Assessing Hospital Management Performance in Intensive Care Units (ICUs) During the COVID-19: A Study from the Pandemic Outbreak Perspective

https://doi.org/10.3991/ijoe.v18i10.32733

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Abstract—In the early stages of the pandemic, both poor and developed nations lacked healthcare infrastructure capacity. ICUs had more patients than ordinary wards, and hospital resources for patients were minimal. The possibility of contamination and infection, as well as restricted resources, pose challenges to ICU staff. The circumstance posed a significant difficulty for ICU management to protect healthcare staff while providing healthcare services to patients. Similarly, technology participation in prevention and dissemination control was limited both within and outside of ICUs treating infected patients. The current study investigated the hospital management performance in intensive care units (ICUs) during the COVID-19. We used the PRISM statement 2020 to include and exclude the records in the study. In addition, the study used the VOS viewer software to identify key term occurrences and classification of literature. The major three categories find COVID-19, ICUs and performance management. The current study findings indicate that healthcare personnel such as physicians, nurses, and other support staff made significant contributions during the peak period of pandemic transmission. Nurses are the closest to the infected patients within the ICUs, and the findings show that a considerable percentage of nurses have been infected with the COVID-19 virus (Kramer et al., 2021). Aside from this, in ICUs, technology engagement and infrastructure are substantially lower than in pandemic control and management. Future pandemic damage control and minimising the strain on healthcare workers require advanced technologies and performance management mechanisms. Furthermore, AI and robotic technology can be utilised to address this challenge.

Keywords—ICUs, COVID-19, performance management, healthcare workers, PRISMA statement

1 Introduction

A cluster of atypical pneumonia cases was discovered in Wuhan, China, in December 2019, and the World Health Organization (WHO) recognised it as Coronavirus disease 2019 (COVID-19) on February 11, 2020. SARS-CoV-2, the causal virus, was a new coronavirus strain with a 79 per cent genetic resemblance to SARS-CoV from the 2003 SARS outbreak [1]. The WHO labelled the outbreak a worldwide pandemic on March 11, 2020 [2]. According to [3], people's lives and many areas of the global, public, and private economies have been severely impacted due to the quickly changing scenario. Tourism, airlines, agribusiness, and the banking industry have all suffered because of the COVID-19 outbreak, with governments worldwide mandating substantial reductions in the economy's supply and demand components. In addition to this, a significant strain was placed on healthcare systems throughout the world as the virus spread and affected everyone's health equation [4]. It appears that the countries were unprepared and ill-equipped to deal with COVID19 and especially vulnerable to the disease's spread. Compared to many other low-income countries, the developed countries also face the brunt of COVID-19 associated damage, based on the quick increase in cases, growing hospital constraints, and the most recent modelling predictions [5].

However, the current infrastructure could not control the pandemic and the medical capabilities were under great challenge during the peak months of the spread of the virus [6]. A global health emergency was declared, with health professionals playing critical roles in assisting infected individuals. While many physicians and nurses were fighting an uphill struggle on the front lines, they played a critical role in preventing the spread of the virus outbreak and contributing to overall emergency management [7]. According to the reports [8], between 80,000 and 18,0000 healthcare professionals might have perished from COVID-19 between January 2020 and May 2021, with a median of 115500 fatalities. The majority of infections and deaths of health workers were recorded in intensive care units (ICUs) throughout the world [9]. In addition, during the pandemic's peak days, health personnel contributed significantly with extra effort and lengthy job hours.

According to [10], during the pandemic, the ICU administration faced two key challenges: the infection of healthcare personnel and the availability of preventative strategies. In the outbreak's early days, both developing and industrialised countries lacked infrastructure capacities. There were more patients in ICUs than good places and facilities for patients in hospitals [11]. In this scenario, prevention and control measures were developed to flatten the contagion curve and minimise the rate of transmission, as well as to maintain the sustainability of health care systems in the face of limited ICU capacity and equipment [12]. Similarly, technology participation in prevention and dissemination control was limited both within and outside of ICUs treating infected patients. According to [13], maintaining and supporting healthcare providers over the projected protracted course of this pandemic, technology is necessary at the bedside. The possibility of contamination and infection, as well as restricted resources, pose challenges to ICU staff. The circumstance posed a significant difficulty for ICU management to protect healthcare staff while simultaneously providing healthcare services to patients.

The present study will concentrate on the issues confronting ICU management during the pandemic outbreak and the performance of healthcare workers in the face of significant health risks. Furthermore, based on the present COVID-19 learning, the current study will suggest future outbreak prevention efforts. We used the PRISMA statement 2020 to include and exclude documents published on the ICUs' management performance during the COVID-19 outbreak.

2 Material and methods

Using the PRISMA statement 2020, we reached the current study goals. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement is a guideline to assist authors in preparing a comprehensive report of their systematic review [14]. The records were chosen using the PRISMA statement inclusion and exclusion criteria. We used the Scopus and Web of Science databases to find records that fit the research goals. The keywords selected were "ICU AND COVID 19" and "ICU AND management performance". We identified the relevant documents for the current investigation by using several keywords. We began by filtering the data after finding 180 items from the search. We confined the publishing of the record to the years after the pandemic's spread, and we chose the articles, review papers, and book chapters during the selection process.

Furthermore, the only published material is used in the current study, including English language papers. We also chose medical, engineering, computer science, nursing, social science, multidisciplinary, business, management, and accounting. Furthermore, we also included the article cited a minimum of 5 times for the more authentications of the results in the study. The number of articles is gradually being reduced, and the most relevant materials are being screened. Figure 1 is illustrated the PRISMA research methodology process.

Moreover, the study deleted duplication, irrelevant entries, and missing author details throughout the screening process. We manually sorted the records into three primary groups before using the VOS viewer software for validation. We included the final 51 articles in the review after the detailed records screening.

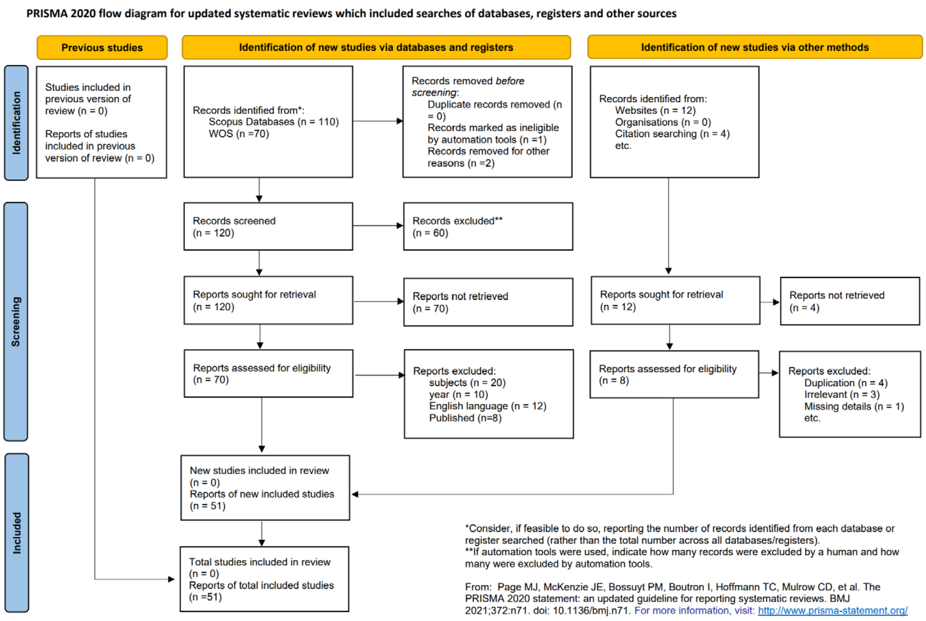

Fig. 1. PRISMA statement 2020 inclusion and exclusion process

2.1 Descriptive

The final 51 articles later categorise the records from each subject, and the subject distributions are depicted in Figure 2 below. The study's most significant contribution comes from medical-related issues, with ten publications chosen. Many records were also produced by engineering, computer science, and social sciences. The study included interdisciplinary nursing subjects and business, management, and accounting disciplines. Figure 2 depicts the publications from the subjects covered in the current study.

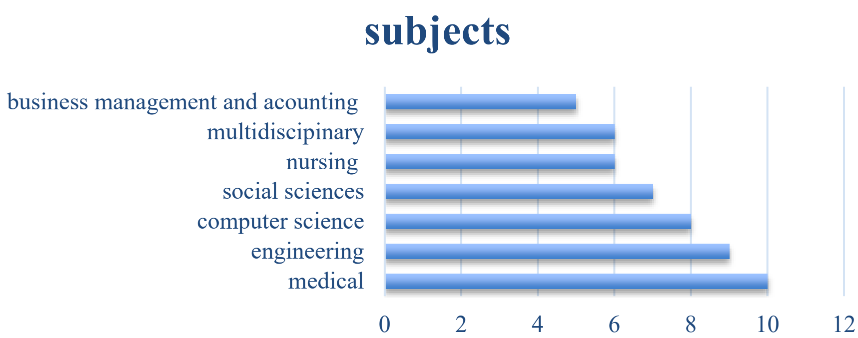

Fig. 2. Missing Figure Caption/Label

In addition, Figure 3 depicts the year-based publishing. The current study's scope is mainly connected to the COVI-19 pandemic and the literature. With 25 papers, the year 2020 generated the most documents. The other significant contribution comes from the year 2021, with 16 articles. However, because of the pandemic spread, the year 2019 and 2022 is still in progress, so the article contribution is low.

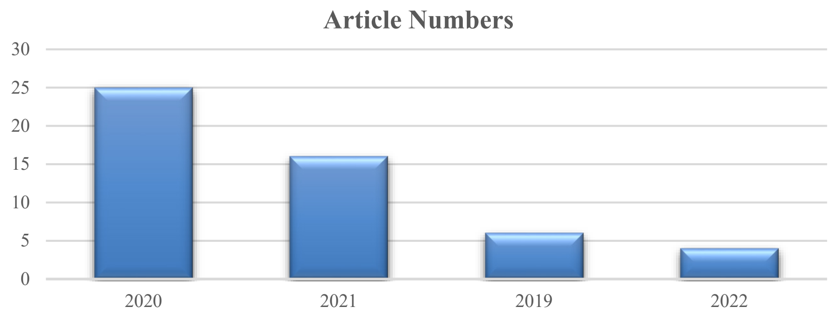

Fig. 3. Distribution of articles in the year-based publication

Furthermore, the sources and citation report are included in Table 1. The primary goal of the sources and citations report is to determine the number of articles chosen from each publication and the overall number of citations in the table. The Ultrasound in Obstetrics and Gynecology publication contributed four papers in the previous two years and received 237 citations. The remaining vital citations and publications are drawn from the Applied Clinical Informatics journal, which has three articles and 92 citations. Similarly, two publications and 73 citations were contributed to the current study by the European Journal of Physical and Rehabilitation Medicine. The other journals and citations are shown in Table 1 below.

Table 1. Source, citations, and number of articles

Source	Citations	Numbers
Ultrasound in Obstetrics and Gynaecology	237	4
Applied Clinical Informatics	92	3
European Journal of Physical and Rehabilitation Medicine	73	2
Physiotherapy Theory and Practice	42	2
Critical Care	29	4
International Journal of Molecular Sciences	25	2
Medical Image Analysis	25	2
Clinical	22	2
Clinical Nutrition	15	2
MedRxiv	15	2
Annals of intensive care	13	2
Simulation and Gaming	11	2

Furthermore, we used vital term occurrences analysis to identify the major themes in the review literature. The VOS Viewer highlighted the number of keywords and key phrases used in the published articles. To examine the critical occurrence, 51 articles were chosen, with 46 essential words occurring more than four times. The three essential areas of data streams are ICUs, COVID-19, and performance management. We also offer the relevancy score for each sentence and the average score. A phrase that occurs at least four times in the current study is included in the critical occurrence term analysis. Table 2 illustrates each term's key terms, classification, occurrences, and relevance score below.

Table 2. Below illustrates the details of important phrase categorization.

Term	Classification	Occurrences	Relevance Score
acute respiratory distress syndrome	COVID-19	6	0.5879
Cedar		5	1.7587
Challenge		5	0.643
Coronavirus		5	0.5902
Day		12	1.1592
Myopathy		4	0.7431
NLR		5	1.7303
Paper		7	0.3741
Paradigm		4	2.4518
physical function		4	1.1315
physical therapist		9	0.7356
physical therapist intervention		4	1.1315
Response		10	0.5136
Review		10	0.4962
Surge		6	1.3594
Admission	ICU	14	0.874
Age		7	1.3453
Ards		9	0.5986
Case		11	0.3738
Delivery		9	0.6063
Discharge		8	0.9685
Icus		6	1.7995
ill patient		14	0.6956
Institution		6	0.8071
Knowledge		5	0.776
Model		11	0.9209
per cent		4	0.6021
Person		4	0.9706
Planning		6	1.0708
Pregnancy		10	0.7594
Risk		10	0.6277

TBA		4	0.4216
Tcc		8	1.1003
Woman		10	0.6467
Approach	Performance Management	12	0.838
Communication		8	1.0658
Function		9	0.7668
Future		4	1.3937
Icuaw		6	0.9061
IoT		5	2.3505
Sars		4	0.7995
Scan		6	2.0496
Statement		8	1.2865
Swift		6	1.4984
Value		8	0.9034
Weakness		8	0.7706

3 Classification

3.1 COVID-19

As the COVID-19 outbreak spreads, the ICU is being physically, materially, and emotionally taxed by the massive caseload. Therefore, assessing the number of patients and capacity and resource consumption is critical for appropriately addressing the 'staff, "stuff, "space,' and' systems' to mount a surge response [15]. In addition, isolating the patient undoubtedly increases tension and anxiety, which may result in an aggravation of symptoms not only connected to COVID-19 but also a worse clinical state and subsequent deterioration with a higher chance of delirium and depression [16]. According to [17] research findings, some of the most often cited delirium risk factors include mobility limitations, undernutrition, and improper patient care offered by the therapeutic team. Furthermore, loudness or a lack of knowledge about the actions being conducted frequently results in greater dread, which might progress to delirium. However, the COVID-19 symptoms include fever, headache, a dry cough, and radiological indications of viral pneumonia. In severe instances, dyspnea typically appears approximately a week after the disease begins, and some patients can quickly advance to acute respiratory distress syndrome (ARDS), septic shock, refractory metabolic acidosis, and coagulation abnormalities [18]. In addition, sleep disturbance is common in COVID-19 patients (Liguori et al., 2020), which may be related to an isolated environment without a family member's companion, physical discomfort induced by the illness, or a psychological aspect [19]. Table 3 illustrates the authors, segment and setting details.

Table 3. Authors, segment, and settings

Authors	Segment	settings
L. Li et al., 2020	COVID-19	vaccine and specific drugs
Y. Liu et al., 2020	management of coagulopathy in COVID-19	monitoring and treatment
P. Zhang et al., 2021	Patients in the poor	recovery
Y. Liu et al., 2020	ICU patients	patients hospitalized
Aziz et al., 2020	clinical management	ICU surge
P. Zhang et al., 2021	Reducing mortality in ICU	World Health Organization
Ma et al., 2020	ICU for severe condition	HD patients
X. Liu et al., 2020	Chinese Management Guideline	ICU admission
Q. Li et al., 2020	critical patients	acute kidney injury
Drożdżal et al., 2020	patients infected	treatment during the COVID-19 pandemic
Ozga et al., 2020	specialised approaches	ICU nurses

Furthermore, according to the findings of [20], during the pandemic's early days, much emphasis was placed on pulmonary problems, whereas less emphasis was placed on other organ dysfunctions, such as acute kidney damage (AKI), which was first documented with a low incidence and might be regarded unimportant. However, the grave concern from the researchers was related to a low platelet count, often known as thrombocytopenia, which is linked to an increased risk of severe sickness and death in SARS and COVID-19 patients for unknown causes [21]. Heparin-induced thrombocytopenia (HIT) is a well-known consequence of heparin treatment that can occur without heparin [22]. Besides this, diabetes has been shown to suppress the innate and humoral immune systems by lowering macrophage, lymphocyte, and neutrophil activity. Diabetes patients are more vulnerable to many illnesses, including the influenza virus, SARS, and MERS [23]. Immunity and nutrition are vital for all patients infected by the COVID-19 pandemic, not only people with diabetes; avoiding mortality in the intensive care unit are critical in treating COVID-19 [24]. Nutritional therapy should not be overlooked in treating severely sick COVID-19 patients. Before administering available therapies, the nutritional condition of each COVID-19 patient, particularly those in ICUs, should be assessed [25].

3.2 Intensive Care Units (ICUs)

The horrific pandemic that has afflicted the world's population has resulted in an unprecedented flood of severe ARDS patients, surpassing ICU bed capacity in many nations [26]. As a result, four new options were considered with the common goal of saving the most significant number of lives: prioritise ICU beds for patients with the best prognosis; increase the number of ICU beds at all costs, thereby creating step-down ICUs; organise transfer to distant ICUs with more beds available; or accelerate the withdrawal of life support in ICUs [27]. Additionally, due to the high number of critically ill patients, several nations' operating rooms are converted into ICUs. The conversion of operating rooms to intensive care units has allowed us to meet the demands of our local community while also allowing an infusion of patients from other hospitals that were at capacity [28]. Precise planning for improving critical care capacity, including interdisciplinary assistance, is necessary for institutions anticipating Covid-19 patient surges [29]. However, in the absence of adequate and consistent government financing, practically all ICUs continue to encounter significant obstacles in providing quality care to the most vulnerable patients [30]. Table 4 illustrates the authors, segment and setting details.

Table 4. Authors, segment, and settings

Authors	Segment	settings
Kiekens et al., 2020	dysfunctions in patients	rehabilitation
Gualtieri et al., 2020	risk of malnutrition	patients admitted
Naik et al., 2020.	ventilator management	critical patient care services
Jin et al., 2021	management of COVID-19 patients	management of COVID-19 patients
Qian et al., 2021	quarantine ICU	critically ill COVID-19 patients
Lei et al., 2020	COVID-19 patients	diabetes
Zhou et al., 2020	ICU beds for severe cases	lymphopenia
Xia et al., 2020	independent risk factor of ICU	stratification management

On the other hand, healthcare personnel spent long hours inside the ICU during the pandemic to safeguard critical patients from infection recovery [31]. The COVID-19 ICU (Intensive Care Unit) hospitalisation can last up to three weeks, longer than the average ICU stay. Furthermore, recovery intervals following waking and bed rest are quite protracted, leading to several acute and long-term issues [32]. The ICUs get a significant intention from the researchers due to innovative designs for health to improve isolation and care facilities for infectious illnesses [33]. One of the preliminary proposals shown is the use of tele-ICUs to prevent the spread of the virus while simultaneously providing treatment to patients [34]. Studies have demonstrated that Tele-ICU has a considerable influence on education, patient safety, and quality of care among residents [35]. In addition, tele-ICUs can be a beneficial option during the present pandemic to provide proper treatment to an overwhelming number of critically sick COVID19 patients while also protecting residents' safety and wellbeing [29], [36].

3.3 Performance management system

During the global COVID-19 outbreak, there is a high demand for ICU assistance for patients and heavy-duty hours for the nurses, doctors and supporting staff [37]. According to [38], nurses are most vulnerable to infection because they interact closely with patients, and their immune systems are impaired due to long working hours and stress. Many nurses combating COVID-19 avoid contact with their families to avoid spreading the virus and infecting their loved ones [39]. In addition, ICU nurses must handle a busy schedule that includes frequent invasive procedures and high levels of attentiveness. As a result, protecting the physical and psychological health of ICU nurses can significantly contribute to the effectiveness of epidemic management [40].

The findings of [41] suggested that The ICU nurses reported symptoms, which could be classified into three symptom clusters, and the average number of symptoms recorded by each nurse was 1.5. A night shift is likely to cause drowsiness and fatigue. The safety of healthcare workers was a critical component of COVID-19 defence measures in hospitals since personnel working in ICUs were at high risk of becoming infected with the virus [42].

According to [43], tertiary class protection is recommended for health care personnel in critical care units due to the high-risk environment (ICU). Disposable surgical caps, N95 masks, work uniforms, disposable medical uniforms, latex gloves, goggles, and full-face shields are personal protective equipment (PPE). However, other studies found that hospitals employed advanced methods and technology to prevent patients and healthcare personnel from the physical connection to control the spread in ICUs [44]. In addition, some hospitals used the AI-assisted CT measurement of COVID-19 pneumonia and ML models for disease severity categorization and clinical outcome prediction in COVID-19 patients. The U-Net architecture based on deep learning provides a practical and effective method for detecting and segmenting pneumonia lesions in CT images [45]. Table 5 illustrates the authors, segment and setting details.

Table 5. Authors, segment, and settings

Authors	Segment	settings
Candan et al., 2020	physical therapists	acute respiratory distress syndrome
Hu et al., 2021	Patients	COVID-19
Cai et al., 2020	ICU treatment	physicians
S. Yang et al., 2021	CU patients	Culture
X. Yang et al., 2020	clinical features	ICU patients
Wang et al., 2021	management strategy	ICU nurses treating
Ichai et al., 2020	Infrastructure	pressure system in ICU
Contou et al., 2021	COVID-19 pneumonia	admission of patients

However, compared to pandemic control and management in ICUs, technological participation and infrastructure are significantly lower [46]. Advance technology and performance management structures are critical for future pandemic damage control and reducing the burden on healthcare professionals. In addition, elective procedures are cancelled to prevent virus transmission, with high physical, mental, and economic costs for patients and institutions. AI and robotic technologies can be used to meet this difficulty. Beyond the operating room, these innovations can be used for a variety of tasks, including digitised patient admission, effective triaging during peak times, vital sign merger and monitoring, classification of high-risk nodes, sterilisation with real-time contamination feedback, blood drawing, and drug and food delivery [47].

4 Conclusion

The current study aimed to evaluate ICU performance management during the COVID-19 pandemic. The current pandemic had a substantial impact on healthcare resources and infrastructure in terms of spread control methods. However, current research indicates that healthcare personnel such as physicians, nurses, and other support staff made significant contributions during the peak period of pandemic transmission [48]. The intensive care units were packed with infected patients, making physical interaction a difficult task. In addition, healthcare personnel are experiencing record levels of COVID-19-related psychological stress in both professional and personal realms. Nurses, in particular, are the closest to the infected patients within the ICUs, and the findings show that a considerable percentage of nurses have been infected with the COVID-19 virus [14]. Similarly, throughout the extended duty working hours within the ICUs, the healthcare personnel's annoyance, stress, and psychological disorders were considerably reported.

Aside from this, in ICUs, technology engagement and infrastructure are substantially lower than in pandemic control and management. Future pandemic damage control and minimising the strain on healthcare workers require advanced technologies and performance management mechanisms. Furthermore, AI and robotic technology can be utilised to address this challenge. These advancements can be used for various tasks outside of the operating room, such as digitised patient admission, effective triaging during peak times, vital sign merger and monitoring, classification of high-risk nodes, sterilisation with real-time contamination feedback, blood drawing, and drug and food delivery.

5 Acknowledgements

Quality Engineering Research Cluster (QEREC), UniKL Research Grant STR18042.

6 References

[1] J. Xiong *et al.*, "Impact of COVID-19 pandemic on mental health in the general population: A systematic review," *Journal of Affective Disorders*, vol. 277. Elsevier, pp. 55–64, Dec. 01, 2020. https://doi.org/10.1016/j.jad.2020.08.001

[2] K. B. Anand, S. Karade, S. Sen, and R. M. Gupta, "SARS-CoV-2: Camazotz's Curse," *Medical Journal Armed Forces India*, vol. 76, no. 2. Elsevier B.V., pp. 136–141, Apr. 01, 2020. https://doi.org/10.1016/j.mjafi.2020.04.008

[3] M. Nicola *et al.*, "The socio-economic implications of the coronavirus pandemic (COVID-19): A review," *International Journal of Surgery*, vol. 78. Elsevier Ltd, pp. 185–193, Jun. 01, 2020. https://doi.org/10.1016/j.ijsu.2020.04.018

[4] J. W. Cabore *et al.*, "The potential effects of widespread community transmission of SARS-CoV-2 infection in the World Health Organization African Region: A predictive model," *BMJ Global Health*, vol. 5, no. 5, p. 2647, 2020. https://doi.org/10.1136/bmjgh-2020-002647

[5] N. Maani and S. Galea, "COVID-19 and Underinvestment in the Public Health Infrastructure of the United States," *Milbank Quarterly*, vol. 98, no. 2, pp. 250–259, Jun. 2020. https://doi.org/10.1111/1468-0009.12463

[6] A. Jarynowski, M. Wójta-Kempa, D. Płatek, and K. Czopek, "Attempt to Understand Public Health Relevant Social Dimensions of COVID-19 Outbreak in Poland," *SSRN Electronic Journal*, Apr. 2020. https://doi.org/10.2139/ssrn.3570609
[7] C. O. L. Ung, "Community pharmacist in public health emergencies: Quick to action against the coronavirus 2019-nCoV outbreak," *Research in Social and Administrative Pharmacy*, vol. 16, no. 4. Elsevier, pp. 583–586, Apr. 01, 2020. https://doi.org/10.1016/j.sapharm.2020.02.003
[8] WHO, "Health and Care Worker Deaths during COVID-19," *World Health Organization*, 2021. https://www.who.int/news/item/20-10-2021-health-and-care-worker-deaths-during-covid-19 (accessed Mar. 06, 2022).
[9] R. J. Thomson *et al.*, "Clinical characteristics and outcomes of critically ill patients with COVID-19 admitted to an intensive care unit in London: A prospective observational cohort study," *PLoS ONE*, vol. 15, no. 12 December, p. e0243710, Dec. 2020. https://doi.org/10.1371/journal.pone.0243710
[10] K. J. Goh *et al.*, "Preparing your intensive care unit for the COVID-19 pandemic: Practical considerations and strategies," *Critical Care*, vol. 24, no. 1. BioMed Central Ltd., pp. 1–12, May 11, 2020. https://doi.org/10.1186/s13054-020-02916-4
[11] T. Dzinamarira, M. Dzobo, and I. Chitungo, "COVID-19: A perspective on Africa's capacity and response," *Journal of Medical Virology*, vol. 92, no. 11. John Wiley & Sons, Ltd, pp. 2465–2472, Nov. 01, 2020. https://doi.org/10.1002/jmv.26159
[12] M. Cruz-Correa *et al.*, "Public health academic alliance for COVID-19 response: The role of a national medical task force in Puerto Rico," *International Journal of Environmental Research and Public Health*, vol. 17, no. 13, pp. 1–14, Jul. 2020. https://doi.org/10.3390/ijerph17134839
[13] F. Rubulotta *et al.*, "Technologies to Optimize the Care of Severe COVID-19 Patients for Health Care Providers Challenged by Limited Resources," *Anesthesia and Analgesia*, pp. 351–364, May 2020. https://doi.org/10.1213/ANE.0000000000004985
[14] V. Kramer *et al.*, "Subjective burden and perspectives of German healthcare workers during the COVID-19 pandemic," *European Archives of Psychiatry and Clinical Neuroscience*, vol. 271, no. 2, pp. 271–281, Mar. 2021. https://doi.org/10.1007/s00406-020-01183-2
[15] S. Aziz *et al.*, "Managing ICU surge during the COVID-19 crisis: rapid guidelines," *Intensive Care Medicine*, vol. 46, no. 7, pp. 1303–1325, Jun. 2020. https://doi.org/10.1007/s00134-020-06092-5
[16] S. Drożdżal *et al.*, "COVID-19: Pain management in patients with SARS-CoV-2 infection—molecular mechanisms, challenges, and perspectives," *Brain Sciences*, vol. 10, no. 7, pp. 1–10, 2020. https://doi.org/10.3390/brainsci10070465
[17] D. Ozga, S. Krupa, P. Witt, and W. Mędrzycka-Dabrowska, "Nursing interventions to prevent delirium in critically ill patients in the intensive care unit during the covid19 pandemic—narrative overview," *Healthcare (Switzerland)*, vol. 8, no. 4. 2020. https://doi.org/10.3390/healthcare8040578
[18] L. Li *et al.*, "Therapeutic strategies for critically ill patients with COVID-19," *Annals of Intensive Care*, vol. 10, no. 1. SpringerOpen, pp. 1–9, Apr. 20, 2020. https://doi.org/10.1186/s13613-020-00661-z
[19] J. Zhang *et al.*, "Poor-sleep is associated with slow recovery from lymphopenia and an increased need for ICU care in hospitalized patients with COVID-19: A retrospective cohort study," *Brain, Behavior, and Immunity*, vol. 88, pp. 50–58, 2020. https://doi.org/10.1016/j.bbi.2020.05.075

[20] Q. Li *et al.*, "Acute kidney injury can predict in-hospital mortality in elderly patients with covid-19 in the icu: A single-center study," *Clinical Interventions in Aging*, vol. 15, pp. 2095–2107, 2020. https://doi.org/10.2147/CIA.S273720
[21] Y. Liu *et al.*, "Prominent coagulation disorder is closely related to inflammatory response and could be as a prognostic indicator for ICU patients with COVID-19," *Journal of Thrombosis and Thrombolysis*, vol. 50, no. 4, pp. 825–832, Nov. 2020. https://doi.org/10.1007/s11239-020-02174-9
[22] X. Liu *et al.*, "Heparin-Induced Thrombocytopenia Is a High Risk of Mortality in Critical COVID-19 Patients Receiving Heparin-Involved Treatment," *SSRN Electronic Journal*, 2020. https://doi.org/10.2139/ssrn.3582758
[23] S. ping Liu *et al.*, "Hyperglycemia is a strong predictor of poor prognosis in COVID-19," *Diabetes Research and Clinical Practice*, vol. 167, 2020. https://doi.org/10.1016/j.diabres.2020.108338
[24] P. Zhang *et al.*, "The modified NUTRIC score can be used for nutritional risk assessment as well as prognosis prediction in critically ill COVID-19 patients," *Clinical Nutrition*, vol. 40, no. 2, pp. 534–541, 2021. https://doi.org/10.1016/j.clnu.2020.05.051
[25] Y. Ma *et al.*, "2019 novel coronavirus disease in hemodialysis (HD) patients: Report from one HD center in Wuhan, China," *medRxiv*, p. 2020.02.24.20027201, Jun. 2020. https://doi.org/10.1101/2020.02.24.20027201
[26] X. Li *et al.*, "Cardiac injury associated with severe disease or ICU admission and death in hospitalized patients with COVID-19: A meta-analysis and systematic review," *Critical Care*, vol. 24, no. 1. BioMed Central, Jul. 28, 2020. https://doi.org/10.1186/s13054-020-03183-z
[27] N. Naik, R. A. Finkelstein, J. Howell, K. Rajwani, and K. Ching, "Telesimulation for COVID-19 Ventilator Management Training With Social-Distancing Restrictions During the Coronavirus Pandemic," *Simulation and Gaming*, vol. 51, no. 4, pp. 571–577, Aug. 2020. https://doi.org/10.1177/1046878120926561
[28] H. Qian *et al.*, "Myocardial Injury on Admission as a Risk in Critically Ill COVID-19 Patients: A Retrospective in-ICU Study," *Journal of Cardiothoracic and Vascular Anesthesia*, vol. 35, no. 3, pp. 846–853, 2021. https://doi.org/10.1053/j.jvca.2020.10.019
[29] A. W. Peters, K. S. Chawla, and Z. A. Turnbull, "Transforming ORs into ICUs," *New England Journal of Medicine*, vol. 382, no. 19, p. e52, May 2020. https://doi.org/10.1056/NEJMc2010853
[30] Y. Zhou *et al.*, "Clinical time course of COVID-19, its neurological manifestation and some thoughts on its management," *Stroke and Vascular Neurology*, vol. 5, no. 2. pp. 177–179, 2020. https://doi.org/10.1136/svn-2020-000398
[31] C. Kiekens *et al.*, "Rehabilitation and respiratory management in the acute and early post-acute phase 'instant paper from the field' on rehabilitation answers to the COVID-19 emergency," *European Journal of Physical and Rehabilitation Medicine*, vol. 56, no. 3, pp. 323–326, 2020. https://doi.org/10.23736/S1973-9087.20.06305-4
[32] P. Gualtieri *et al.*, "Body composition findings by computed tomography in sars-cov-2 patients: Increased risk of muscle wasting in obesity," *International Journal of Molecular Sciences*, vol. 21, no. 13, pp. 1–13, 2020. https://doi.org/10.3390/ijms21134670
[33] T. Jin *et al.*, "SARS-CoV-2 presented in the air of an intensive care unit (ICU)," *Sustainable Cities and Society*, vol. 65, p. 102446, Feb. 2021. https://doi.org/10.1016/j.scs.2020.102446
[34] M. Lei *et al.*, "Clinical Features and Risk Factors of ICU Admission for COVID-19 Patients with Diabetes," *Journal of Diabetes Research*, vol. 2020, 2020. https://doi.org/10.1155/2020/5237840

[35] H. Xia *et al.*, "Development of Predictive Nomogram for ICU Mortality in Severe COVID-19," *SSRN Electronic Journal*, 2020. https://doi.org/10.2139/ssrn.3627282
[36] I. Mustapha, N. T. Van, M. Shahverdi, M. I. Qureshi, and N. Khan, "Effectiveness of Digital Technology in Education During COVID-19 Pandemic. A Bibliometric Analysis," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 8, pp. 136–154, Apr. 2021. https://doi.org/10.3991/ijim.v15i08.20415
[37] S. A. Candan, N. Elibol, and A. Abdullahi, "Consideration of prevention and management of long-term consequences of post-acute respiratory distress syndrome in patients with COVID-19," *Physiotherapy Theory and Practice*, vol. 36, no. 6, pp. 663–668, Jun. 2020. https://doi.org/10.1080/09593985.2020.1766181
[38] F. Hu *et al.*, "Nurses' experiences of providing care to patients with COVID-19 in the ICU in Wuhan: A descriptive phenomenological research," *BMJ Open*, vol. 11, no. 9, 2021. https://doi.org/10.1136/bmjopen-2020-045454
[39] Q. L. Zeng *et al.*, "Clinical course and treatment efficacy of COVID-19 near Hubei Province, China: A multicentre, retrospective study," *Transboundary and Emerging Diseases*, vol. 67, no. 6, pp. 2971–2982, Nov. 2020. https://doi.org/10.1111/tbed.13674
[40] P. Ichai, F. Saliba, P. Baune, A. Daoud, A. Coilly, and D. Samuel, "Impact of negative air pressure in ICU rooms on the risk of pulmonary aspergillosis in COVID-19 patients," *Critical Care*, vol. 24, no. 1. BioMed Central Ltd, Sep. 01, 2020. https://doi.org/10.1186/s13054-020-03221-w
[41] D. Contou, M. Fraissé, O. Pajot, J. A. Tirolien, H. Mentec, and G. Plantefève, "Comparison between first and second wave among critically ill COVID-19 patients admitted to a French ICU: no prognostic improvement during the second wave?," *Critical Care*, vol. 25, no. 1, Dec. 2021. https://doi.org/10.1186/s13054-020-03449-6
[42] S. Yang *et al.*, "Bacterial and fungal co-infections among COVID-19 patients in intensive care unit," *Microbes and Infection*, vol. 23, no. 4–5, p. 104806, May 2021. https://doi.org/10.1016/j.micinf.2021.104806
[43] X. Yang *et al.*, "Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study," *The Lancet Respiratory Medicine*, vol. 8, no. 5, pp. 475–481, May 2020. https://doi.org/10.1016/S2213-2600(20)30079-5
[44] X. Wang *et al.*, "Be aware of acute kidney injury in critically ill children with COVID-19," *Pediatric Nephrology*, vol. 36, no. 1, pp. 163–169, Jan. 2021. https://doi.org/10.1007/s00467-020-04715-z
[45] W. Cai *et al.*, "CT Quantification and Machine-learning Models for Assessment of Disease Severity and Prognosis of COVID-19 Patients," *Academic Radiology*, vol. 27, no. 12, pp. 1665–1678, Dec. 2020. https://doi.org/10.1016/j.acra.2020.09.004
[46] V. Haldane *et al.*, "Health systems resilience in managing the COVID-19 pandemic: lessons from 28 countries," *Nature Medicine*, vol. 27, no. 6. Nature Publishing Group, pp. 964–980, May 17, 2021. https://doi.org/10.1038/s41591-021-01381-y
[47] A. Zemmar, A. M. Lozano, and B. J. Nelson, "The rise of robots in surgical environments during COVID-19," *Nature Machine Intelligence*, vol. 2, no. 10, pp. 566–572, Oct. 2020. https://doi.org/10.1038/s42256-020-00238-2
[48] A. Shechter *et al.*, "Psychological distress, coping behaviors, and preferences for support among New York healthcare workers during the COVID-19 pandemic," *General Hospital Psychiatry*, vol. 66, pp. 1–8, Sep. 2020. https://doi.org/10.1016/j.genhosppsych.2020.06.007

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Article submitted 2022-04-26. Resubmitted 2022-05-30. Final acceptance 2022-05-31. Final version published as submitted by the authors.