Public Health of Indonesia
E-ISSN: 2477-1570 | P-ISSN: 2528-1542

Original research

Survival Analysis of Diabetes Mellitus and Cardiovascular Patients With COVID-19: A Secondary Data Analysis

Ariyanto Nugroho[1], Siti Fadlilah[2,3]*, Herry Susanto[4,5], Santi Damayanti[2], Agus Suharto[6], Sugiyarto[7]

[1]*Program Study of Public Health, Universitas Respati Yogyakarta, Indonesia*
[2]*Program Study of Nursing, Universitas Respati Yogyakarta, Indonesia*
[3]*School of Nursing, College of Nursing, Taipei Medical University, Taipei 11031, Taiwan, R.O.C.*
[4]*School of Nursing, National Taipei University of Nursing and Health Sciences, Taiwan, R.O.C*
[5]*Faculty of Nursing, Universitas Islam Sultan Agung, Semarang, Indonesia*
[6]*Nursing Staff at Dr Soeradji Tirtonegoro Hospital, Klaten, Indonesia*
[7]*Department of Nursing, Poltekkes Kemenkes Surakarta, Indonesia*

Corresponding author:
Siti Fadlilah
Program Study of Public Health, Universitas Respati Yogyakarta, Indonesia, Laksda Adisucipto Street km 6.3 Caturtunggal Depok, Sleman, Yogyakarta, Indonesia, Telephone : +6285710844204, Fax : 0274-489780,
E-mail : sitifadlilah@respati.ac.id

DOI: https://doi.org/10.36685/phi.v10i2.788

Abstract
Background: Patients with diabetes mellitus (DM) and cardiovascular disorders who suffer from COVID-19 may have an increased risk of death.
Objective: This study aims to analyze the time of death and influencing factors in patients with DM and cardiovascular disorders with COVID-19.
Methods: We used a retrospective observational cohort study using medical records of COVID-19 patients treated at Dr Soeradji and Penembahan Senopati hospitals from March 2020 to June 2022. There were 2,959 participants: patients without comorbidities, with DM, and with cardiovascular problems. We extracted sociodemographic and clinical data on patient characteristics using medical records. Data analysis used Kaplan-Meier and Cox regression analysis to estimate survival probability and investigate predictors of death with a 5% significance level.
Results: The median survival time was highest in the group without comorbidities (70.00) and lowest in the DM+others group (21.75). Years of treatment, age, presence of comorbidities, and type of hospital were related to the survival rate of COVID-19 patients ($p<0.05$). Diabetes mellitus and cardiovascular system disorders are significantly associated with survival of COVID-19 patients ($p<0.001$). There were significant differences between patients without cardiovascular disorders and patients with cardiovascular disorders (Non-Hypertension, Hypertension, and Hypertension + Others) adjusted by year, gender, age, and hospital type ($p<0.001$). There were significant differences between patients without DM and patients with DM (DM only, DM+Hypertension, and DM+Others) adjusted by year, gender, age, and hospital type($p<0.001$).
Conclusion: Years of treatment, age, gender, comorbid DM, and cardiovascular problems are associated with the survival rate of COVID-19 patients. Older age, DM patients who have comorbidities other than hypertension, and patients with cardiovascular issues other than hypertension show a greater risk of death than other groups.

Article history:
Received 1 March 2024
Revised 23 April 2024
Accepted 23 May 2024

Keywords: COVID-19; diabetes mellitus; hypertension; hardiovascular hiseases; survival rate

Background

The coronavirus disease (COVID-19), as of January 2024, has infected more than 774.2 million people worldwide, with the most cases in Europe. The United States, China, and India have the highest COVID-19 cases, with 103.4 million, 99.3 million, and 45 million, respectively. Meanwhile, Indonesia ranks 20th with a total of 6.8 million cases. At the same time, the number of active cases was recorded at more than 143 thousand cases. Malaysia has the highest number of active cases, namely 29.7 thousand (World Health Organization, 2024). In the period 2020 to 2022, COVID-19 as an infectious disease has become a big problem for the world with high morbidity and mortality rates; until now, this disease poses a threat of morbidity and death, although not as high as before (Chang et al., 2022). COVID-19 has resulted in the deaths of more than 7 million people in the world, and the highest deaths occurred in the United States (1.2 million), Brazil (702.1 thousand), and India (533.4 thousand) (World Health Organization, 2024).

Many factors cause the high death rate of COVID-19 patients apart from the nature of the disease itself. Older age groups are more susceptible to disease, getting sicker, and dying. According to studies in Brazil, someone aged 60-79 years is 1.62 times more likely to die from COVID-19, and this will increase to 2.56 times when they are >80 years old (Garbin et al., 2022). In line with studies in Mexico at ages >80 years showing a death rate of 60.1% (Bustos-Vázquez et al., 2021). In addition, comorbidities previously suffered by patients also increase the mortality of people with COVID-19. Survival analysis shows that old age and the presence of comorbidities further increase mortality and reduce survival rates (S. Bobdey et al., 2021).

Diabetes Mellitus (DM) and cardiovascular disease are the most common comorbidities in COVID-19 sufferers (Bustos-Vázquez et al., 2021). Even the results of meta-analysis studies state that a person can have more than one comorbidity, which makes the patient's condition even more detrimental (de Almeida-Pititto et al., 2020). Other findings from meta-analysis studies show that cardiovascular patients of all ages with other risk factors, such as DM, are significantly associated with COVID-19 mortality (Bae et al., 2021). COVID-19 patients with chronic cardiovascular disease have a 2.20 times risk of death compared to non-sufferers (Garbin et al., 2022). A study in Mexico showed that DM patients had a risk of 1,062 times compared to non-DM patients (Bustos-Vázquez et al., 2021); data from another study in Korea showed that the risk figure for DM patients was more significant, namely 1.86 (Byeon et al., 2021).

Although studies on survival analysis in COVID-19 patients, especially those with a history of comorbidities, have been carried out previously, studies specifically on DM and cardiovascular comorbidities have yet to be carried out. Previous research discussed comorbidities in general or analyzed them into DM and non-DM or cardiovascular disease and non-cardiovascular disease groups. Further analysis of the survival rate of COVID-19 patients with DM and cardiovascular disease with other comorbidities has never been carried out. Therefore, we are interested in conducting a study on survival analysis of diabetes mellitus and cardiovascular patients with COVID-19.

METHODS

Study Design

We used a retrospective observational cohort study research design based on patient medical records.

Setting

Data was collected at two hospitals in Indonesia, namely the Dr. Soeradji Tirtonegoro Central General Hospital (tertiary hospital) and the Penembahan Senopati Regional General Hospital (secondary hospital). The data taken is from COVID-19 patients from March 2020 to June 2022.

Participants

Participants in this study were COVID-19 patients diagnosed using the Real-time reverse transcriptase polymerase chain reaction (RT-PCR) SARS-CoV-2 examination using a nasopharyngeal swab. COVID-19 patients who meet the inclusion criteria are without comorbidities or with comorbid DM (diagnosed by a doctor) or comorbid cardiovascular problems (diagnosed by a doctor) and have complete medical records. COVID-19 patients with comorbidities other than DM and cardiovascular are excluded from the study. We estimated the optimum number of samples using the survival analysis formula and the number of events (deaths) using the formula $E=(Z\alpha/2 + Z\beta)\ 2/(\log (HR))2q0q1$ (Li et al., 2018). We used the assumption of a 95% confidence level, a study power of 80%, the number of cases is balanced, and cardiovascular disease and DM with COVID-19 hazard rates from previous studies are 8.9 and 1.3 (we use

the highest numbers) (Sousa et al., 2020). Based on the formula, it is known that Zα/2=1.96, Zβ=0.84, HR=8.9, q1=proportion of subjects in the exposed group and q0=proportion of subjects in the unexposed group. Based on the calculations, the number of events obtained is 11. The optimum sample size is calculated using the formula N=E/PE, where PE=cumulative mortality rate; previous studies found 6.3% (Sousa et al., 2020). The minimum number of samples obtained was 175; in this study, the number of samples was 2959 using the total sampling.

Variables and Operational Definition

The outcomes in this study are the time to death of COVID-19 patients without comorbidities, with comorbid DM, and with comorbid cardiovascular problems since the onset of COVID-19 symptoms. Outcomes are categorized as binary with "1" if the participant dies (event) and "0" if the participant is censored. Participants were classified as censored if they recovered, were allowed to go home with improvement in their condition, or were referred to another health facility. The event verification and censoring process is carried out by the doctor in charge and written in the medical record. The independent variables in this study are year of treatment, gender, age, hospital type, DM condition, and cardiovascular condition. Age is categorized based on the World Health Organization into Child (0-14), Young Age (15-24), Adult (25-64), and Elderly (>64) (Ahmad et al., 2001), but for reasons of statistical analysis, in the Log-rank test age test was categorized into ≤64 and >64. DM condition is classified by looking at the comorbidities other than the participant's DM. As with cardiovascular conditions, participants are categorized by looking at comorbidities other than cardiovascular problems.

Data Analysis

We obtained participant retrospective data from the hospital medical records department in the form of soft files in Excel data form. We reviewed and extracted data into a form containing respondent characteristics (year of treatment, gender, and age), type of hospital, date of admission, date of discharge, length of stay, outcome, presence or absence of comorbidities, and type of comorbidity. We analysed data using SPSS V.27 software. Univariate categorical data is presented using a frequency distribution, while numerical data uses the mean and standard deviation (SD). We used life table analysis to determine the survival probability between groups. We used the Kaplan-Meier method and log-rank test to calculate survival time and compare between groups. We used Cox regression analysis to explain factors associated with death in COVID-19 patients. Variables with a p-value of less than 0.05 indicate statistically significant results.

Ethical consideration

We collected data after obtaining ethical clearance from the ethics commission of Universitas Respati Yogyakarta number 110.3/FIKES/PL/VII/2022 and research permission from the hospital with numbers LB.02.02/XIII/2243/2022 and LB.02.01/XXVI.3/ 1720/2022.

RESULTS

Demographic Characteristic and Outcome Status of Participants

In this study, 2959 patients had a mean age of 51.57 ± 18,639 years, a length of stay of 9.75 ± 6,565 days, and 33.8% had cardiovascular system problems. The highest number of patients in 2021 (67.4%) with a mortality rate of 26.2%. A total of 1491 male patients, 23.1% of whom died. The majority of respondents were adults (66.4%), had comorbidities (52.9%), and were treated in tertiary hospitals (60.4%), with the respective deaths being 21.1%, 30.1%, and 22.4%. Years of treatment, age, presence of comorbidities, and type of hospital were related to the survival rate of COVID-19 patients ($p<0.05$), while gender did not show a significant relationship (p.0263). A total of 2287 combined patients with DM and non-DM, non-DM patients had higher survival compared to DM patients (86.6%), while DM patients who had other diseases had the most increased mortality (41.6%) compared to DM only or DM patients with hypertension. Of 2394 COVID-19 patients with and without cardiovascular problems, survival was highest in patients without cardiovascular issues (86.6%), and mortality was most increased in the non-hypertension group (31.1%) compared to the hypertension only or Hypertension+Others groups. Diabetes mellitus and cardiovascular system disorders are significantly associated with survival of COVID-19 patients ($p<0.001$) (Table 1).

Table 1. Demographic Characteristic of Respondents and Outcome Status of Patients With COVID-19 (n=2.959)

Characteristic	Mean ± SD or n (%)	Death (%)	Survived (%)	CI	p#
Age (years old)	51.57 ± 18.639				
Time (Days)	9.75±6.565				
Health Problem*					
Diabetes Mellitus	892 (30.1)				
Cardiovascular System	999 (33.8)				
Status					
Censor	2301 (77.8)				
Event (Death)	658 (22.2)				
Year					
2020	599 (20.2)	86 (14.4)	513 (85.6)	50.673-60.275	
2021	1993 (67.4)	522 (26.2)	1471 (73.8)	25.409-29.696	<0.001
2022	367(12.4)	50 (13.6)	317 (86.4)	15.521-19.949	
Gender					
Male	1491 (50.4)	345 (23.1)	1146 (76.9)	37.589-46.599	0.263
Female	1468 (49.6)	313 (21.3)	1155 (78.7)	30.050-35.051	
Age					
Child (0-14)	161 (5.4)	2 (1.2)	159 (98.8)	25.301-26.111	
Young Age (15-24)	114 (3.9)	3 (2.6)	111 (97.4)	39.783-42.122	<0.001
Adult (25-64)	1965 (66.4)	416 (21.2)	1549 (78.8)	42.454-50.095	
Elderly (>64)	719 (24.3)	237 (37.0)	482 (67.0)	21.482-27.488	
Comorbid					
No	1395 (47.1)	188 (13.5)	1207 (86.5)	45.918-55.599	<0.001
Yes	1564 (52.9)	470 (30.1)	1094 (69.9)	25.245-29.461	
Type of Hospital					
Secondary Hospital	1171 (39.6)	257 (21.9)	914 (78.1)	43.418-52.016	0.012
Tertiary Hospital	1788 (60.4)	401 (22.4)	1387 (77.6)	24.959-30.565	
Diabetes Mellitus Problem (n=2287)					
No	1395 (61.0)	187 (13.4)	1208 (86.6)	45.658-55.413	
Diabetes Mellitus Only	256 (11.2)	74 (28.9)	182 (71.1)	21.009-27.587	
Diabetes Mellitus + Hypertension	290 (12.7)	101 (34.8)	189 (65.2)	25.615-32.794	<0.001
Diabetes Mellitus + Others	346 (15.1)	144 (41.6)	202 (58.4)	19.502-25.395	
Cardiovascular System Problem (n=2394)					
No	1395 (58.3)	187 (13.4)	1208 (86.6)	45.658-55.413	
Non-Hypertension	135 (5.6)	42 (31.1)	93 (68.9)	16.660-29.612	
Hypertension Only	279 (11.7)	61 (21.9)	218 (78.1)	18.006-24.955	<0.001
Hypertension + Others	585 (24.4)	168 (28.7)	417 (71.3)	29.270-34.174	

*One person can be >1 health problem; # Kaplan-Mayer (log rank test); CI=Confident interval; n=number; p=p-value; SD=Standard deviation

Death and Survival Probability of DM and Cardiovascular System Diseases Patients With COVID-19

The Life table in Table 2 shows that based on intervals of every 14 days, it is known that the initial 14 days of patients without comorbidities have the highest cumulative survival probability among others (82%), while patients with DM + other diseases have the lowest value (54%). At the 28-41 interval, the cumulative survival probability of patients without comorbidities still showed the highest value (61%), while the group of patients with DM+others and hypertension only had the lowest value (24%). In the 70-83 interval, patients without comorbidities had a better cumulative survival probability than all participants (61% vs 47%). The median survival time was highest in the group without comorbidities (70.00) and lowest in the DM+others group (21.75). The median survival time for all participants is 38.21.

Table 2. Life Table of DM and Cardiovascular System Diseases Patients With COVID-19

Intervals (Days)	At Risk	Death (%)	Censored	Survival Probability	CSP
All Participants[a]					
0-13	2959	584	1803	0.72	0.72
14-27	572	65	438	0.82	0.58
28-41	69	9	47	0.80	0.47
42-55	13	0	11	1.00	0.47
56-69	2	0	1	1.00	0.47
70-83	1	0	1	1.00	0.47
No Comorbid[b]					
0-13	1395	162	991	0.82	0.82
14-27	242	22	187	0.85	0.70
28-41	33	3	21	0.87	0.61
42-55	9	0	7	1.00	0.61
56-69	2	0	1	1.00	0.61
70-83	1	0	1	1.00	0.61
DM only[c]					
0-13	256	63	142	0.66	0.66
14-27	51	10	34	0.71	0.47
28-41	7	1	6	0.75	0.35
DM+Hypertension[d]					
0-13	290	96	139	0.56	0.56
14-27	55	5	43	0.85	0.48
28-41	7	0	6	1.00	0.48
42-55	1	0	1	1.00	0.48
DM+Others[e]					
0-13	346	132	122	0.54	0.54
14-27	92	7	71	0.88	0.47
28-41	14	5	8	0.50	0.24
42-55	1	0	1	1.00	0.24
Non-Hypertension[f]					
0-13	135	37	72	0.63	0.63
14-27	26	5	19	0.70	0.44
28-41	2	0	1	1.00	0.44
42-55	1	0	1	1.00	0.44
Hypertension[g]					
0-13	279	50	185	0.73	0.73
14-27	44	10	31	0.65	0.48
28-41	3	1	2	0.50	0.24
Hypertension+Others[h]					
0-13	585	154	302	0.65	0.65
14-27	129	14	105	0.82	0.53
28-41	10	0	8	1.00	0.53
42-55	2	0	2	1.00	0.53

CSP:Cumulative Survival Probability

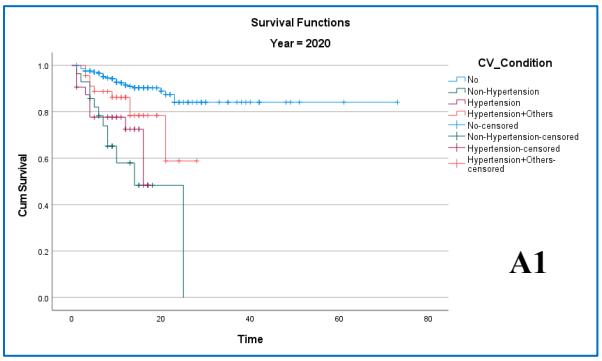
The median survival time: a=38.21, b=70.00, c=25.51, d=24.74, e=21.75, f=23.31, g=26.64, h=42.00

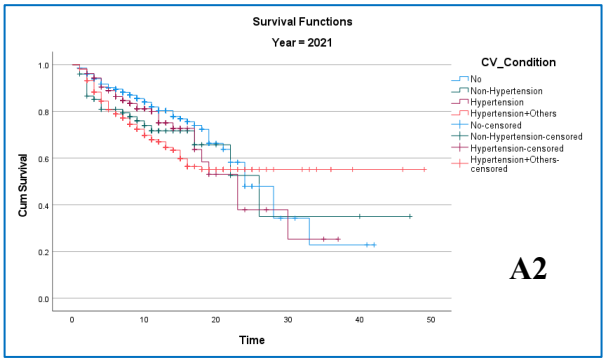
Outcome Status of Patient Cardiovascular System Diseases with COVID-19 Adjusted by Demographic Characteristic

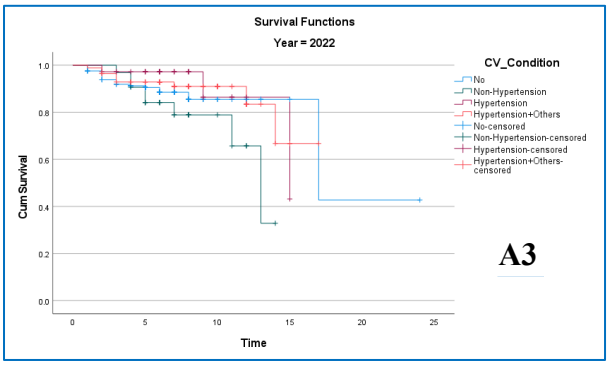
Table 3 shows significant differences between patients without cardiovascular disorders and patients with cardiovascular disorders (Non-Hypertension, Hypertension, and Hypertension + Others) adjusted by year, gender, age, and hospital type with the respective log-rank test p values <0.001. The non-hypertension group showed the most were in 2021 ((75), male (77), age ≤64 years (89), and treated in secondary hospitals (98), with survival rates of 70.7%, 62.3%, 75.3%, and 69.4%, respectively. The largest hypertension group in 2021 (211) was men (145), age ≤64 years (174) and treated in tertiary

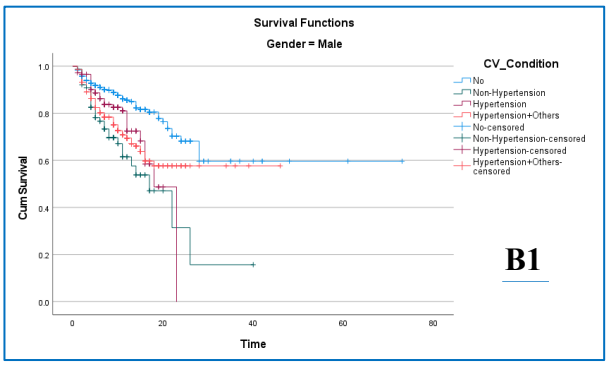
hospitals (245), with survival rates of 77.3%, 76.6%, 83.3%, and 76.3%, respectively. The hypertension + other disease group showed the highest number in 2021 (455), men (295), aged ≤64 years (408), and treated in secondary hospitals (309), with survival values of 67.0%, 69.8%, 72.3%, and 78.0%, respectively. Survival time for each group of cardiovascular system disease patients based on year of treatment, gender, age, and type of hospital can be seen in **Figure 1**.

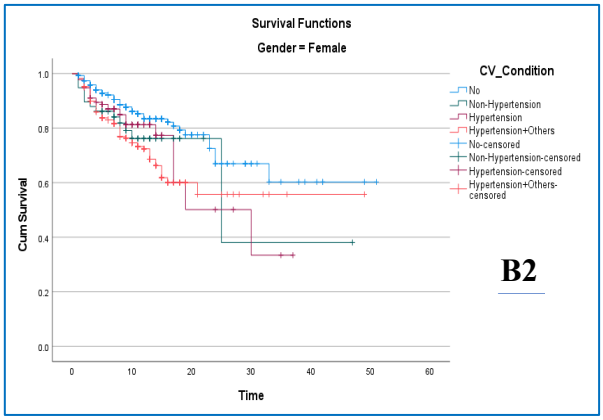
Figure 1. Survival Time of Patients with Cardiovascular System Diseases with COVID-19 Adjusted by Demographic Characteristic Part A shows the survival time adjusted for year of treatment, A1 for patients in 2020, A2 in 2021, and A3 in 2022. Part B shows the survival function adjusted for gender, B1 for female and B2 for male patients. Part C offers the survival function based on age, C1 for patients aged ≤64 and C2 for patients > 64. Part D shows survival time adjusted for hospital type, D1 for secondary and D2 for tertiary hospitals.

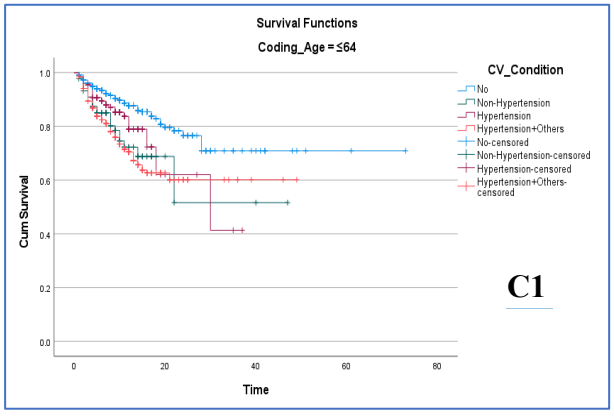


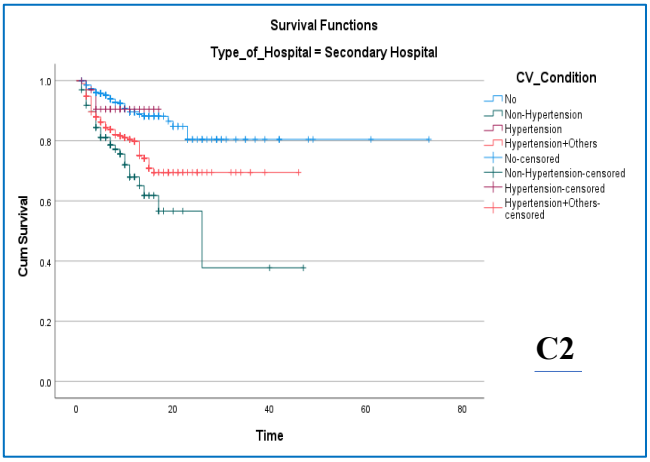


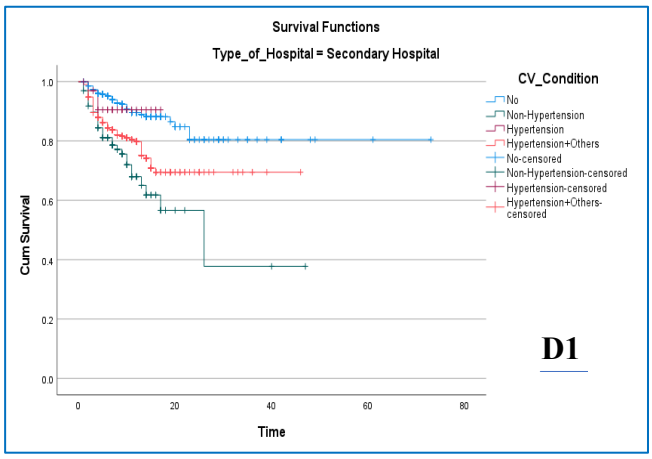


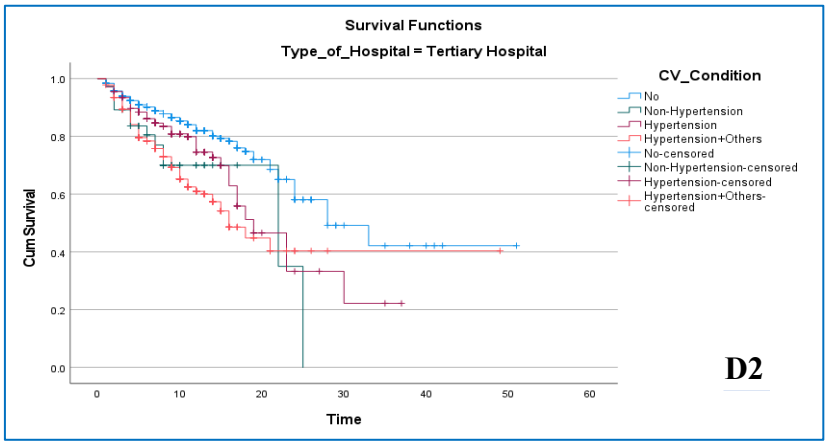








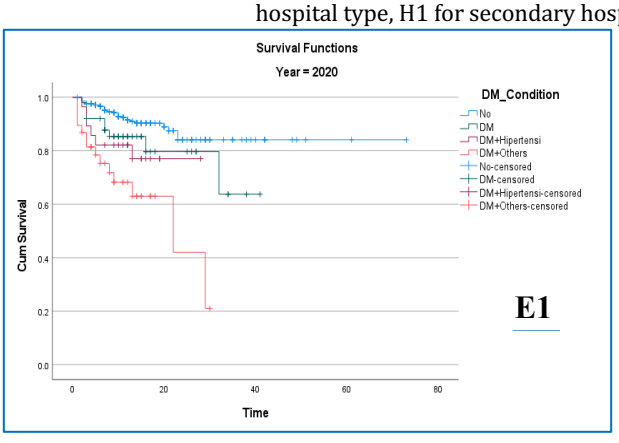


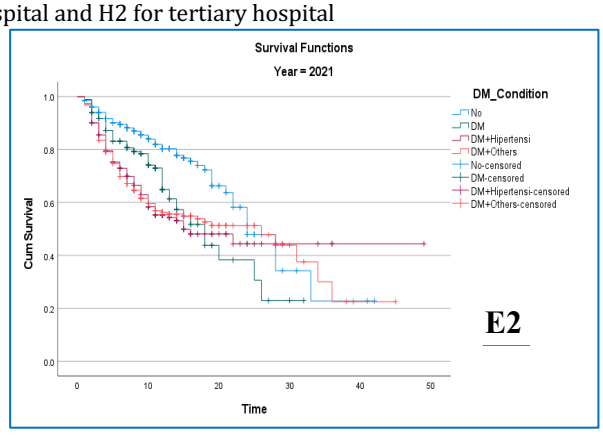


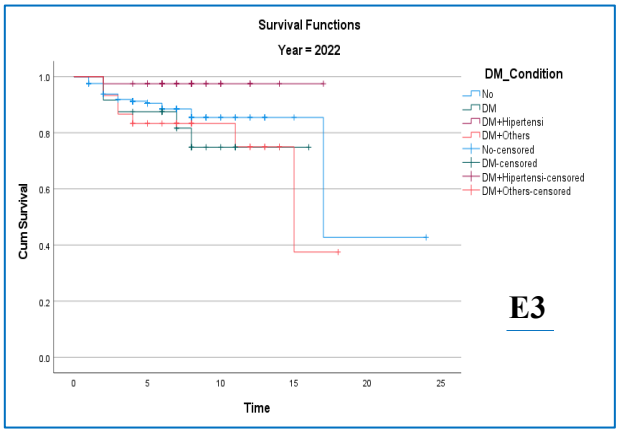
Outcome Status of Patient Diabetes Mellitus with COVID-19 Adjusted by Demographic Characteristic

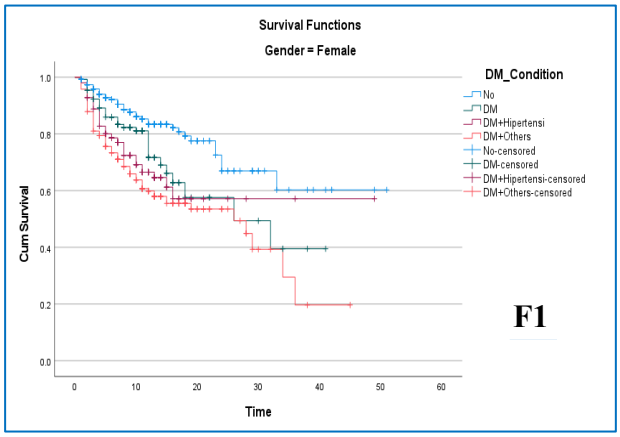
Table 4 shows significant differences between patients without DM and patients with DM (DM only, DM+Hypertension, and DM+Others) adjusted by year, gender, age, and hospital type with log-rank test p-value <0.001 each. The DM-only group showed the most in 2021 ((182), female (131), age ≤64 years (195), and treated in tertiary hospitals (195), with survival rates of 67.0%, 74.0%, and 74.9%, and 65.6%, respectively. The highest number of DM+hypertension groups were in 2021 (222), female (153), aged ≤64 years (190), and treated in tertiary hospitals (205), with survival rates of 57.7%, 69.3%, 65.8%, and 61.5%, respectively. The DM + other disease group showed the highest number in 2021 (278), female (190), aged ≤64 years (249), and treated in secondary hospitals (299), with a survival value of 55.8%, 57.9%, 59.8%, and 58.9%, respectively. Survival time for each group of DM patients based on years of treatment, gender, age, and type of hospital can be seen in **Figure 2**.

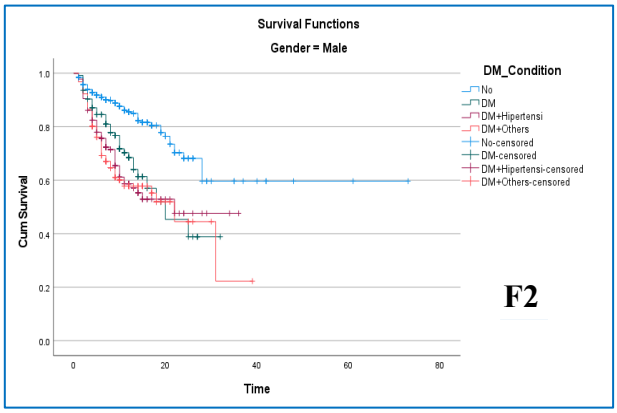
Figure 2. Survival Time of Diabetes Mellitus Patients with COVID-19 Adjusted by Demographic Characteristic. Part E shows the survival time adjusted for year of treatment, E1 for patients in 2020, E2 in 2021, and E3 in 2022. Part F offers the survival function adjusted for gender, F1 for female and F2 for male patients. Part G offers the survival function based on age, G1 for patients aged ≤64 and G2 for patients > 64. Part H shows survival time adjusted for hospital type, H1 for secondary hospital and H2 for tertiary hospital

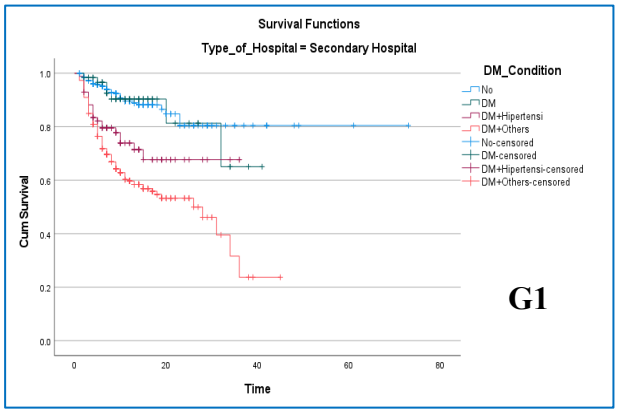


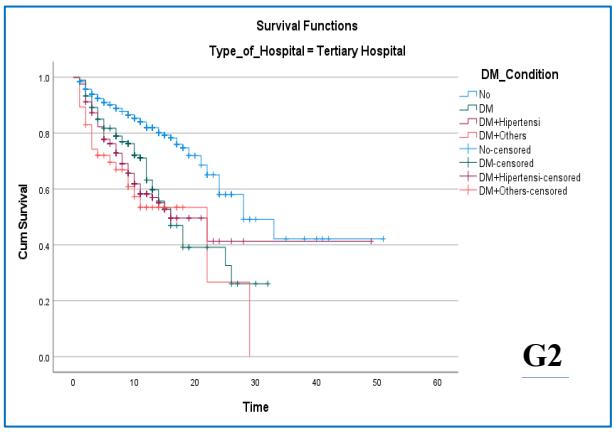


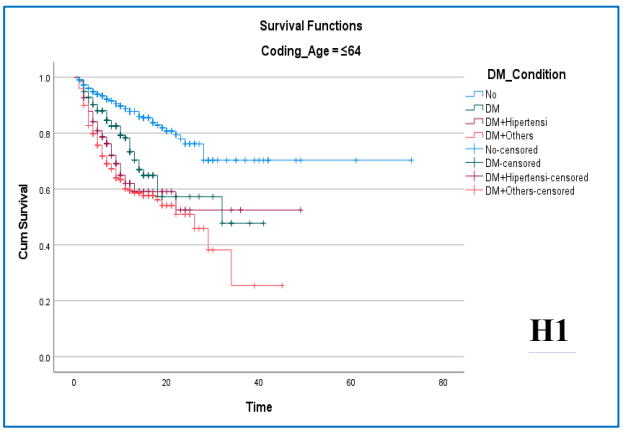

Survival Functions
Year = 2022
DM_Condition
No
DM
DM+Hipertensi
DM+Others
No-censored
DM-censored
DM+Hipertensi-censored
DM+Others-censored
Cum Survival
Time
E3

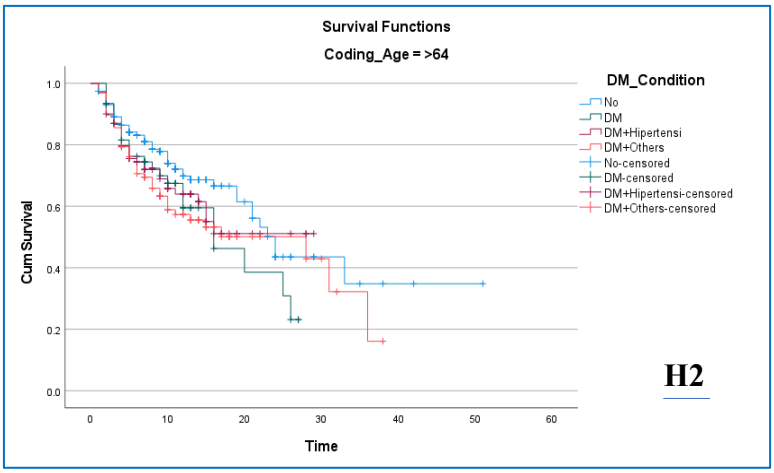

Survival Functions
Gender = Female
DM_Condition
No
DM
DM+Hipertensi
DM+Others
No-censored
DM-censored
DM+Hipertensi-censored
DM+Others-censored
Cum Survival
Time
F1


Survival Functions
Gender = Male
DM_Condition
No
DM
DM+Hipertensi
DM+Others
No-censored
DM-censored
DM+Hipertensi-censored
DM+Others-censored
Cum Survival
Time
F2


Survival Functions
Type_of_Hospital = Secondary Hospital
DM_Condition
No
DM
DM+Hipertensi
DM+Others
No-censored
DM-censored
DM+Hipertensi-censored
DM+Others-censored
Cum Survival
Time
G1


Survival Functions
Type_of_Hospital = Tertiary Hospital
DM_Condition
No
DM
DM+Hipertensi
DM+Others
No-censored
DM-censored
DM+Hipertensi-censored
DM+Others-censored
Cum Survival
Time
G2


Survival Functions
Coding_Age = ≤64
DM_Condition
No
DM
DM+Hipertensi
DM+Others
No-censored
DM-censored
DM+Hipertensi-censored
DM+Others-censored
Cum Survival
Time
H1


Survival Functions
Coding_Age = >64
DM_Condition
No
DM
DM+Hipertensi
DM+Others
No-censored
DM-censored
DM+Hipertensi-censored
DM+Others-censored
Cum Survival
Time
H2

Cox regression of the risk factors for death in COVID-19 cases

The Cox regression results in Table 5 show that years of treatment, age, type of hospital, cardiovascular system problems, and DM condition are related to the survival rate of COVID-19 patients ($p<0.05$). Patients treated in 2021 had the highest mortality (CHR=1.449, CI=1.082-1.941). The higher the age, the higher the mortality; this can be seen in the elderly age group, which has the most increased mortality among other age groups (CHR=21.956, CI=5.458-88.326). Patients treated in tertiary hospitals had higher mortality than those in secondary hospitals (CHR=1.222, CI=1.043-1.432). Non-hypertension cardiovascular problems have the most increased mortality among other groups (CHR=2.392, CI=1.711-3.343), while DM patients who have a combination of other diseases also have the most increased mortality (CHR=2.965, CI=2.384-3.686). Even though gender is not related to the mortality of COVID-19 patients, the CHR value shows that male mortality is 1.090 higher than female (CI=0.936-1.271).

Table 5 Cox regression of the risk factors to death in COVID-19 cases

Variable	CHR	p**	95% CI
Year			
2020	0.611	0.006	0.429-0.869
2021	1.449	0.013	1.082-1.941
Gender			
Male	1.090	0.269	0.936-1.271
Age (years)			
Young Age (15-24)	1.817	0.513	0.303-10.873
Adult (25-64)	14.173	<0.001	3.532-56.872
Elderly (>64)	21.956	<0.001	5.458-88.326
Type of Hospital			
Tertiary hospitals	1.222	0.013	1.043-1.432
Cardiovascular System Problem			
Non-Hypertension	2.392	<0.001	1.711-3.343
Hypertension + Others	2.073	<0.001	1.683-2.554
Hypertension Only	1.693	<0.001	1.267-2.261
DM Condition			
Diabetes Mellitus Only	2.024	<0.001	1.546-2.649
Diabetes Mellitus + Hypertension	2.599	<0.001	2.040-3.311
Diabetes Mellitus + Others	2.965	<0.001	2.384-3.686

**Cox Regression; CHR=Cox's Hazard Ratio; CI=Confident interval; p=p-value

DISCUSSION

The findings show that the presence of comorbidities is related to the survival rate of COVID-19 patients; patients who have comorbidities show a higher mortality rate than those who do not. These findings reinforce previous studies linking these comorbidities to adverse outcomes of COVID-19 as independent predictors of mortality (Imam et al., 2020; Piskač Živković et al., 2022; Ssentongo et al., 2020). Studies in Syria (Najjar et al., 2023), Egypt (Albadawy et al., 2021), and India (Saurabh Bobdey et al., 2021) reported lower survival rates in COVID-19 patients with comorbidities. The study showed that COVID-19 patients with cardiovascular system problems were associated with survival rates before and after adjusting for respondent characteristics. Patients without comorbidities have a higher survival rate than patients with cardiovascular issues. The study results align with previous research that cardiovascular assessment predicts the survival rate of patients suffering from COVID-19; patients with cardiovascular problems have a lower survival rate (Hirata & Yamakage, 2021; Lakhani et al., 2022). The involvement of cardiovascular issues in COVID-19 patients admitted to the ICU and the higher mortality rate further support the idea that the survival rate of COVID-19 patients with cardiovascular comorbidities is lower (Badkoubeh et al., 2020).

Patients with non-hypertension cardiovascular problems have the highest mortality rate compared to other cardiovascular problems, while patients with hypertension alone have the lowest mortality rate. The majority of patients with non-hypertension cardiovascular problems are congestive heart failure (CHF) patients. These findings are by systematic reviews and meta-analyses revealing an increased risk of death in COVID-19 patients with CHF (Dalia et al., 2021; Ssentongo et al., 2020), confirmed by Nasrullah et al. that poor cardiopulmonary reserve in the hyperinflammatory state seen in CHF and COVID-19 patients

contributes to higher mortality rates (Nasrullah et al., 2023). CHF in COVID-19 patients increases the risk of death due to maladaptive activation of the renin-angiotensin system (Bhatt et al., 2021) and also causes an increase in endotoxins and cytokines, which can trigger a cytokine storm (Choi et al., 2021).

Another comorbid that influences the survival rate of COVID-19 patients is diabetes mellitus, in line with the study results showing that the survival rate of patients without comorbidities is better than that of patients with DM from an analysis that is adjusted for the characteristics of respondents. This research supports previous research that COVID-19 patients with comorbid DM show an increase in severity (Sharif et al., 2021; Souza et al., 2022) and mortality rates (Huang & Huang, 2023; Yan et al., 2020). A meta-analysis study reported that the mortality rate and severity increased twofold in COVID-19 patients with DM compared to non-DM patients (Kumar et al., 2020). The death rate for COVID-19 patients with DM and other diseases is much higher than for patients with DM alone or DM with hypertension, a trend that can be caused by several factors. A systematic review and meta-analysis study by Bepouka et al. highlighted that DM is associated with a pro-inflammatory environment (Bepouka et al., 2022), which triggers a cytokine storm (Azhar et al., 2021), exacerbating mortality in COVID-19 patients.

DM is also correlated with glycemic instability and impaired immune response, which coincides with obesity and heart disease (Kandil et al., 2021), thereby leading to lung dysfunction, such as decreased lung volume (Yan et al., 2020). Typical DM complications such as cardiovascular disease and chronic obstructive pulmonary disease, especially when accompanied by other comorbidities, significantly increase the risk of death in COVID-19 patients (Lim et al., 2021; Najjar et al., 2023). Bello-Chavolla et al. supported this by noting that DM was associated with a threefold increased risk of death from COVID-19 after adjusting for age, sex, and comorbidities (Bello-Chavolla et al., 2020).

Apart from comorbid factors, the results also show that the survival rate of COVID-19 patients is influenced by the year the patient was treated, age and type of hospital. Patients treated in 2021 have a higher death rate than in 2020 or 2022. 2020 was the first time COVID-19 cases occurred, and virus mutations were not as dangerous as the following year (Farhud & Mojahed, 2022). The role of COVID-19 vaccination on mortality rates, although varied (Lv et al., 2021), is also essential; the number of people receiving vaccination and the stages obtained are also greater after 2021 (Surianta & Patunru, 2024). Furthermore, elderly people show almost 23 times the chance of death compared to other age groups. Results are in line with previous studies that case fatality rates were exceptionally high among those who were elderly (Woodall et al., 2021), exacerbated by dementia (Yoshino & Takechi, 2021), and using mechanical ventilation (Tanaka et al., 2021). Factors such as gradual decline of the immune system with age may explain the increased susceptibility to infections and high mortality rates in elderly patients (Yanez et al., 2020). Furthermore, frailty and sarcopenia are significant contributors to increased mortality in the elderly (Na et al., 2022; Seong et al., 2021).

In a comprehensive analysis of outcomes of COVID-19 patients across hospital types, our study found higher mortality rates in tertiary hospitals compared with secondary hospitals. Many factors can cause this difference. Tertiary hospitals typically admit more severely ill patients, often requiring intensive care, indicating a higher initial disease severity (Gupta et al., 2020). Hospital characteristics significantly influence patient outcomes, including variations in survival rates and the economic burden of COVID-19 (Di Fusco et al., 2021; Hayek et al., 2020). Tertiary hospitals often treat more patients with comorbidities such as heart failure and diabetes, which are associated with higher mortality rates (Mok et al., 2021; Niedziela et al., 2022). Increased hospital burden in tertiary settings may strain resources, contributing to higher mortality rates (Rossman et al., 2021). In line with studies such as Asch et al. (Asch et al., 2021), our findings showed significant hospital-level outcome differences, underscoring the need for tailored patient management strategies across different hospital settings.

Several things are limitations to this study. Even though the use of secondary data in survival analysis studies is prevalent, it cannot be denied that secondary data has weaknesses in the form of information bias. Another area for improvement is that many patients had incomplete variables such as date of discharge or reason for leaving the hospital, so this became an exclusion criterion for the research sample. This is likely due to the high workload and movement of workers during the pandemic, so several variables need to be filled in consistently. The following limitation is that the data does not show PCR results in detail; it only says positive or negative; however, these results can still be accounted for. Despite these limitations, the number of respondents is quite large, and the study results are consistent with world literature and are expected to contribute to the epidemiological analysis of COVID-19.

CONCLUSION

Years of treatment, age, and type of hospital are related to the survival rate of COVID-19 patients. Older age indicates a greater risk of death than other age groups. Also, DM and cardiovascular comorbidities are related to the survival rate of COVID-19 patients. DM patients who have comorbidities other than hypertension have a greater risk of death compared to DM patients alone. Likewise, patients with cardiovascular problems other than hypertension have a greater risk of death than others. For this reason, COVID-19 patients with comorbidities, especially DM and cardiovascular issues, need special attention and supervision to reduce the risk of death.

Conflicts of Interest

The authors declare that they have no competing interests.

Funding

This study was funded by grant funds from Universitas Respati Yogyakarta

Acknowledgments

We want to thank the Director of Dr Soeradji Tirtonegoro Hospital Klaten, Central Java, Indonesia and Panembahan Senopati Hospital Bantul, Yogyakarta, Indonesia, for the grant of research permission

Author Contribution

Study conception and design	: AN, SF, SD
Data collection	: SF, AS, S
Data analysis and interpretation	: AN, SF, HS
Drafting of the article	: AN, SF, HS, SD, AS, S
Critical revision of the article	: AN, SF

Author Biography

Ariyanto Nugroho is an Associate professor at Program Study of Public Health, Universitas Respati Yogyakarta, Indonesia

Siti Fadlilah is an Associate professor at Program Study of Nursing, Universitas Respati Yogyakarta, Indonesia

Herry Susanto is an Assistant professor Faculty of Nursing, Universitas Islam Sultan Agung, Semarang, Indonesia

Santi Damayanti is an Assistant professor at Program Study of Nursing, Universitas Respati Yogyakarta, Indonesia

Agus Suharto is a Nursing staff at Dr Soeradji Tirtonegoro Hospital Klaten, Central Java, Indonesia

Sugiyarto is an Assistant professor at at Department of Nursing, Poltekkes Kemenkes Surakarta, Indonesia

References

Ahmad, O. B., Boschi-Pinto, C., Lopez, A. D., Murray, C. J., Lozano, R., & Inoue, M. (2001). Age standardization of rates: a new WHO standard. *Geneva: World Health Organization*, *9*(10), 1-14. https://cdn.who.int/media/docs/default-source/gho-documents/global-health-estimates/gpe_discussion_paper_series_paper31_2001_age_standardization_rates.pdf

Albadawy, R. M., Jadoon, B. A., Mogahed, M. M., Ibrahim, M. E., Essawy, T. S., Amin, A. M., Abd-Elraouf, M. S., & Elawady, M. A. (2021). The impact of comorbidities on the outcomes of Egyptian COVID-19 patients: a follow-up study. *Journal of Environmental and Public Health*, *2021*, 1-7. https://doi.org/https://doi.org/10.1155/2021/6662476

Asch, D. A., Sheils, N. E., Islam, M. N., Chen, Y., Werner, R. M., Buresh, J., & Doshi, J. A. (2021). Variation in US hospital mortality rates for patients admitted with COVID-19 during the first 6 months of the pandemic. *JAMA internal medicine*, *181*(4), 471-478. https://doi.org/https://doi.org/10.1001/jamainternmed.2020.8193

Azhar, Z., Widyastuti, C. T., Khotimah, K., Rajin, M., Fatmawati, D. A., & Mawarti, H. (2021). Relationship of Commorbid Disease to Mortality Events in COVID-19 Patients. *International Journal of Social Science*, *1*(2), 135-142. https://doi.org/https://doi.org/10.53625/ijss.v1i2.5046

Badkoubeh, R. S., Almassi, N., Farahani, M. M., Movassaghi, N., Khosravi, A., Mirdamadi, A., Kamali, M., Manshouri, S., Tabrizi, M. T., & Farrashi, M. (2020). The Iranian Society of Echocardiography (ISE) statement on performing echocardiography during the COVID-19 pandemic. *Cardiol*, *45*, 100620.

Bae, S., Kim, S. R., Kim, M. N., Shim, W. J., & Park, S. M. (2021). Impact of cardiovascular disease and risk factors on fatal outcomes in patients with COVID-19 according to age: a systematic review and meta-analysis. *Heart*, *107*(5), 373-380. https://doi.org/10.1136/heartjnl-2020-317901

Bello-Chavolla, O. Y., Bahena-López, J. P., Antonio-Villa, N. E., Vargas-Vázquez, A., González-Díaz, A., Márquez-Salinas, A., Fermín-Martínez, C. A., Naveja, J. J., & Aguilar-Salinas, C. A. (2020). Predicting mortality due to SARS-CoV-2: a mechanistic score relating obesity and diabetes to COVID-19 outcomes in Mexico. *The Journal of Clinical Endocrinology & Metabolism*, *105*(8), 2752-2761. https://doi.org/https://doi.org/10.1210/clinem/dgaa346

Bepouka, B., Odio, O., Mangala, D., Mayasi, N., Mandina, M., Longokolo, M., Makulo, J. R., Mbula, M., Kayembe, J. M., & Situakibanza, H. (2022). Diabetes Mellitus is Associated With Higher COVID-19 Mortality Rates in Sub-

Saharan Africa: A Systematic Review and Meta-analysis. *Cureus*, *14*(7). https://doi.org/https://doi.org/10.7759/cureus.26877
Bhatt, A. S., Jering, K. S., Vaduganathan, M., Claggett, B. L., Cunningham, J. W., Rosenthal, N., Signorovitch, J., Thune, J. J., Vardeny, O., & Solomon, S. D. (2021). Clinical outcomes in patients with heart failure hospitalized with COVID-19. *Heart Failure*, *9*(1), 65-73. https://doi.org/https://doi.org/10.1016/j.jchf.2020.11.003
Bobdey, S., Chawla, N., Behera, V., Ray, S., Ilankumaran, M., Koshy, G., & Kaushik, S. (2021). An analysis of mortality and survival of COVID 19 patients admitted to a tertiary care hospital in Maharashtra, India. *medical journal armed forces india*, *77*, S353-S358.
Bobdey, S., Chawla, N., Behera, V., Ray, S., Ilankumaran, M., Koshy, G., & Kaushik, S. K. (2021). An analysis of mortality and survival of COVID 19 patients admitted to a tertiary care hospital in Maharashtra, India. *Med J Armed Forces India*, *77*(Suppl 2), S353-s358. https://doi.org/10.1016/j.mjafi.2021.02.004
Bustos-Vázquez, E., Padilla-González, E., Reyes-Gómez, D., Carmona-Ramos, M. C., Monroy-Vargas, J. A., Benítez-Herrera, A. E., & Meléndez-Mier, G. (2021). Survival of COVID-19 with Multimorbidity Patients. *Healthcare (Basel)*, *9*(11). https://doi.org/10.3390/healthcare9111423
Byeon, K. H., Kim, D. W., Kim, J., Choi, B. Y., Choi, B., & Cho, K. D. (2021). Factors affecting the survival of early COVID-19 patients in South Korea: An observational study based on the Korean National Health Insurance big data. *International Journal of Infectious Diseases*, *105*, 588-594. https://doi.org/https://doi.org/10.1016/j.ijid.2021.02.101
Chang, D., Chang, X., He, Y., & Tan, K. J. K. (2022). The determinants of COVID-19 morbidity and mortality across countries. *Scientific Reports*, *12*(1), 5888. https://doi.org/10.1038/s41598-022-09783-9
Choi, Y. J., Park, J.-Y., Lee, H. S., Suh, J., Song, J. Y., Byun, M.-K., Cho, J. H., Kim, H. J., & Park, H. J. (2021). Variable effects of underlying diseases on the prognosis of patients with COVID-19. *PloS one*, *16*(7), e0254258. https://doi.org/https://doi.org/10.1371/journal.pone.0254258
Dalia, T., Lahan, S., Ranka, S., Acharya, P., Gautam, A., Goyal, A., Mastoris, I., Sauer, A., & Shah, Z. (2021). Impact of congestive heart failure and role of cardiac biomarkers in COVID-19 patients: A systematic review and meta-analysis. *Indian heart journal*, *73*(1), 91-98. https://doi.org/ https://doi.org/10.1016/j.ihj.2020.12.002
de Almeida-Pititto, B., Dualib, P. M., Zajdenverg, L., Dantas, J. R., de Souza, F. D., Rodacki, M., & Bertoluci, M. C. (2020). Severity and mortality of COVID 19 in patients with diabetes, hypertension and cardiovascular disease: a meta-analysis. *Diabetol Metab Syndr*, *12*, 75. https://doi.org/10.1186/s13098-020-00586-4
Di Fusco, M., Shea, K. M., Lin, J., Nguyen, J. L., Angulo, F. J., Benigno, M., Malhotra, D., Emir, B., Sung, A. H., & Hammond, J. L. (2021). Health outcomes and economic burden of hospitalized COVID-19 patients in the United States. *Journal of Medical Economics*, *24*(1), 308-317. https://doi.org/https://doi.org/10.1080/13696998.2021.1886109
Farhud, D. D., & Mojahed, N. (2022). SARS-COV-2 Notable Mutations and Variants: A Review Article. *Iran J Public Health*, *51*(7), 1494-1501. https://doi.org/10.18502/ijph.v51i7.10083
Garbin, J. R. T., Leite, F. M. C., Lopes-Júnior, L. C., Dell'Antonio, C., Dell'Antonio, L. S., & Santos, A. (2022). Analysis of Survival of Patients Hospitalized with COVID-19 in Espírito Santo, Brazil. *Int J Environ Res Public Health*, *19*(14). https://doi.org/10.3390/ijerph19148709
Gupta, S., Kaushik, A., & Gupta, J. (2020). Management and outcomes of patients hospitalized with severe COVID-19 at a tertiary care center in midwestern United States. *Monaldi Archives for Chest Disease*, *90*(4). https://doi.org/https://doi.org/10.4081/monaldi.2020.1592
Hayek, S. S., Brenner, S. K., Azam, T. U., Shadid, H. R., Anderson, E., Berlin, H., Pan, M., Meloche, C., Feroz, R., & O'Hayer, P. (2020). In-hospital cardiac arrest in critically ill patients with covid-19: multicenter cohort study. *bmj*, *371*. https://doi.org/https://doi.org/10.1136/bmj.m3513
Hirata, N., & Yamakage, M. (2021). Cardiovascular considerations for anesthesiologists during the COVID-19 pandemic. *Journal of anesthesia*, *35*, 361-365. https://doi.org/https://doi.org/10.1007/s00540-020-02852-1
Huang, A. A., & Huang, S. Y. (2023). Diabetes is associated with increased risk of death in COVID-19 hospitalizations in Mexico 2020: A retrospective cohort study. *Health Science Reports*, *6*(7), e1416. https://doi.org/https://doi.org/10.1002/hsr2.1416
Imam, Z., Odish, F., Gill, I., O'Connor, D., Armstrong, J., Vanood, A., Ibironke, O., Hanna, A., Ranski, A., & Halalau, A. (2020). Older age and comorbidity are independent mortality predictors in a large cohort of 1305 COVID-19 patients in Michigan, United States. *Journal of internal medicine*, *288*(4), 469-476. https://doi.org/https://doi.org/10.1111/joim.13119
Kandil, H., Ibrahim, A. E., Afifi, N., & Arafa, A. (2021). Diabetes and risk of COVID-19 mortality: A systematic review and meta-analysis. *Infectious Diseases in Clinical Practice (Baltimore, Md.)*, *29*(3), e195. https://doi.org/https://doi.org/10.1097/IPC.0000000000000992
Kumar, A., Arora, A., Sharma, P., Anikhindi, S. A., Bansal, N., Singla, V., Khare, S., & Srivastava, A. (2020). Is diabetes mellitus associated with mortality and severity of COVID-19? A meta-analysis. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 535-545. https://doi.org/https://doi.org/10.1016/j.dsx.2020.04.044
Lakhani, A., Laturkar, N., Dhok, A., & Mitra, K. (2022). Prognostic utility of cardiovascular indices in COVID-19 infection: A single-center prospective study in India. *Journal of Family Medicine and Primary Care*, *11*(10), 6297. https://doi.org/https://doi.org/10.4103/jfmpc.jfmpc_501_22

Li, Z., Wang, X., Wu, Y., & Owzar, K. (2018). Sample size calculation for studies with grouped survival data. *Stat Med*, *37*(27), 3904-3917. https://doi.org/10.1002/sim.7847

Lim, S., Bae, J. H., Kwon, H.-S., & Nauck, M. A. (2021). COVID-19 and diabetes mellitus: from pathophysiology to clinical management. *Nature Reviews Endocrinology*, *17*(1), 11-30. https://doi.org/https://doi.org/10.1038/s41574-020-00435-4

Lv, G., Yuan, J., Xiong, X., & Li, M. (2021). Mortality rate and characteristics of deaths following COVID-19 vaccination. *Frontiers in Medicine*, *8*, 670370. https://doi.org/https://doi.org/10.3389/fmed.2021.670370

Mok, J., Malpartida, J. C., O'Dell, K., Davis, J., Gao, C., & Manyam, H. (2021). Vascular comorbidities worsen prognosis of patients with heart failure hospitalised with COVID-19. *Open heart*, *8*(1). https://doi.org/https://doi.org/10.1136/openhrt-2021-001668

Na, Y. S., Kim, J. H., Baek, M. S., Kim, W.-Y., Baek, A.-R., young Lee, B., Seong, G. M., & Lee, S.-I. (2022). In-hospital mortality prediction using frailty scale and severity score in elderly patients with severe COVID-19. *Acute and Critical Care*, *37*(3), 303-311. https://doi.org/https://doi.org/10.4266/acc.2022.00017

Najjar, M., Albuaini, S., Fadel, M., Aljbawi, A., AlAwad, Y., & Mohsen, F. (2023). Impact of comorbidities on hospitalised Syrian patients with COVID-19: a retrospective study. *BMJ open*, *13*(3), e068849. https://doi.org/https://doi.org/10.1136/bmjopen-2022-068849

Nasrullah, A., Gangu, K., Cannon, H. R., Khan, U. A., Shumway, N. B., Bobba, A., Sagheer, S., Chourasia, P., Shuja, H., & Avula, S. R. (2023). COVID-19 and Heart Failure with Preserved and Reduced Ejection Fraction Clinical Outcomes among Hospitalized Patients in the United States. *Viruses*, *15*(3), 600. https://doi.org/https://doi.org/10.3390/v15030600

Niedziela, J. T., Jaroszewicz, J., Wita, K., Cieśla, D., & Gąsior, M. (2022). High in-hospital and post-discharge mortality in patients with a pre-existing diagnosis of heart failure hospitalized due to COVID-19. *Kardiologia Polska (Polish Heart Journal)*, *80*(1), 90-92. https://doi.org/https://doi.org/10.33963/KP.a2021.0163

Piskač Živković, N., Lucijanić, M., Bušić, N., Jurin, I., Atić, A., Andrilović, A., Penović, T., Domić, I., Gnjidić, J., & Demaria, M. (2022). The associations of age, sex, and comorbidities with survival of hospitalized patients with coronavirus disease 2019: data from 4014 patients from a tertiary-center registry. *Croatian Medical Journal*, *63*(1), 36-43. https://doi.org/https://doi.org/10.3325/cmj.2022.63.36

Rossman, H., Meir, T., Somer, J., Shilo, S., Gutman, R., Ben Arie, A., Segal, E., Shalit, U., & Gorfine, M. (2021). Hospital load and increased COVID-19 related mortality in Israel. *Nature communications*, *12*(1), 1904. https://doi.org/https://doi.org/10.1038/s41467-021-22214-z

Seong, G. M., Baek, A.-R., Baek, M. S., Kim, W.-Y., Kim, J. H., Lee, B. Y., Na, Y. S., & Lee, S.-I. (2021). Comparison of clinical characteristics and outcomes of younger and elderly patients with severe COVID-19 in Korea: a retrospective multicenter study. *Journal of Personalized Medicine*, *11*(12), 1258. https://doi.org/https://doi.org/10.3390/jpm11121258

Sharif, N., Ahmed, S. N., Opu, R. R., Tani, M. R., Dewan, D., Daullah, M. U., Shanto, R. I., Parvez, A. K., Talukder, A. A., & Dey, S. K. (2021). Prevalence and impact of diabetes and cardiovascular disease on clinical outcome among patients with COVID-19 in Bangladesh. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *15*(3), 1009-1016. https://doi.org/https://doi.org/10.1016/j.dsx.2021.05.005

Sousa, G. J. B., Garces, T. S., Cestari, V. R. F., Florêncio, R. S., Moreira, T. M. M., & Pereira, M. L. D. (2020). Mortality and survival of COVID-19. *Epidemiol Infect*, *148*, e123. https://doi.org/10.1017/s0950268820001405

Souza, S. M. d., Quintão, A. P. d. C., Soares, M. C. B., Mendes, I. R., Freitas, B. A. C. d., Siman, A. G., & Toledo, L. V. (2022). Survival of patients with diabetes mellitus hospitalized for acute respiratory syndrome due to COVID-19. *Revista do Instituto de Medicina Tropical de São Paulo*, *64*. https://doi.org/https://doi.org/10.1590/S1678-9946202264074

Ssentongo, P., Ssentongo, A. E., Heilbrunn, E. S., Ba, D. M., & Chinchilli, V. M. (2020). Association of cardiovascular disease and 10 other pre-existing comorbidities with COVID-19 mortality: A systematic review and meta-analysis. *PloS one*, *15*(8), e0238215. https://doi.org/https://doi.org/10.1371/journal.pone.0238215

Surianta, A., & Patunru, A. A. (2024). The political economy of COVID-19 vaccination in Indonesia. *Asia & the Pacific Policy Studies*, *11*(1), e381.

Tanaka, C., Tagami, T., Nakayama, F., Kudo, S., Takehara, A., Fukuda, R., Kaneko, J., Ishiki, Y., Sato, S., & Shibata, A. (2021). Association between mortality and age among mechanically ventilated COVID-19 patients: a Japanese nationwide COVID-19 database study. *Annals of Intensive Care*, *11*(1), 171. https://doi.org/https://doi.org/10.1186/s13613-021-00959-6

Woodall, M. N., Masonou, T., Case, K. M., & Smith, C. M. (2021). Human models for COVID-19 research. *The Journal of Physiology*, *599*(18), 4255-4267. https://doi.org/https://doi.org/10.1113/JP281499

World Health Organization, W. (2024). *WHO COVID-19 dashboard*. Retrieved January 31 from https://data.who.int/dashboards/covid19/cases?n=c

Yan, Y., Yang, Y., Wang, F., Ren, H., Zhang, S., Shi, X., Yu, X., & Dong, K. (2020). Clinical characteristics and outcomes of patients with severe covid-19 with diabetes. *BMJ open diabetes research & care*, *8*(1). https://doi.org/https://doi.org/10.1136/bmjdrc-2020-001343

Yanez, N. D., Weiss, N. S., Romand, J.-A., & Treggiari, M. M. (2020). COVID-19 mortality risk for older men and women. *BMC public health*, *20*(1), 1-7. https://doi.org/https://doi.org/10.1186/s12889-020-09826-8

Yoshino, H., & Takechi, H. (2021). Influences of COVID-19 in a dementia outpatient clinic: experience from the Fujita-Health University Hospital in Aichi, Japan. *Psychogeriatrics*, *21*(3), 438. https://doi.org/https://doi.org/10.1111/psyg.12684

Cite this article as: Nugroho, A; Fadlilah, S; Susanto, H; Damayanti, S; Suharto, A; Sugiyarto, A. (2024). Survival Analysis of Diabetes Mellitus and Cardiovascular Patients With COVID-19: A Secondary Data Analysis, *Public Health of Indonesia, 10*(1), 143-156. https://doi.org/10.36685/phi.v10i2.788