Article

Workforce and Task Sharing For Nurses in the Japanese Intensive Care Unit -Cross Sectional Postal Survey

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Abstract: Aim: The aim of this study was to estimate the number of nurses who independently care for patients with severe respiratory failure receiving mechanical ventilation (MV) or veno-venous extracorporeal membrane oxygenation (VV-ECMO). Additionally, the study analyzed the actual role of nurses in the treatment of patients with MV and VV-ECMO. Methods: We conducted a cross-sectional study using postal surveys. The study included 725 Japanese intensive care units (ICUs). Descriptive statistics were conducted. Results: Among the 725 ICUs, we obtained 302 responses (41.7%) and analyzed 282 responses. The median number of nurses per bed was 3.25. The median proportion of nurses who independently cared for patients with MV was 60% [IQR: 42.3-77.3]. The median proportion of nurses who independently cared for patients with VV-ECMO was 46.9 (35.7-63.3%) in the ICU experiencing VV-ECMO use. Concerning task-sharing, 33.8% of ICUs and nurses did not facilitate weaning from MV. Nurses always titrated sedatives in 44.5% of ICUs. Conclusion: Nurse staffing might be inadequate in all ICUs, especially for severe respiratory failure. The proportion of competent nurses for caring for severe respiratory failure in ICUs should be considered when determining the work force of nurses.

Keywords: Intensive Care Units; Workforce; Mechanical Ventilation; Extracorporeal Membrane Oxygenation

1. Introduction

Coronavirus disease 2019 (COVID-19) has been spreading worldwide since January 2020. An increase in infections has led increasing numbers of severely ill patients. Critically ill COVID-19 patients require mechanical ventilation (MV) as with severe respiratory failure, alongside veno-venous extracorporeal membrane oxygenation (VV-ECMO), resulting in a heavy burden on ICUs [1]. The surge in infected patients has overburdened

 doi:10.20944/preprints202107.0204.v1

ICUs. As manpower and quality of nurses are associated with quality of care [2], the number of ICU nurses who can tend to COVID-19 patients is crucial information.

ICUs who met Japan's Ministry of Health, Labor and Welfare (MHLW) 's criteria are divided into eight types of ICUs for reimbursement purposes. Among them, the six detailed below, must have more than 0.5 nurses per patient at all times. ICU types 1 and 2 must include at least two physicians with ICU experience (not necessarily intensivists) and nurses with specialized training. ICU types 3 and 4 have the same nursing arrangements, but no such requirements for physicians or specialized nurses. The ICU types 2 and 4 at the emergency medical center, has the same requirements for nursing staff, but no requirements for physicians or specialized nurses.

From the 2018 governmental report, there were 785 units, with approximately 24,000 nurses working in the ICU. COVID-19 can cause severe respiratory failure and the patients were admitted to the ICU. Critical care nurses provide holistic nursing, including management of complicated devices such as MV and VV-ECMOs. Therefore, a certain amount of experience and training are essential for critical care nurses [3]. A previous study indicated that the workload of nurses in the ICU was related to hospital mortality [4]. Therefore, availability of equipment like MV and VV-ECMOs, alongside competent nurses is essential for COVID-19 patients.

However, the number of competent nurses for critically ill patients with MV and/or VV-ECMO is unknown.

Intensive care is provided by a multi-professional team; however, the role of nursing varies among facilities. Generally, the role of nurses tends to expand in the ICU. For example, previous study suggested that weaning from MV provided by nurses based on the protocol decreased the duration of MV [5]. Additionally, the titillate of sedative and analgesic agents by nurses decreases the duration of MV [6]. However, there are no data regarding the actual role of nurses working in ICUs in Japan.

This study aimed to estimate the proportion of nurses who could care independently for patients with severe respiratory failure, alongside analyzing the actual role of nurses towards caring for such patients.

2. Materials and Methods

Study Design

A cross-sectional study on Japanese ICUs using postal surveys, wherein survey sets were sent to each ICU, followed by descriptive statistics. Some parts of data detailing COVID-19 have been published previously due to the importance of the preliminary results [7].

Setting

The survey was sent to the target ICUs (25% were in university hospitals) on October 20, 2020 and collected on November 15, 2020. We included a delayed survey response until January 10, 2021.

Participants

ICUs that met the MHLW's regulations concerning medical fees were deemed eligible for the study, and data concerning the same were extracted from government reports from 2020. Pediatric ICUs were excluded.

Variables

The research team developed a questionnaire-discussion basis. The survey set included the ICU and hospital characteristics. Additionally, we obtained the number of nurses working in ICUs, new graduates, and assigned nurses, who were independently providing nursing care for patients with severe respiratory failure with MV and VV-ECMO. Respondents described the numbers of nurses as of January 2021, just before the

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pandemic in Japan. Actual work sharing situation according to equipment and medical management was detailed (i.e., MV maintenance, titillation for medication according to the protocol, and priming for the circuit for VV-ECMO). Respondents were asked to rate their implementation status using a five-point scale with responses ranging from "always" to "never."

Measurement

Only nurse managers, certified nurse specialists, and certified nurses filled the survey. All data were extracted from the returned survey sheet, except for the number of hospital beds.

Data Analysis

Some datasets were incomplete due to missing values. Thus, the number of denominators varied in each analysis. On visual inspection, impossible answers were excluded by setting standards based on the discussion of the research team. For example, if a nurse-to-patient ratio of 1:2 was not reliably maintained, the answer concerning the number of patients was considered missing. Descriptive statistical analyses were conducted. Continuous and ordinal variables were expressed as median and interquartile range.

Ethical Considerations

This study was approved by the research ethics review committee of Sapporo City University (No.2008-1). The survey instructions clearly stated that study participation was voluntary. Further, consent was implied when the checkbox on the front cover of the returned survey form was checked.

3. Results

302 responses were obtained from 725 ICUs. The response rate was 41.7%. We excluded 20 responses, as seven units focused on pediatric patients, and 11 were ineligible. Two surveys were excluded as one was not filled by a predefined person, while another contained invalid answers. Consequently, 282 responses from ICUs were analyzed. Concerning geographical distribution, Figure 1 indicates the proportion of ICUs, by prefecture, that were mailed and those who responded.

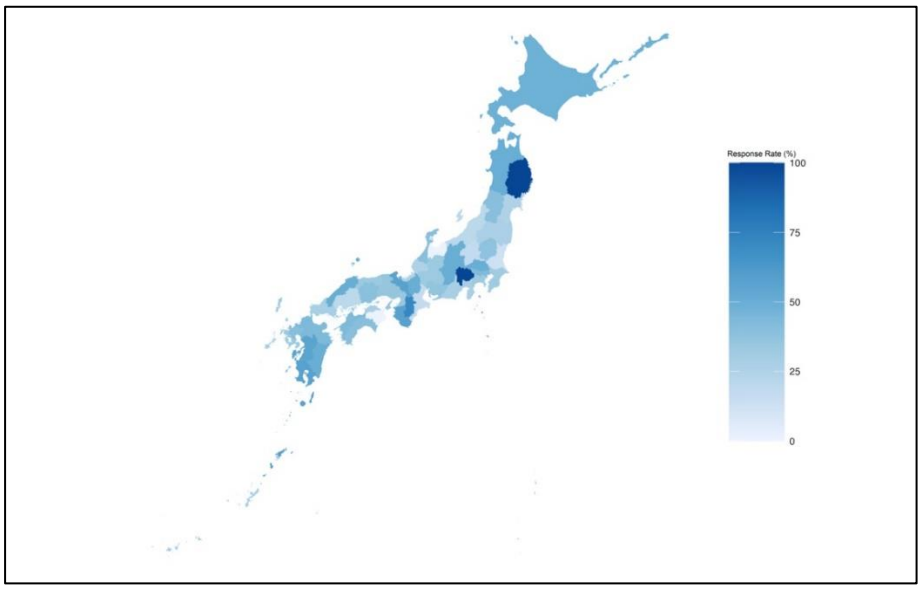

Figure 1. The response rate of the postal survey in each prefecture.

Dark blue indicates a high response rate at the prefecture level.

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Table 1. Characteristics of responded intensive care unit

Variables	
Type of hospital (%), n=282	
University hospital	73 (25.9%)
Missing	5 (1.8%)
Type of ICU based on medical fee, n(%),n=282	
ICU type 1,2	108 (38.3%)
ICU type 3,4	130 (46.1%)
Emergency ICU 2,4	44 (15.6%)
Physician staffing (%), n=282	
Closed ICU†	21 (7.4%)
Mandatory intensivist consultation	156 (55.3%)
Elective intensivist consultation	48 (17%)
No intensivist	56 (19.9%)
Missing	1 (0.4%)
Number of ICU beds, median [IQR], n=282	8 [6-12]
Number of ICU nurses*, median [IQR], n=265	30 [22-38]
Proportion for number of nurses with < 1 year of ICU experience, median [IQR], n=263	15.6% [11.1-22.6]
No certified nurse or certified nurse specialist, n (%), n=282	41 (14.5%)

†Intensivists manage all of patients in the ICU
Abbreviations: VV-ECMO, Veno-Venous extracorporeal membrane oxygenation: IQR, interquartile range

The characteristics of the responding ICUs are shown in Table 1. The median numbers of ICU beds and nurses per bed were 8 [6-12] and 3.25 [2.85-3.75], respectively.

Number of nurses independently providing care for patients with MV and/or VV-ECMO was shown in Table 2. The median proportion of nurses who independently cared for patients with MV was 60% (42.3-77.3%).

133 (47.1%) ICUs had experience with VV-ECMO. In the experienced ICU, the median proportion of the number of nurses who independently cared for patients with VV-ECMO was 46.9% (35.7-63.3%). (Table 2)

 doi:10.20944/preprints202107.0204.v1

Table 2 Number of nurses independently providing care for mechanical ventilation and VV-ECMO for severe acute respiratory failure

Mechanical ventilation for severe respiratory failure	
Number of nurses independently providing care for those population in a unit, median [IQR], n=259	17 [12-23]
Proportion of number of nurses independently providing care for those population in a unit, median [IQR], n=259	60 [42.3-77.3]
VV-ECMO for severe respiratory failure	
Characteristics of ICU using VV-ECMO, n (%), n=133	
University hospital	48 (36%)
Missing	4 (3%)
Number of cases with VV-ECMO per a year, median [IQR], n=133	2 [1-5]
Number of nurses independently providing care for those population in a unit, median [IQR], n=117	15 [10-21]
Proportion of number of nurses independently providing care for those population in a unit, median [IQR], n=117	46.9 [35.7-63.3]

Abbreviations: Veno-Veno extracorporeal membrane oxygenation: *IQR,* interquartile range

Figure 2 indicates the actual task-sharing status. In 33.8% of ICUs, nurses never facilitated weaning from MV. In 44.5% of the ICUs, nurses always titrated sedatives.

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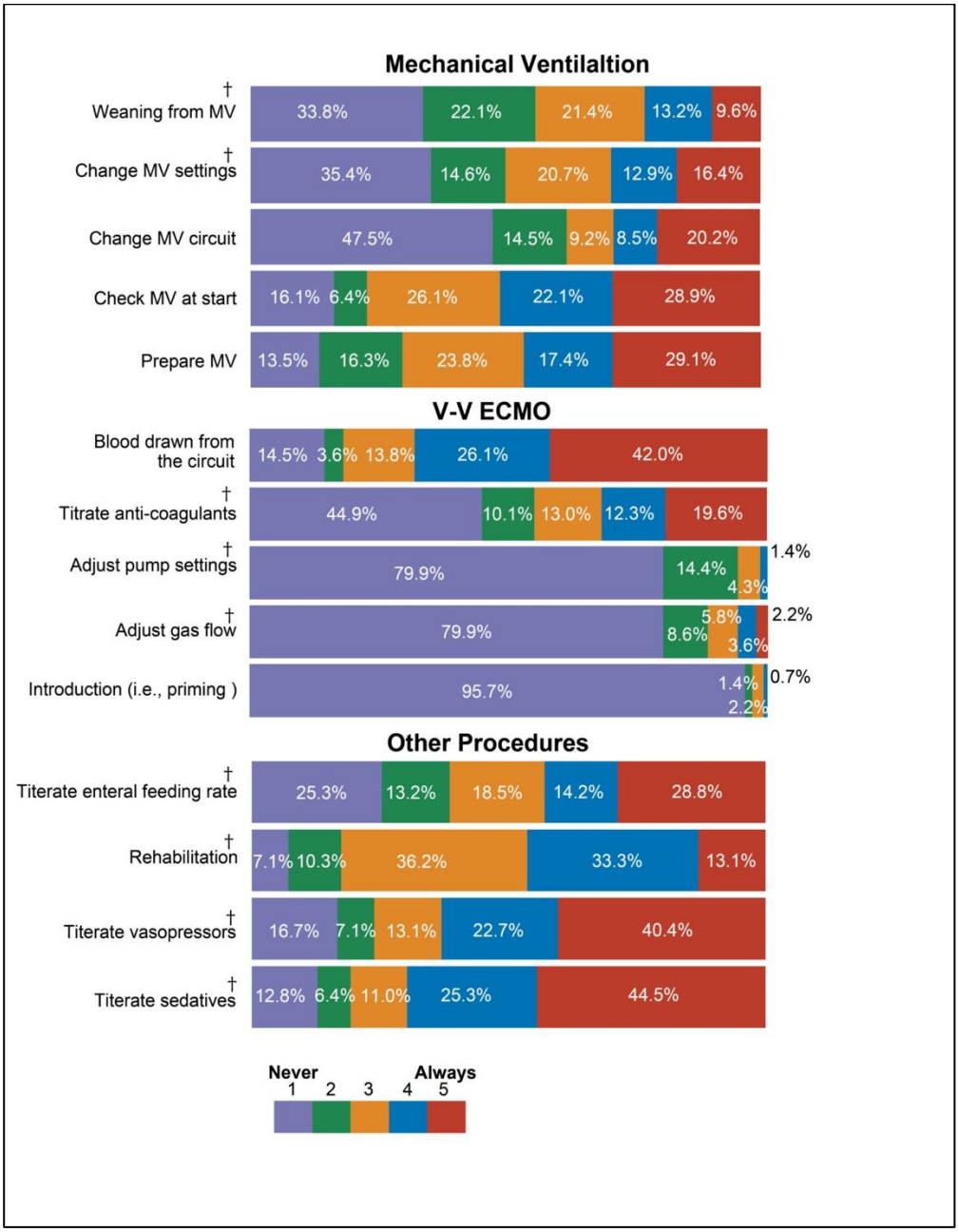

Figure 2. Nursing activities for specific procedures.

Note: Missing data were included in this analysis.
Abbreviations: MV, Mechanical Ventilator: *VV-ECMO*, Veno-Veno extracorporeal membrane oxygenation† indicates under pre-prescribed protocol

4. Discussion

This is the first survey to estimate the actual number of competent nurses for severe respiratory failure patients. To our knowledge, this is the first study to clarify actual task sharing among multi-professionals in the ICU. From the geographic distribution and proportion of ICUs from university hospitals, our findings did not indicate significant selection bias and were representative of Japanese ICUs.

ICUs may not have a sufficient number of nurses per bed, the median number being 3.25. However, the median numbers from Australia and New Zealand were 4.7 +/- 1.2 and 4.2+/-1.4 nurses per bed, respectively [8]. In Japan, the number of nurses per patient at all

 doi:10.20944/preprints202107.0204.v1

times is more than 0.5, as determined by the government. Maintaining a nurse-to-patient ratio of 1:1 or 1:2 for critically ill patients throughout the day, is determined by the facility. Perhaps, a small number of nurses per bed means fewer nurses during the daytime to maintain a 1:2 nurse-to-patient ratio. For reimbursement purposes, a 1:2 nurse-to-patient ratio during the daytime is acceptable, as there is no regulation determining the number of patients per assigned nurse based on disease severity. Internationally, the nurse-to-patient ratio ranges from 1:1 to 1:2, as determined by the acuity scoring system in Massachusetts [9]. The majority of ICUs in the UK had a nurse-to-patient ratio of 1:1 [10]. A nurse was assigned for every patient with invasive MV in Australia and New Zealand [8]. Recently, it was suggested that a nurse-to-patient ratio of 1:1.5 in the ICU was associated with reduced mortality [11,12]. It is difficult to generalize the situation since there are varying systems and different populations entering the ICU globally. However, we can potentially consider a system that requires nurses to be assigned according to disease severity. The adequate assignment of patients in the ICU is not necessarily determined by the amount of assistance or monitoring devices. Alongside these factors, we analyzed whether frequent observation is an important requisite. There is a potential need for reconsidering the adequate nurse-to-patient ratio in Japanese ICUs.

We emphasized that not all critical care nurses were able to independently care for patients with severe respiratory failure. Nursing management for those population is challenging [13]. To our knowledge, there are no formal training courses in Japan with the exception of certified nurses and certified nurse specialists; however, certified courses take 0.5 to 2 years with full-time requirements. Hence, not many nurses take up the courses. To facilitate the competency of care for critically ill patients, such as severe respiratory failure, formal and standardized courses such as e-learning are needed [14]. The development of a standardized course and certification should be considered.

Approximately half of ICU had experience to use VV-ECMO. Approximately 46% of nurses in the ICU were able to care for patients with severe respiratory failure patients with VV-ECMO. Notably, this information is only available for facilities that have experience with VV-ECMO. We noted that the number of cases receiving VV-ECMO in an ICU was very low, which indicated that ICU treatment with VV-ECMO was not centralized. VV-ECMO is complex [15,16] and requires experience; thus, for sufficient caseload and maintaining competence, ICU using VV-ECMO should be centralized [17].

The number of intensivists in Japan is very low [18], hence they are often overburdened. Promotion of the work style reform of physicians is among the most important medical policies of the Japanese government. Task-shifting in ICUs may contribute to reducing the burden on intensivists. Especially in VV-ECMO, nurses did not perform introductions, including priming and maintenance. Clinical engineers should perform these tasks for safety [19]. Conversely, nurses are often involved in the titration of sedatives, analgesics, and vasopressors. As described above, previous studies have suggested that nurse-led sedation protocols lead to favorable outcomes.[20] From a patient-centered point of view, these contribute to optimal outcomes. It is important to promote task-sharing, to reduce the burden on intensivists and improve the outcomes of critically ill patients. However, systematic continuous education of administration for these drugs is required [21]. Further studies are required to determine whether critical care nurses receive adequate education for safety.

Limitations

As the response rate was approximately 40%, there was a potential for selection bias. However, ICUs that responded had a broad range of characteristics, including different geographical areas, various numbers of ICU beds, and were within different types of hospitals (university versus non-university). Therefore, our findings reflect the current clinical practices of various ICUs in Japan.

5. Conclusions

Our findings suggest that approximately 60% of nurses are competent for care associated with severe respiratory failure with mechanical ventilation. Additionally, limited nurses are competent for severe respiratory failure with VV-ECMO. Adequate staffing assignment according to ICU function and the severity of admitted patients was required, due to the inadequacy of nursing staff in ICUs. Alongside experience, continuous, standardized education is required to increase nurses who can care for severe respiratory failure patients.

Author Contributions: Conceptualization, all authors; methodology, T.U., M.H., M.T., H.S., Y.K., T.M., Y.I., and E.M.; formal analysis, M.H., M.T., and T.U.; investigation, T.U.; writing—original draft preparation, T.U., Y.K., M.H..; writing—review and editing, T.U., M.H., M.T., H.S., Y.K., T.M., Y.I. J.T.; visualization, TU and MT.; supervision, O.N.; project administration, T.U.; funding acquisition, T.U. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the Health, Labor, and Welfare Policy Research Grants, Special Research, Grant Number 20CA2028, and a Research Grant from Sapporo City University (Takeshi Unoki, 2020-2021).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Sapporo City University (No.2008-1, 18th August 2020).

Informed Consent Statement: The survey instructions clearly stated that study participation was voluntary. Further, consent was implied when the checkbox on the front cover of the returned survey form was checked.

Data Availability Statement: All data were within the manuscript.

Acknowledgments: This study was officially supported by Japan Society of Intensive Care Medicine.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Fujii, Y.; Hirota, K. Critical Care Demand and Intensive Care Supply for Patients in Japan with COVID-19 at the Time of the State of Emergency Declaration in April 2020: A Descriptive Analysis. *Medicina* **2020**, *56*, doi:10.3390/medicina56100530.
2. Penoyer, D.A. Nurse staffing and patient outcomes in critical care: a concise review. *Crit. Care Med.* **2010**, *38*, 1521–8; quiz 1529.
3. Farnell, S.; Dawson, D. "It's not like the wards". Experiences of nurses new to critical care: a qualitative study. *Int. J. Nurs. Stud.* **2006**, *43*, 319–331.
4. Tarnow-Mordi, W.O.; Hau, C.; Warden, A.; Shearer, A.J. Hospital mortality in relation to staff workload: a 4-year study in an adult intensive-care unit. *Lancet* **2000**, *356*, 185–189.
5. Hirzallah, F.M.; Alkaissi, A.; do Céu Barbieri-Figueiredo, M. A systematic review of nurse-led weaning protocol for mechanically ventilated adult patients. *Nurs. Crit. Care* **2019**, *24*, 89–96.
6. Arias-Rivera, S.; Sánchez-Sánchez, M. del M.; Santos-Díaz, R.; Gallardo-Murillo, J.; Sánchez-Izquierdo, R.; Frutos-Vivar, F.; Ferguson, N.D.; Esteban, A. Effect of a nursing-implemented sedation protocol on weaning outcome. *Crit. Care Med.* **2008**, *36*, 2054–2060.
7. Hamamoto, M.; Unoki, T.; Sakuramoto, H.; Kawai, Y. Survey on the actual number of nurses required for critical COVID-19 patients in Japanese intensive care units: Preliminary report. *Japan J Nurs Sci in press*.
8. Rose, L.; Nelson, S.; Johnston, L.; Presneill, J.J. Workforce profile, organisation structure and role responsibility for ventilation and weaning practices in Australia and New Zealand intensive care units. *J. Clin. Nurs.* **2008**, *17*, 1035–1043.
9. Law, A.C.; Stevens, J.P.; Hohmann, S.; Walkey, A.J. Patient Outcomes After the Introduction of Statewide ICU Nurse Staffing Regulations. *Crit. Care Med.* **2018**, *46*, 1563–1569.
10. Bakhru, R.N.; McWilliams, D.J.; Wiebe, D.J.; Spuhler, V.J.; Schweickert, W.D. Intensive Care Unit Structure Variation and Implications for Early Mobilization Practices. An International Survey. *Ann. Am. Thorac. Soc.* **2016**, *13*, 1527–1537.
11. Checkley, W.; Martin, G.S.; Brown, S.M.; Chang, S.Y.; Dabbagh, O.; Fremont, R.D.; Girard, T.D.; Rice, T.W.; Howell, M.D.; Johnson, S.B.; et al. Structure, process, and annual ICU mortality across 69 centers: United States Critical Illness and Injury Trials Group Critical Illness Outcomes Study. *Crit. Care Med.* **2014**, *42*, 344–356.

12. Sakr, Y.; Moreira, C.L.; Rhodes, A.; Ferguson, N.D.; Kleinpell, R.; Pickkers, P.; Kuiper, M.A.; Lipman, J.; Vincent, J.-L.; Extended Prevalence of Infection in Intensive Care Study Investigators The impact of hospital and ICU organizational factors on outcome in critically ill patients: results from the Extended Prevalence of Infection in Intensive Care study. *Crit. Care Med.* **2015**, *43*, 519–526.
13. Kane, C.; Galanes, S. Adult respiratory distress syndrome. *Crit. Care Nurs. Q.* **2004**, *27*, 325–335.
14. Lahti, M.; Kontio, R.; Pitkänen, A.; Välimäki, M. Knowledge transfer from an e-learning course to clinical practice. *Nurse Educ. Today* **2014**, *34*, 842–847.
15. Daly, K.J.; Camporota, L.; Barrett, N.A. An international survey: the role of specialist nurses in adult respiratory extracorporeal membrane oxygenation. *Nurs. Crit. Care* **2017**, *22*, 305–311.
16. Umeda, A.; Sugiki, Y. Nursing care for patients with COVID-19 on extracorporeal membrane oxygenation (ECMO) support. *Glob Health Med* **2020**, *2*, 127–130.
17. Aokage, T.; Palmér, K.; Ichiba, S.; Takeda, S. Extracorporeal membrane oxygenation for acute respiratory distress syndrome. *J. Intensive Care Med.* **2015**, *3*, 17.
18. Shime, N. Clinical and investigative critical care medicine in Japan. *Intensive Care Med.* **2016**, *42*, 453–455.
19. Committee on ICU-CE, Japanese Society of Intensive Care Medicine Evaluation of Clinical Engineer in ICU. *J Jpn Soc Intensive Care Med* **2019**, *26*, 139–48.
20. Qi, Z.; Yang, S.; Qu, J.; Li, M.; Zheng, J.; Huang, R.; Yang, Z.; Han, Q.; Li, H. Effects of nurse-led sedation protocols on mechanically ventilated intensive care adults: A systematic review and meta-analysis. *Aust. Crit. Care* **2020**, doi:10.1016/j.aucc.2020.07.013.
21. Ramoo, V.; Abdullah, K.L.; Tan, P.S.; Wong, L.P.; Chua, P.Y. Intervention to improve intensive care nurses' knowledge of sedation assessment and management. *Nurs. Crit. Care* **2016**, *21*, 287–294.