.15	0.903 (0.342)
		Recovery / Выздоровление	5	20.0%	20	80.0%				
	No / Нет	Death / Смерть	59	5.9%	938	94.1%	2.53 (1.52–4.21)			
		Recovery / Выздоровление	19	2.3%	793	97.7%				
Malignancy / Злокачественное новообразование	Yes / Да	Death / Смерть	3	100.0%	0	0.0%	∞	3.14 (2.02–4.88)	1.59	∞
		Recovery / Выздоровление	0	0.0%	1	100.0%				
	No / Нет	Death / Смерть	92	8.9%	947	91.1%	3.08 (1.99–4.79)			
		Recovery / Выздоровление	24	2.9%	812	97.1%				
Imunological disorders / Болезни иммунной системы	Yes / Да	Death / Смерть	2	100.0%	0	0.0%	∞	3.12 (2.01–4.85)	2.24	∞
		Recovery / Выздоровление	0	∞	0	∞				
	No / Нет	Death / Смерть	93	8.9%	947	91.1%	3.12 (2.01–4.85)			
		Recovery / Выздоровление	24	2.9%	814	97.1%				
Chronic renal failure / Хроническая почечная недостаточность	Yes / Да	Death / Смерть	5	50.0%	5	50.0%	∞	3.08 (1.98–4.78)	3.57	∞
		Recovery / Выздоровление	0	0.0%	1	100.0%				
	No / Нет	Death / Смерть	90	8.7%	942	91.3%	3.04 (1.95–4.73)			
		Recovery / Выздоровление	24	2.9%	813	97.1%				
COPD / ХОБЛ	Yes / Да	Death / Смерть	7	50.0%	7	50.0%	1.00 (0.23–4.40)	2.97 (1.93–4.59)	7.41	22.77 (0.000)
		Recovery / Выздоровление	1	50.0%	1	50.0%				
	No / Нет	Death / Смерть	88	8.6%	939	91.4%	3.11 (1.98–4.88)			
		Recovery / Выздоровление	23	2.8%	812	97.2%				
Obesity / Ожирение	Yes / Да	Death / Смерть	1	100.0%	0	0.0%	∞	3.16 (2.04–4.90)	0.95	∞
		Recovery / Выздоровление	0	∞	0	∞				
	No / Нет	Death / Смерть	94	9.0%	945	91.0%	3.16 (2.04–4.90)			
		Recovery / Выздоровление	24	2.9%	814	97.1%				
Number of comorbidity / Число сопутствующих заболеваний	≥ 2	Death / Смерть	25	75.8%	8	24.2%	1.97 (0.96–4.02)	2.75 (1.81–4.18)	16	0.969 (0.325)
		Recovery / Выздоровление	5	38.5%	8	61.5%				
	0–1	Death / Смерть	70	6.9%	939	93.1%	3.02 (1.83–4.97)			
		Recovery / Выздоровление	19	2.3%	807	97.7%				
Number of comorbidities / Число сопутствующих заболеваний	3–4	Death / Смерть	9	81.8%	2	18.2%	∞	2.32 (1.54–3.51)	37.5	0.116 (0.734)
		Recovery / Выздоровление	0	0.0%	2	100.0%				
	1–2	Death / Смерть	51	69.9%	22	30.1%	2.38 (1.38–4.08)			
		Recovery / Выздоровление	10	29.4%	24	70.6%				
	None / Отсутствуют	Death / Смерть	35	3.7%	923	96.3%	2.10 (1.14–3.87)			
		Recovery / Выздоровление	14	1.7%	789	98.3%				

Abbreviations: HR, hazard ratio; LR, likelihood ratio.

Аббревиатуры: ОР, отношение рисков; ОП, отношение правдоподобия.

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***Table 4.* Results of a full model multivariate analysis**

***Таблица 4.* Результаты многомерного анализа полной модели**

Variable / Переменная	B	SE / СО	*p*	HR / ОР	95% CI / ДИ
COVID-19 vaccination status / Статус вакцинации от COVID-19	1.09	0.25	0.000	2.98	1.81 – 4.91
Sex / Пол	0.29	0.20	0.150	1.34	0.90 – 1.99
Age group, years (≤ 50 and >50) / Возрастная группа, лет (≤ 50 и >50)	1.77	0.26	0.000	5.86	3.55 – 9.67
Symptoms (present/absent) / Наличие/отсутствие симптомов	2.89	0.40	0.000	17.91	8.15 – 39.37
Diabetes / Сахарный диабет	0.62	0.33	0.062	1.86	0.97 – 3.58
Heart disease / Болезнь сердца	0.67	0.35	0.054	1.95	0.99 – 3.84
Hypertension / Гипертония	0.98	0.30	0.001	2.65	1.47 – 4.78
Malignancy / Злокачественные новообразования	1.27	0.68	0.062	3.58	0.94 – 13.68
Immunological disorders / Болезни иммунной системы	1.20	0.82	0.141	3.33	0.67 – 16.56
Chronic renal failure / Хроническая почечная недостаточность	0.04	0.51	0.938	1.04	0.39 – 2.80
COPD / ХОБЛ	0.35	0.41	0.386	1.42	0.64 – 3.14
Obesity / Ожирение	1.28	1.07	0.233	3.59	0.44 – 29.30
Number of comorbidities / Число сопутствующих заболеваний	–0.36	0.49	0.472	0.70	0.27 – 1.85

Abbreviations: SE, standard error; HR, hazard ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease.
Аббревиатуры: СО, стандартная ошибка; ОР, отношение рисков; ДИ, доверительный интервал; ХОБЛ, хроническая обструктивная болезнь лёгких.

***Table 5.* Results of multivariate analysis after excluding chronic renal failure, obesity, sex, malignancy and immunological disorders**

***Таблица 5.* Результаты многомерного анализа после исключения хронической почечной недостаточности, ожирения, пола, злокачественных новообразований и болезней иммунной системы**

Variable / Переменная	B	SE / СО	*p*	HR / ОР	95% CI / ДИ
COVID-19 vaccination status / Статус вакцинации от COVID-19	1.18	0.25	0.000	3.26	1.99 – 5.36
Age group, years (≤ 50 and >50) / Возрастная группа, лет (≤ 50 и >50)	1.71	0.25	0.000	5.55	3.41 – 9.04
Symptoms (present/absent) / Наличие/отсутствие симптомов	2.93	0.40	0.000	18.75	8.55 – 41.12
Diabetes / Сахарный диабет	0.47	0.32	0.142	1.60	0.85 – 3.01
Heart disease / Болезнь сердца	0.73	0.33	0.028	2.07	1.08 – 3.96
Hypertension / Гипертония	0.82	0.30	0.007	2.28	1.26 – 4.13
COPD / ХОБЛ	0.29	0.40	0.465	1.33	0.62 – 2.90
Number of comorbidities / Число сопутствующих заболеваний	–0.11	0.48	0.812	0.89	0.34 – 2.90

Abbreviations: SE, standard error; HR, hazard ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease.
Аббревиатуры: СО, стандартная ошибка; ОР, отношение рисков; ДИ, доверительный интервал; ХОБЛ, хроническая обструктивная болезнь лёгких.

***Table 6.* Analysis of confounding variables in the multivariate model**

***Таблица 6.* Анализ мешающих переменных (конфаундеров) в многомерной модели**

Variable / Переменная	HR / ОР	HR change (%) / Изменение ОР (%)	Confounding effect / Эффект смешения
Complete model (vaccination status, sex, age, symptoms, diabetes, heart disease, hypertension, malignancy, immunological disorders, chronic renal failure, COPD, obesity, number of comorbidities) / **Полная модель**, включающая в себя переменные статуса вакцинации, пол, возраст, наличие/отсутствие симптомов, сахарного диабета, болезней сердца, гипертонии, ЗН, болезней иммунной системы, хронической почечной недостаточности, ХОБЛ и ожирения, а также число сопутствующих заболеваний	**2.98**		
Covariate excluded: / После исключения ковариаты:			
Sex / Пол	3.04	2.01	–
Age group / Возрастная группа	**2.32**	**22.15**	+
Symptoms / Симптомы	3.21	7.7	–
Diabetes mellitus / Сахарный диабет	3.16	6.04	–
Heart disease / Болезнь сердца	3.14	5.37	–
Hypertension / Гипертония	**3.30**	**10.73**	+
Malignancy / Злокачественное новообразование	3.14	5.37	–
Immunological disorders / Болезни иммунной системы	3.05	2.34	–
Chronic renal failure / Хроническая почечная недостаточность	2.98	0	–
COPD / ХОБЛ	3.04	2.01	–
Obesity / Ожирение	3.01	1.01	–
Number of comorbidities / Число сопутствующих заболеваний	3.03	1.68	–

Abbreviation: HR, hazard ratio.
Аббревиатура: ОР, отношение рисков.

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Table 7. **Interaction analysis of vaccine completeness status variables and covariates**
Таблица 7. **Анализ взаимодействия переменных вакцинального статуса и ковариатов**

Interaction / Взаимодействие	–2LL	G	p LR value / *p*-значение ЛВ	Interaction / Взаимодействие
Complete model without interaction / Полная модель без взаимодействия	–1180.39			
Complete model + vaccination*age / Полная модель + вакцинация*возраст	–1180.31	0.08	0.78	–
Complete model + vaccination*sex / Полная модель + вакцинация*пол	**–1174.96**	**5.43**	**0.02**	+
Complete model + vaccination*symptom / Полная модель + вакцинация*симптом	–1179.65	0.74	0,39	–
Complete model + vaccination*diabetes / Полная модель + вакцинация*диабет	–1180.20	0.19	0,66	–
Complete model + vaccination*heart disease / Полная модель + вакцинация*болезнь сердца	**–1166.70**	**13.69**	**0.00**	+
Complete model + vaccination*hypertension / Полная модель + вакцинация*гипертония	–1179.90	0.49	0,48	–
Complete model + vaccination*COPD / Полная модель + вакцинация*ХОБЛ	–1180.16	0.23	0,63	–
Complete model + vaccination*num. comorbidity / Полная модель + вакцинация*число сопутствующих заболеваний	–1176.82	3,57	0.06	–

Abbreviation: LL, log likelihood.
Аббревиатура: ЛВ, логарифмическая вероятность.

completeness status and death from COVID-19 after adjusting for confounding variables, interactions, and modification effects (Table 8).

The adjusted hazard ratio of 3.47 (95 % CI: 2.13–5.67) means that death in confirmed COVID-19 cases with incomplete vaccination status is 3.47 times higher than confirmed COVID-19 cases with complete vaccination status after adjusting for confounding groups of age, symptoms, heart disease, and hypertension.

Discussion

This study shows that the percentage of deaths of confirmed COVID-19 cases in the group with incomplete COVID-19 vaccination status is higher than the number of deaths in the group with complete COVID-19 vaccination status with a ratio of 3:1. The relationship between the completeness of COVID-19 vaccination status and death of COVID-19 confirmed cases obtained the crude hazard ratio of 3.19 (95 % CI: 2.06–4.96). Multivariate analysis shows that the adjusted hazard ratio is 3.5 after being controlled by the covariate variables of age group, symptoms, heart disease, and hypertension. The final model of multivariate analysis shows that the risk of death in COVID-19 confirmed cases with incomplete COVID-19 vaccination is 3.5 times greater than those with complete vaccination status after being controlled by covariate variables, namely age group, symptom criteria, heart disease, and hypertension comorbid.

The results of this study are in accordance with the statement issued by the MoH that complete doses of vaccination reduce the risk of death in health workers. Based on the official release, the proportion of deaths of health workers in the January–March 2021 was 0.03 %. In that period, health workers only received one vaccination dose, so the risk of death was no different from the group who had never received the COVID-19 vaccination. Meanwhile, in April–June 2021, health workers received a complete vaccination dose, so the proportion of deaths fell to 0.01 % [20].

A cohort study conducted in the United States on 19,625 nursing home residents found that those who had received a complete dose of mRNA vaccination (Pfizer and Moderna) had a lower risk of death compared to those who had only received one dose of vaccine. The study found that the group that received dose 1 of the Pfizer vaccination had an RR of 0.41 (95 % CI: 0.38–0.44), while after dose 2, the RR was 0.34 (95 % CI: 0.3–0.36). Meanwhile, the group that received the first dose of the Moderna vaccine had an RR of 0.34 (95 % CI: 0.32–0.37) and after dose 2, the RR was 0.31 (95 % CI: 0.30–0.33) [4]. This study aligns with the study above, although this study examined all types of vaccinations without distinguishing brands or platforms and only compared them based on dose.

This study also aligns with a study in Israel involving 758,118 respondents aged ≥ 50 years.

Table 8. **Relationship between vaccination completeness status and death from COVID-19 after being controlled by confounding variables, interactions and modification effects**
Таблица 8. **Связь между полнотой вакцинации и смертностью от COVID-19 после поправки на мешающие переменные, взаимодействия и эффекты модификации**

Variable / Переменная	β	SE / СО	*p*	HR / ОР	95% CI / ДИ
COVID-19 vaccination status / Статус вакцинации от COVID-19	1.24	0.25	0.000	3.47	2.13 – 5.67
Age group, years (≤ 50 and >50) / Возрастная группа, лет (≤ 50 и >50)	1.80	0.24	0.000	6.02	3.74 – 9.69
Symptoms (present/absent) / Наличие/отсутствие симптомов	2.98	0.40	0.000	19.69	9.01 – 43.04
Heart disease / Болезнь сердца	0.66	0.26	0.013	1.93	1.15 – 3.24
Hypertension / Гипертония	0.91	0.23	0.000	2.50	1.59 – 3.91

Abbreviations: SE, standard error; HR, hazard ratio; CI, confidence interval.
Аббревиатуры: СО, стандартная ошибка; ОР, отношение рисков; ДИ, доверительный интервал.

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The study revealed that over the 54-day period, the group that received vaccine boosters experienced 65 confirmed COVID-19 deaths (0.16 deaths per 100,000 people per day), whereas the group without vaccine boosters had 137 deaths (2.98 deaths per 100,000 people per day). The adjusted hazard ratio of the risk of death in the booster recipient group compared to the group that did not receive the booster was 0.10 (95 % CI: 0.07–0.14). It can be concluded that vaccine boosters protect against the risk of death ten times better than non-boosters [21].

Based on the results of this study, the risk of death in COVID-19 cases is not only influenced by the main independent variable, namely vaccination completeness status, but also by several covariate variables, including age group, symptom criteria, heart disease, and hypertension comorbidities. There was also an interaction between heart disease, comorbid variables and vaccination. In addition, age group and hypertension were also found to be confounding variables for the correlation between vaccination completeness status and death in confirmed cases.

This study also found a significant correlation between the age group variables and COVID-19-confirmed death with an adjusted HR value of 6.02 (95 % CI: 3.74–9.69). Several studies have shown a significant correlation between age group variable and COVID-19-confirmed death. The study conducted by Wulandari EW in 2021, which was analyzed using a retrospective cohort of the same data source for the 2020 period, found that the age group as a covariate variable had an adjusted HR value of 2.7 (95 % CI: 1.7–4.3) [17]. Meanwhile, research by Drew 2021, who took data in 2020 from the same data source, found that the RR in the age group ≥ 60 years was 6.74 (95 % CI: 5.5–8.19) [13].

Besides the age group, another covariate that significantly correlated is symptom criteria (symptomatic or asymptomatic). This covariate had the highest adjusted hazard ratio of 19.69 (95 % CI: 9.01–43.4). This is in line with the research of Drew with the 2020 data, which found that people who had respiratory symptoms were at risk of death with an RR of 2.56 (95 % CI: 2.03–3.23), while the variable symptoms other than respiratory were at risk of death with an RR of 2.49 (95 % CI: 1.97–3.14). This shows that the risk of death is directly proportional to the level of death.

Another covariate variable that correlated significantly with death in confirmed cases of COVID-19 is hypertension, with an adjusted hazard ratio of 2.50 (95 % CI: 1.59–3.91). This finding is also in line with previous studies. At the beginning of the COVID-19 pandemic, the author also found that hypertension is a risk of death in confirmed cases of COVID-19 with an adjusted hazard ratio of 1.50 (95 % CI: 1.21–1.87). Endang W's research on the same data source with different periods also found a significant correlation between hypertension variables as covariates with an adjusted hazard ratio value of 1.6 (95 % CI: 1.2–2.2) [20]. Likewise, the research of Drew also found that hypertension was significantly correlated with confirmed COVID-19 death with an RR of 4.40 (95 % CI: 3.20–6.05) [13].

This study has several limitations. The data used is secondary data from the Jakarta Health Office COVID-19 surveillance. The sample selection method used was purposive and relied heavily on the completeness of the data availability, and selection bias may occur because the completeness of the data is less than 60 %.

Conclusion

Individuals who have not been vaccinated or have only received one dose are at a higher risk of death due to COVID-19 infection compared to those who have received two or more doses. This conclusion remains consistent even after adjusting for age group, symptom criteria, heart disease, and hypertension. Given the ongoing risk of severe illness among vulnerable populations, adults over the age of 50 should continue to be prioritized for booster doses of the COVID-19 vaccine, particularly those with comorbidities. The integration of COVID-19 vaccination into routine immunization programs, similar to annual influenza vaccination, should be considered for long-term protection and preparedness. In addition, the Jakarta Health Office should focus on strengthening disease surveillance and early warning systems by improving the quality and responsiveness of testing, contact tracing, and case isolation (TTI), not only for COVID-19 but also for other emerging infectious diseases. This will ensure timely detection and intervention, thereby reducing morbidity and mortality rates. Future research should expand beyond binary outcomes such as recovery or death and instead explore the relationship between vaccine type, timing, and the clinical severity of infection. Moreover, there is a growing need to evaluate vaccine effectiveness across various infectious diseases, particularly among high-risk groups, to inform comprehensive immunization strategies.

Abbreviations: CFR: Case Fatality Rate; PM: Preventive Measure; TTI: Testing, Tracing and Isolation; PCR: Polymerase Chain Reaction; MoH: Ministry of Health; DM: Diabetes Mellitus; COPD: Chronic Obstructive Pulmonary Disease; RR: Relative Risk; HR: Hazard Ratio; LR: Log Likelihood Ratio; CHR: Crude Hazard Ratio; SE: Standard Error; CI: Confidence Interval; LL: Log Likelihood.

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