Original Article

Mortality Audit In COVID-19 Cases of the Omicron Variant in Persahabatan Hospital

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Abstract

Background: SARS-CoV-2, the virus that causes COVID-19, has mutated into various variants. Deaths in COVID-19 cases caused by the Omicron variant had the highest rate compared to other variants. This research aims to mortality audit of the Omicron variant of COVID-19 in 2022 at Persahabatan Hospital.

Method: This is a cross-sectional observational study focusing on the death audit form recommended by the official Indonesian Hospital Association. Used data from Medical Cause of Death Certificate (SMPK) and medical records of patients treated and died at Persahabatan Hospital in January-December 2022. The causes of death (COD) from the audit results were compared with SMPK. Conducted interviews with the doctor who takes care of patients to explore the root of the problem and improvement efforts.

Results: Of the 568 COVID-19 patients with the Omicron variant hospitalized, 130/568 died. As many as 42.52% of the COVID-19 variant Omicron patients died from COVID-19 and 57.48% had COVID-19. The three most COD were respiratory failure, MOF and septic shock. The three underlying COD were COVID-19, bacterial pneumonia and lung cancer. The COD in SMPK and the results of the mortality audit are only appropriate for 23.62%. The best three suggestions for improving clinical management are evaluating the patient supervision/monitoring system, testing for COVID-19 antigens carried out earlier before PCR, and providing special services for COVID-19 patients with comorbid. The top three suggestions for improving hospital managerial aspects are to create and evaluate a special SOP for COVID-19 patients with comorbid, add special service facilities for COVID-19 patients with comorbid and increase ICU bed capacity and human resources.

Conclusion: The COVID-19 variant Omicron patients died due to COVID-19 and had COVID-19. The three most COD were respiratory failure, MOF and septic shock. Only 23.62% of COD from SMPK were consistent with the results of the mortality audit.

Keywords: COVID-19, immediate cause, mortality audit, Omicron, underlying cause

INTRODUCTION

Coronavirus Disease 2019(COVID-19) is a disease caused by infection with the SARS-CoV-2 virus. The virus was first identified in Wuhan, China, in December 2019 and then spread throughout the world. In March 2020, the World Health Organization (WHO) declared COVID-19 a global pandemic.[1]

During this pandemic period, Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) has experienced mutations and produces various variants. One of the SARS-CoV-2 variants is the Omicron variant (B.1.1.529), which was first reported in South Africa on November 24, 2021. The death rate for the Omicron variant is also lower than the Delta variant. Data from the United States and South Africa shows that the case fatality ratio for the Omicron variant is two times lower than for the Delta variant.[1]

Hospitals, as one of the providers of health services, need to make efforts to maintain service quality. In an effort to maintain the quality of service in health facilities, the concept of clinical governance, which can be defined as a framework in which health service organizations are responsible for continuously improving the quality of their services and maintaining high service quality, can be applied.[2]

Efforts to prevent morbidity and mortality in hospitals are one of the main components in providing safe services in health facilities. This can be achieved through meetings and discussions related to morbidity and mortality, which are carried out routinely in hospitals to identify unwanted events and deaths. Death audits of death cases that occur in hospitals can also be a method for identifying various causes of death and efforts to prevent them in the future.[2]

Death audits are useful in preventing and reducing death rates in hospitals, but their implementation still faces various obstacles.[3] Another challenge in death audits that is often faced is the incompleteness or mismatch of the cause of death written on the Medical Cause of Death Certificate (*Sertifikat Medis Penyebab Kematian*/SMPK) with the cause of death obtained in the death audit. A study at Persahabatan Hospital of lung cancer patients found that more than half (55.2%) of the death sheets did not match the medical record and 61.5% of the death sheet writing did not comply with the SOP.[4]

Persahabatan Hospital, as the National Respiratory Center, has become a national referral hospital for COVID-19 cases. During the emergency response period, the spike in COVID-19 cases in early 2022 was dominated by the Omicron variant. The COVID-19 death rate that occurred at Persahabatan Hospital was quite high during the emergency response period for the spike in COVID-19 cases in early 2022 (18.54%). However, whether deaths that occur in patients treated with or because of COVID-19 are caused by COVID-19 as the underlying cause or due to other causes still needs to be further evaluated through death audit activities.

This research aims to conduct an audit of death cases related to the COVID-19 variant Omicron during 2022. It is hoped that with the death audit, the basic cause and direct cause of death in cases of COVID-19 variant Omicron who died at Persahabatan Hospital will be known, and it will be known whether the death was avoidable or not avoidable, what is the level of conformity between the causes of death listed in the Medical Cause of Death Certificate (SMPK) and those determined through the death audit as well as suggestions for improvement efforts that can be made in the future from the results of the death audit carried out.

METHOD

This is an observational study with a cross-sectional research design. Secondary data from SMPK and medical records of patients who died while being treated at National Respiratory Center Persahabatan Hospital from January 2022 to December 2022 were extracted. Death audits were done using the form recommended by the official Indonesian Hospital Association.[5] The causes of death from the audit results were compared with SMPK.

The research also took qualitative data by interviewing the doctor who takes care of the patient/*dokter penanggung jawab pasien* (DPJP), to explore the root of the problem and improvement efforts that could be made. Inclusion criteria are confirmed COVID-19 patients, age greater than or equal to 15 years, Whole Genome Sequence (WGS) results in variant Omicron or if there are no WGS results, positive Spike Gene Target Failure (SGTF) results.

The sampling method is the total sampling method. The research instruments were the COVID-19 death audit form recommended by the official Indonesian Hospital Association,[5] an interview form and the Medical Cause of Death Certificate (SMPK) form. The research has received ethical approval from the Health Research Ethics Committee of Persahabatan Hospital with number 0039/KEPK-RSUPP/02/2024.

RESULT

A total of 1580 COVID-19 patients were hospitalized between January to December 2022 at Persahabatan Hospital. Of the 1580, there were 568 patients with COVID-19 variant Omicron or probable Omicron, 298 patients were non-Omicron, 676 had no data on SGTF and/or WGS results and 38 patients were not tested for SGTF.

Of the 568 COVID-19 variant Omicron or probable Omicron patients who were treated, 130 patients died and 438 patients recovered and went home after being treated. From the data above, the proportion of COVID-19 variant Omicron patients who died while being treated at Persahabatan Hospital was 130/568 (22.89%).

Men (86 subjects, 67.7%) are the most common sex found compared to women subjects (41 subjects, 32.2%). From the age aspect, the majority were elderly (>60 years), namely 69 subjects

(54.3%), followed by adults (19-60 years) with 55 subjects (43.3%).

The most common occupations include private employees with 34 subjects (26.8%), housewives (IRT) with 28 subjects (22.0%) and entrepreneurs with 21 subjects (16.5%). For nutritional status determined by body mass index (BMI), the majority were above normal, as many as 58 subjects (45.7%), consisting of overweight as many as 18 subjects (14.2%) and obesity as many as 40 people (31.5%).

Based on clinical data, the majority of subjects in this study had never received a COVID-19 vaccination, namely 53 subjects (41.7%), followed by subjects who had received two vaccinations, 45 subjects (35.4%). There were 17 subjects (13.4%) who had received more than 2 vaccinations and 12 subjects (9.4%) who had only received the vaccine once.

Almost all subjects, namely 114 subjects (89.8%), underwent treatment for less than 14 days at Persahabatan Hospital until they died. Meanwhile, the most common comorbidities found were hypertension in 55 subjects (43.3%); diabetes mellitus as many as 47 subjects (37.0%); kidney disease in 41 subjects (32.3%); heart disease as many as 30 subjects (23.6%); and cancer as many as 24 subjects (18.9%).

The majority of research subjects who came/were referred to Persahabatan Hospital for treatment were already in a critical condition of COVID-19 (52 subjects, 40.9%), followed by a moderate degree of COVID-19 (37 subjects, 29.1%). Based on the type of ward, more subjects were treated in the ICU (65 subjects, 51.2%) while the remainder were treated in non-ICU COVID-19 isolation wards (62 subjects, 48.8%).

The death audit carried out finds the underlying cause of death, the immediate cause of death, and the indirect cause of death (COD). Analysis of the death audit conducted showed that the three most immediate causes of death were respiratory failure with 49 cases (38.58%), multiple organ failure (MOF) with 33 cases (25.98%) and septic shock with 21 cases. (16.54%). The complete direct causes of death according to the audit results can be seen in Table 1.

Table 1. Immediate causes of death according to audit results (n=127)

List of immediate COD	n	%
Respiratory Failure	49	38.58
Multiple organ failure (MOF)	33	25.98
Septic shock	21	16.54
Acute heart failure (include cardiac arrest)	10	7.87
Cardiogenic shock	5	3.94
Acute respiratory distress syndrome (ARDS)	3	2.36
Circulatory failure (include shock)	2	1.57
Aspiration	1	0.79
Hepaticum coma	1	0.79
Non-ST-segment Elevation Myocardial Infarction (NSTEMI)	1	0.79
Hemorrhagic shock	1	0.79

Meanwhile, the 3 (three) underlying causes of death were COVID-19 with 54 cases (42.52%), bacterial pneumonia with 24 cases (18.90%) and tumor/lung cancer with 16 cases (12.59%) (Table 2).

The results of further analysis from the death audit process found that there were 102 cases of COVID-19 variant Omicron deaths that were not avoidable

and 25 cases of deaths of COVID-19 variant Omicron that were avoidable. Of the 25 avoidable cases, 9 were avoidable cases related to late detection of the cause of death, while 25 cases were related to inadequate or suboptimal management.

Table 2. Underlying Causes of Death According to Audit Results (n=127)

List of Underlying COD	n	%
COVID-19	54	42.52
Bacterial Pneumoniae	24	18.90
Lung Tumor/Cancer	16	12.59
Coronary Heart Disease	3	2.36
Acute Lymphoid Leukemia (ALL)	2	1.57
Asphyxia	2	1.57
Bacterial Infection	2	1.57
Chronic Kidney Disease (CKD)	2	1.57
Chronic Hepatitis B	2	1.57
Cerebellar tumor/mass	2	1.57
Decubitus ulcus	2	1.57
Acute limb ischaemic	1	0.79
Infected Bronchiectasis	1	0.79
Carcinoma colon	1	0.79
Carcinoma mammae	1	0.79
Carcinoma tiroid	1	0.79
Catheter-related bloodstream infection (infected CDL)	1	0.79
Cerebrovascular disease (CVD)	1	0.79
Enterocutan fistulla	1	0.79
Gangrene	1	0.79
Neuroendocrine carcinoma, high grade	1	0.79
Meningoensefalitis bacterial	1	0.79
Trauma Multiple	1	0.79
Osteosarcoma st. IV	1	0.79
Peritonitis	1	0.79
Chronic Obstructive Pulmonary Disease	1	0.79
Atrioventricular (AV) Block	1	0.79

The root of the problem with late detection of the cause of death was a lack of alertness, so that it did not predict worsening from the start, 4 (33.3%). Next, there were 2 patients (16.67%) who assessed the Early Warning System (EWS) which was not appropriate to the patient's clinical condition, 2 patients (16.67%) reported late detection of COVID infection due to decreased alertness and 2 patients (16.67%) reported that patient supervision was less than optimal (both in terms of monitoring aspects and whether monitoring devices were not installed) there were 2 patients (16.67%) (Table 3).

Meanwhile, the root of the problem of inadequate management is that the hospital ICU room is full as many as 6 (13.04%), patients in end-stage or DNR condition, so that the ICU is not a priority as many as 4 (8.69%), facilities for special management of COVID-19 are less than optimal as many as 3 (6.52%). There were 3 (6.52%) late for consult to the ICU or late ACC from the ICU, 3 (6.52%) were given late antivirals and 3 (6.52%) had poor general condition due to severe comorbidities (Table 4).

In assessing the suitability of the causes of death listed in the SMPK with the results of the death audit, it showed that only 30 patients (23.62%) were appropriate and the remaining 97 patients (76.38%) were not appropriate. The correspondence between SMPK and death audits is still quite low, namely only 23.62% for direct causes of death, 14.96% for indirect causes of death (intermediate causes of death) and 51.97% for the basic cause of death.

From interviews with DPJP, many suggestions were obtained for improving future services at Persahabatan Hospital. This improvement proposal is divided into clinical management aspects and

managerial aspects. The most frequent suggestion for improving patient clinical management was evaluation of the patient supervision/monitoring system (13 DPJP).

Then, the second most proposed improvement in clinical management is the COVID-19 antigen examination carried out as a first step before the COVID-19 PCR examination to detect COVID-19 infection more quickly. This suggestion was from 5 DPJP. The third most common suggestion for clinical improvement is the need to provide special services for patients with COVID-19 (bronchoscopy, PCI, HD).

Several DPJPs proposed increasing the number of High Flow Nasal Cannula (HFNC) in hospitals. One of the many suggestions is the need to periodically discuss serious/emergency cases with a multidisciplinary team (DPJP, PPRA and related parties) with 3 DPJPs each. Complete suggestions for improving clinical management are in Table 6.

Table 3. The root of the problem late detection of the causes of death

The root of the problem late detection of the causes of death	n	%
Lack of alertness, not predicting earlier	4	33.3
Writing an EWS is not clinically appropriate	2	16.67
Late COVID screening/awareness of COVID infection falls	2	16.67
Patient supervision is less than optimal (both in terms of supervision aspects, and the monitoring equipment is not installed)	2	16.67
Difficulty monitoring patients (monitoring fluid balance in CKD patients on HD)	1	8.3
Patient management before referral is not optimal.	1	8.3

Table 4. The root of the problem of inadequate management

The root of the problem of inadequate management	n	%
The ICU room is full	6	13.04
End-stage disease or DNR patients are not ICU priority	4	8.69
Special treatment facilities for COVID are not available (PCI, radiotherapy)	3	6.52
Late/not consulted ICU/late approval from ICU	3	6.52
Antivirus has not been given because we are waiting for the PCR results	3	6.52
Poor general condition, severe comorbidities	3	6.52
Monitoring is less than optimal	3	6.52
COVID awareness is down, COVID diagnosis is late, and treatment for COVID is late	3	6.52
Program Pengendalian Resistensi Antimikroba (PPRA) approval is late/no approval, an application for antibiotics has been made	2	4.35
No worsening (sepsis) is expected from the start	2	4.35
The patient can not receive HFNC	2	4.35
The patient did not have an NGT installed	2	4.35
The patient is not transportable when going to HD	2	4.35
Not getting optimal therapy because of contraindications (not getting anticoagulants because there is hematemesis, not CRRT because UC is bad)	2	4.35
Too late to consult another specialist in the ICU	1	2.17
The HD procedure was delayed because the CDL device was installed 7 hours before death.	1	2.17
Delayed treatment decisions in the emergency room (within the first 6 hours)	1	2.17
The patient was not consulted for bronchoscopy after hemoptysis	1	2.17
Quick deterioration, no time for intubation	1	2.17
Cito radiation is not prepared	1	2.17

Table 5. Suggestions for improving clinical management

Suggestions for improving clinical management	n
Evaluation of the supervision/monitoring system during maintenance, including recording and reporting	13
Initial COVID-19 antigen examination	5
The need to provide special services for COVID-19 patients (bronchoscopy, PCI, HD, radiotherapy)	4
Increased number of HFNC	3
It is necessary to discuss serious/emergency cases with the multidisciplinary team (DPJP, PPRA and related parties) regularly	3
Giving antivirals with antigen results without waiting for PCR	3
Faster antibiotic escalation	2
Procurement of special medicines for severe/critical cases such as albumin, gamaras, tocilizumab	2
Have a referral system to other hospitals if the ICU is full	1
Emergency triage assessment in cases of severe desaturation, immediately consult the ICU	1
Cito bronchoscopy in asphyxia patients	1
Better HD timing evaluation	1
Covid PCR screening results must be faster	1
Intubation in the ER in CITO cases without waiting for the DPJP's answer	1
Maintain COVID awareness	1
Periodic Laboratory and radiology examination	1
Patients can still enter the ICU/HCU for close monitoring	1
Preparation of Bronchiectasis Clinical Practical Guideline (PPK)	1
Minimally non-invasive examination for cases with a history of post-chemo malignancy	1
Increasing awareness of pulmonary embolism cases in chronic diseases	1

Table 6. Proposed improvements to managerial aspects

Proposed improvements to managerial aspects	n
There is a need to create and evaluate special SOPs for COVID-19 with comorbid conditions, such as HD CITO SOP, radiotherapy SOP for COVID, aspiration SOP for COVID, COVID referral SOP if the ICU is full, etc	13
Additional facilities for COVID-19 patients, such as HD, monitoring equipment, portable radiology, portable ventilators are in both isolation rooms, the ICU and the emergency room	9
Increase ICU bed capacity and ICU human resources	6
Addition of special rooms for additional services specifically for COVID-19, such as radiotherapy rooms, operating rooms, cathlabs, chemotherapy rooms, resuscitation isolation room	6
Improved EWS training and implementation systems	3
The multidisciplinary team (Pulmonologist - Internal Medicine - Cardiologist) handles emergencies and intensive care in the ER	3
Training improved nursing skills	2
EWS automation system in computer/EMR	1
Have a handover checklist when moving rooms	1
There is a provision for antivirals other than favipiravir	1
Flow and placement of ER patients according to EWS	1
A medical audit was carried out	1
Evaluation of the transport of patients with HFNC from the ER to the HD	1
Case manager for comorbidities and acute infections	1
Accelerate Approval of Stent Applications	1
Optimization/monitoring and evaluation of SPO patient monitoring/supervision	1
Separation of patients with acute infections	1
Stepdown patient management (ICU -> stepdown)	1
Increased monitoring of infectious/isolated Eds	1
Increase isolation resuscitation rooms	1

Meanwhile, the most proposed improvement for hospital managerial aspects is the need to create and evaluate special operation procedures standard (SOPs) for COVID-19 with comorbid conditions, such as HD CITO SOP, radiotherapy COP for COVID, aspiration SOP for COVID, COVID referral SOP if the ICU is full, etc. with 13 DPJPs. Next is the addition of facilities for COVID-19 patients, such as HD, monitoring equipment, portable radiology, portable ventilators, both in the isolation room and ICU, as well as 9 DPJP emergency rooms. Increasing ICU bed capacity and human resources is proposed by the 6 DPJP.

The next is the addition of special rooms for additional services specifically for COVID-19, such as radiotherapy rooms, operating rooms, cathlabs, and chemotherapy rooms, totaling 5 DPJPs. One of the important suggestions is improving training and the EWS implementation system, proposed by 2 DPJPs.

DISCUSSION

From the research results, it was found that the proportion of COVID-19 variant Omicron patients who died while being treated at Persahabatan Hospital was 130/568 (22.89%). The research results show a higher proportion of deaths compared to several studies abroad. Research in South Africa found 9,555 deaths from 492,181 cases of COVID-19 infection in the Omicron predominance period. Data from South Africa shows the death ratio for the Omicron variant is 1.9%.[6] Research in the United States involving 12,936 patients with the Omicron variant of COVID-19 reported that 563 died within 14 days of testing positive for COVID-19 (mortality rate of 4.35%).[7]

The much higher proportion of deaths from the Omicron variant at Persahabatan Hospital could be due to the fact that the COVID-19 variant Omicron patients being treated were referral patients from various hospitals. Persahabatan Hospital, as a COVID-19 Referral Hospital, is prioritized for severe and critical COVID-19 patients.[8] Research data in Indonesia shows that the severity of the disease is very strongly related to the mortality of COVID-19 patients treated in hospital.[9]

Based on the demographic characteristics of the subjects in this study, the majority of subjects were male (67.7%) and aged over 60 years (54.3%). This is in line with previous studies, such as an autopsy study in Germany, which found a male predominance of 699 out of 1094 (63.9%) and most were aged 50-80 years.[10] Studies in India also show something similar, with 73% of the sample being men and the median age of death being 64 years and a range of 4-97 years.[11] Studies in Ireland obtained balanced gender proportions (50% men and 50% women) but with a much higher prevalence of ages over 60 years, namely 93.3% of the total sample.[12]

In this study, it was found that the highest nutritional status was in subjects who were overweight & obese, namely

45.7%, and as many as 14.2% were underweight. Other studies regarding death audits in COVID-19 have not recorded nutritional status in cases of COVID-19 deaths, but White et al included obesity and nutritional status among case comorbidities, with a prevalence of 13.3%.[12]

It is known that excessive nutritional status is also a risk factor for infection and more severe symptoms of COVID-19 and death. As in other studies that did not involve COVID-19 mortality audits, it was found that patients with excess body weight had a higher risk of death (HR=2.13; P=0.038) compared with patients with normal body weight.[13]

The majority (41.7%) of the subjects in this study were known to have never undergone vaccination. Incomplete vaccination status is known to be a risk factor for death in cases of the Omicron variant of COVID-19, as stated by several previous studies.[7,14] Several previous studies regarding COVID-19 death audits did not include vaccination status in their research, due to the longer data collection period in the period before COVID-19 vaccination was intensified, so that vaccination data was quite small/non-existent.[10,11]

Another study found that cases of COVID-19 deaths with unvaccinated status were only 10% of the sample, but incomplete vaccination status (only 1 time) was the majority (63.3%), which could also be due to the fact that almost the entire population in the study was elderly. which is the main target of the COVID-19 vaccination.[12]

Comorbidities such as diabetes mellitus, cardiovascular disease, and kidney disease are also known to be significant risk factors for death in the Omicron variant of COVID-19.[7,14] In this study, the most common comorbidities found were hypertension (43.3%), diabetes mellitus (37%), kidney disease (32.3%), heart disease (23.6%), and cancer (18.9%).

That is similar to the results of an audit study of COVID-19 deaths in India, where the most comorbidities from 2000 deaths were diabetes mellitus (66%), hypertension (54%), coronary artery disease (18%), and chronic kidney disease (15 %).[11] While the study in Ireland found that the most comorbidities were chronic respiratory disease (33.3%) and coronary artery disease (33.3%), followed by diabetes (23.3%), chronic neurological conditions (16.7%) and kidney disease. chronic (15%).[12]

In this study, the majority (40.9%) of patients were referred to Persahabatan Hospital in critical condition with COVID-19 and 51.2% of patients were treated in the ICU. Another study found a smaller proportion of treatment in the ICU, namely 28.3%.[12] But there has been no COVID-19 death audit study that includes the severity of COVID-19 at the time of initial admission. Another study that did not involve an audit of COVID-19 deaths stated that more severe degrees of COVID-19 and receiving invasive ventilation in intensive care had a higher risk of death (OR=3.32;

95% CI=2.01–5.48; P<0.001) compared to others.[15]

The majority (89.8%) of subjects in this study were treated for a period of <14 days until they died at Persahabatan Hospital. This critical level of COVID-19 and intensive care is in line with the short duration of hospitalization due to poor initial conditions, as also stated by studies in India, which found that the median period between the start of treatment and being declared dead in hospital was only around 2.8 to 3.6 days.[11]

This research analyzed death audits on 127 cases of deaths related to the Omicron variant of COVID-19 at Persahabatan Hospital. Based on the death audit of the entire sample, it was found that the three most common immediate causes of death were respiratory failure (38.58%), multiple organ failure/MOF (25.98%) and septic shock (16.54%). A multicenter autopsy-based study in German found that the immediate cause of death in deaths related to COVID-19 in that country was diffuse alveolar damage (DAD)/acute respiratory distress syndrome (ARDS). which covers 52.5% of all death case data found, followed by MOF at 18%.[10]

Another study based on public data in India stated that ARDS due to pneumonia was the most reported immediate cause of death, accounting for 54% of all reported deaths.[11] Meanwhile, in the pediatric population in India, the most reported causes of death are septic shock (21%), COVID pneumonia/ARDS (19%) and neonatal disease (17%), consisting of prematurity and related complications.[16]

The immediate cause of death is a condition/disease that directly causes the patient's death.[17] In this study, respiratory failure was the most direct cause of death in Omicron COVID-19 patients based on death audits, while in other studies, ARDS was the most common cause. Respiratory failure associated with COVID-19 can be included in ARDS according to the Berlin definition, but in practice, the clinical presentation of COVID-19 is different from typical ARDS.[18]

In addition to the diffuse alveolar injury typical of ARDS, respiratory failure in COVID-19 also has pathological features of endothelial injury, extensive microthrombi, and pulmonary capillary hyperplasia and has a heterogeneous clinical presentation of progressive respiratory distress and "silent hypoxemia". This difference between acute respiratory failure associated with COVID-19 and typical ARDS has given rise to much debate as to whether pneumonia due to COVID-19 is considered ARDS or not.[18] This may explain the differences between the direct causes of death reported in this study and previous studies of death audits.

Apart from that, the difference in results could also be due to differences in methods, whether an autopsy was carried out or not, as well as differences in research time, which could cause differences in the COVID-19 variant between Omicron or other variants that dominated in the time period before this research was conducted. On the other hand, multiorgan failure and septic shock were also frequently found as direct causes

of death in this study, in line with reports in previous studies.[10,16]

This research found that the three underlying causes of death were confirmed COVID-19 (42.52%), bacterial pneumonia (18.90%) and lung tumors/cancer (12.59%). These findings are quite consistent with several previous studies regarding death audits in COVID-19. The most common underlying/primary cause of death reported by autopsy-based studies in German was COVID-19 at 86.2%, while the other 13.8% was non-COVID-19, consisting of circulatory disorders (7.5%), respiratory disorders (0.9%), and others (5.4%).[10]

A prospective audit study in Ireland found that COVID-19 was the underlying cause of death in the majority (72.7%) of COVID-19-related deaths reported to the country's national surveillance system.[12] Quite different things were reported by a study in Sweden, which reported that although as many as 84% of cases of death related to COVID-19 were reported to have the underlying cause of death being COVID-19; the results of the clinical audit process were that COVID-19 was the underlying cause of death in only around 29% of cases, while the other 24% were not even related to COVID-19.[19]

The death process involves a series of events from the underlying cause of death to the immediate cause of death, which can be mediated by one/two conditions/diseases called indirect causes of death or intermediate causes of death. In this study, several causes of death were found, including sepsis (8.7-33.7%), COVID-19 pneumonia (18.9%), ARDS (11.2%), and myocarditis/myocardial injury COVID-19. As many as 19 (7.87%), which could be one of two conditions that mediate the underlying cause of death and the immediate cause of death.

There are no previous studies regarding COVID-19 death audits that clearly describe the various intermediate causes of death, but there is a study that mentions COVID-19 as an indirect cause of death in 71% of deaths related to COVID-19 in Sweden,[19] being a contributing factor to death in 21.8% of COVID-19 related deaths in Ireland,[12] as well as being a comorbidity in 13.8% of COVID-19 related deaths undergoing autopsy in German.[10]

This research found that although the majority of deaths in COVID-19 patients were deaths that could not be avoided (not avoidable), there were 25 cases (19.7%) of deaths that could have been avoided (avoidable) but occurred due to late detection of the cause of death or inadequate/optimal management given to the patient. Late detection of the cause of death is related to a lack of awareness of patient deterioration or the COVID-19 infection itself, differences in EWS writing and clinical conditions, and less than optimal supervision of patients due to limited conditions.

Delays in getting optimal service (from the regular ward to the intensive care ward) for inpatients whose clinical condition is deteriorating but which are not recognized by health workers are still common in the current era of inpatient medicine and are associated with

increased mortality rates at the hospital. A study at a tertiary teaching hospital in the United States found that as many as 64.6% of patients were transferred to the ICU facility more than 4 hours later than when they should have experienced clinical deterioration. The study also found that the mortality rate increased significantly in the 12 hours from clinical deterioration to transfer to the ICU.[20]

Early Warning Score is an approach to recognizing acute physiological deterioration in patients early, which allows the initiation of escalation of care services for patients and/or calling a rapid response medical team to provide further management. EWS can speed up the detection of deterioration and reduce mortality rates in hospitals, but sometimes there are several obstacles, such as errors in determining clinical indicators, patient variability, or individual factors of the health workers on duty, which cause its implementation to be ineffective.[21]

Meanwhile, inadequate management is related to not getting optimal treatment (including getting a place in the ICU), serious/critical medical conditions and to lack of facilities or other technical problems. Limited intensive care facilities have also been a big problem in various other studies.

A study in Uganda found that as many as 75% of treated COVID-19 patients required intensive care (experiencing oxygen desaturation or severe respiratory distress and requiring mechanical ventilation), but only 48% were able to get to the ICU. Of patients who do not receive mechanical ventilation, as many as 27% do not receive it because there is no ventilator or ICU space in the health facility where they are treated. Furthermore, the study also stated that of 71 patients with deaths that could have been avoided, 51% of deaths could have been prevented if there were empty rooms in the ICU and 33% could have been prevented if the patient had received treatment earlier.[22]

This problem of limited space has a huge impact on the health system and the death rate that occurs, especially when there is a spike in COVID-19 cases. Negative binomial regression modeling carried out by the Cybersecurity & Infrastructure Security Agency (CISA) COVID Task Force in the United States in the period July 2020-July 2021 estimates that if national ICU bed use reaches 75% capacity, there will be 12,000 additional deaths nationally in 2 weeks. If ICU bed use exceeds 100%, the additional death rate nationally is estimated at 80,000 in the next 2 weeks.[23]

A study that analyzed the results of death audits from 41 hospitals in Limpopo, South Africa, found that there were at least four important aspects that were factors related to the mortality of COVID-19 patients hospitalized in hospitals. First, provision of medical services in the emergency department is below standard, such as delays in triage & laboratory results, less than optimal monitoring & resuscitation of COVID-19 patients. Second, delayed access to health services due to an inefficient referral system,

therefore, patients come with serious/ critical conditions and complications.[24]

Third, advanced age of patients with known and unknown comorbidities, such as respiratory complications, diabetes mellitus and diabetic ketoacidosis. And last, poor case management, medical records, and medical resources and equipment related to COVID-19 (lack/exhaustion of essential medicines, undocumented medical records, staff shortages, etc.).[24]

This study compares the causes of death listed in the SMPK with the results of the death audit. It was found that the correspondence between the causes of death between SMPK and the death audit of COVID-19 patients at Persahabatan Hospital during 2022 was still quite low, namely only 23.62% for direct causes of death; 14.96% for indirect causes of death (intermediate causes of death); and 51.97% for the basic cause of death.

A study in Sweden also found that the conformity in writing the cause of death between the death certificate and the death audit by the research team was still quite low. Based on data on death certificates obtained from the Swedish National Board of Health and Welfare, COVID-19 was the underlying cause of death in 84% of cases and an indirect cause of death in 16% of cases; Meanwhile, based on the results of an audit conducted, it was found that COVID-19 was only the basic cause of death in 29% of cases, was an indirect cause of death in 71% of cases, and was not related to 24% of other deaths.[19]

A study that analyzed autopsy results on 65 cases of death related to COVID-19 in Cuba also found that there was a discrepancy between the cause of death determined from the autopsy and that written on the medical death certificate. In cases related to COVID-19, the discrepancy rate reached 19.4% for the basic cause of death and 64.5% for the direct cause of death.[25]

Further analysis of the factors that influence the differences in causes of death between SMPK and death audits needs to be carried out to reduce existing discrepancies. Inconsistencies in filling out the SMPK can be caused by problems with the patient's condition, administration, differences in definitions of causes of death, and staff compliance with operational standards.[3]

The various problems that can be identified as root causes of avoidable causes of COVID-19 deaths in this research deserve special attention so that they can be corrected to reduce the death rate in the future. This is in line with the stages in a death audit, namely making efforts to correct the deficiencies that have been identified and then carrying out a re-evaluation to determine the impact of whether there is a reduction in the death rate that can be prevented after making improvements.[26]

Systemic and collaborative efforts are needed to make improvements related to problems identified from audit results. Based on the results of the interview, there were various inputs from the DPJP regarding service improvements at

Persahabatan Hospital, which can be grouped into clinical patient management aspects and hospital managerial aspects.

Improvements to aspects of clinical patient management proposed by DPJP include evaluation of the patient supervision/monitoring system; COVID-19 antigen examination to detect COVID-19 more quickly; increase in the number of HFNC in hospitals; providing special services for COVID-19 patients (bronchoscopy, PCI, HD) as well as discussing serious/emergency cases with the multidisciplinary team. Meanwhile, improvements to hospital managerial aspects include creating and evaluating special operation procedures standard (SOPs) for COVID-19 with comorbid conditions; as well as adding facilities, capacity, human resources and space for additional services specifically for COVID-19 patients.

Evaluation of the patient supervision/monitoring system can be carried out through education and training for clinicians and teams related to patient care so that they have sufficient knowledge regarding EWS and patient deterioration; can respond responsibly; follow protocols well; and can provide ongoing support to advocate for service improvements and activate *tim medis reaksi cepat* (TMRC) if necessary.[21]

Innovations such as the use of technology in the form of wireless devices worn on patients can enable continuous monitoring of vital signs & signs of clinical deterioration of patients which is useful in reducing TMRC activation by up to 53%, strengthening decision-making steps for 74% of nurses, and reducing length of stay in the ICU from 2.82 days to 2.19 days.[27] The strategy of implementing the COVID-19 antigen test on patients, which is faster and cheaper than RT-PCR, also has the benefit of reducing patient isolation time to 144 hours so that patients can also receive appropriate treatment more quickly.[28]

Increasing the capacity of medical facilities and equipment needed by COVID-19 patients has become a global response to the increasing need for these facilities at the peak of the wave of COVID-19 cases. ICU facilities across Australia have succeeded in increasing bed capacity to 191% of the initial number and increasing invasive ventilation to 120% of the initial number in response to increasing needs during the COVID-19 pandemic.[29] With the increase in hospital facilities, it is hoped that more severe to critical COVID-19 patients will be able to receive optimal treatment.

Apart from that, many COVID-19 patients also have comorbidities and require special treatment such as hemodialysis, percutaneous coronary intervention (PCI) and bronchoscopy. Restrictions on these services are often carried out as an effort to guard against the spread of COVID-19 infection, so that additional special isolation places are needed along with special standard operating procedures so that COVID-19 patients can still receive health services according to their medical condition with minimal risk of virus transmission.

The success of the strategy for creating special facilities and protocols for COVID-19, for example, in one of the hemodialysis services in London, is that the hemodialysis unit that implemented this special strategy had a lower number of COVID-19 cases and deaths due to infection compared to units in other areas of London.[30] Another study in Italy that implemented a special protocol for acute coronary syndrome patients with COVID-19 infection stated that carrying out emergency PCI according to a special protocol improved the prognosis for all patients except for patients with the most severe medical conditions.[20]

Efforts to improve facilities and special operational standards can be replicated in other units, accompanied by increasing human resource capacity in order to reduce the death rate due to/with COVID-19, as per the results of the death audit in this study.

CONCLUSION

From the death audit analysis carried out and the discussion of this research, it can be concluded that the proportion of COVID-19 variant Omicron patients who died while being treated at Persahabatan Hospital was 22.89%. The three most common direct causes of death are respiratory failure, multiple organ failure (MOF) and septic shock. Meanwhile, the 3 (three) basic causes of death were confirmed COVID-19 at 42.52%, bacterial pneumonia at 24 cases at 18.90% and tumor/lung cancer at 12.59%.

As many as 42.52% of the Omicron variant COVID-19 patients who died during 2022 were due to COVID-19 and 57.48% were due to COVID-19. There are 25 cases of avoidable COVID-19 variant Omicron deaths. The root of the problem of late detection of the cause of death is a lack of alertness, so that it does not predict worsening, EWS assessments that are not clinically appropriate, and late detection of COVID infection due to decreased alertness.

Meanwhile, the 3 biggest roots of inadequate management problems are that the hospital ICU room is full, patients are in end-stage or "do not resuscitate" (DNR) condition, so that the ICU is not as much of a priority and the facilities for special management of patients with COVID-19 are less than optimal. In assessing the suitability of the causes of death listed in the SMPK with the results of the death audit, only 23.62% corresponded to the direct cause of death, and 51.97% were appropriate for the underlying cause of death.

There are 3 most significant suggestions for improving clinical management, namely evaluating the patient supervision/monitoring system, testing for COVID-19 antigens carried out earlier before polymerase chain reaction (PCR), and providing special services for patients with COVID-19 with comorbidities. Meanwhile, the top 3 suggestions for improving hospital managerial aspects are the need to create and evaluate a special SOP for COVID-19 with comorbid conditions, adding special service facilities

for COVID-19 patients with comorbidities and increasing ICU bed capacity and human resources.

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