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Minimum standards of clinical practice for physiotherapists working in adult intensive care units in Singapore

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Abstract

Background: Physiotherapists play a crucial role in rehabilitating critically ill patients in intensive care units (ICU). However, variations are found in clinical practice amongst physiotherapists working in the ICU, both locally and internationally, due to the lack of minimum clinical standards and varying knowledge on critical care rehabilitation resulting in inconsistent quality of care.

Purpose: To establish a framework of the minimum standards of clinical practice for physiotherapists working in ICU in Singapore and compare the standards with existing literature.

Methods: A three-round modified Delphi questionnaire survey technique collated responses from ICU physiotherapists. The questionnaire contained 222 items, categorised into assessments, conditions and treatments. Responses to the items were either: "Yes, it is essential", "No, it is not essential", or "I am not sure". Consensus for an item was reached when 70% of participants ranked it essential or non-essential. Participants comprised registered physiotherapists who have worked in the ICU for at least six months in the last 12 months and are currently working in the ICU.

Results: 23 physiotherapists (median ICU-experience 7.0 (4.3–9.8) years) gave consent and completed the initial survey. 13 completed all three rounds of questionnaires. Overall, 163 items were regarded as essential, 21 as non-essential, and 38 did not reach consensus. The identified 163 items varied from similar studies due to different scopes of physiotherapy practice and professional autonomy.

Conclusion: This framework may guide the content of the physiotherapy education curriculum on critical care rehabilitation and minimise variability in clinical practice across different healthcare institutions in Singapore.

Keywords

critical care, minimum standards, physiotherapy, clinical competency framework, intensive care units

Introduction

The advancement of intensive care medicine and multidisciplinary team management has improved the survival of critically ill patients.[1] Physiotherapists play a role in managing respiratory complications and preventing and treating consequences of prolonged immobility in intensive care units (ICU).[2,3] However, as patients' cardiorespiratory and haemodynamic status may rapidly change and require life-supporting equipment and pharmacological therapy, the role of physiotherapists becomes more complicated.[4] Hence, ICU physiotherapists need to be deft in understanding the

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complex medical issues and equipment in order to provide effective and safe rehabilitation for critically ill patients.[5]

In Singapore, entry-level physiotherapists can begin working in ICU after a year of general rotations to the different disciplines. The on-call system of acute hospitals potentially dictates that physiotherapists who are not respiratory specialists practice in the ICU during their weekend shifts, despite being unfamiliar with the setting. To date, there is only one study that describes the vast profiles of patients who require after-hours physiotherapy services in Singapore.[6] In a separate study, the clinically important differences between the treatment provided by the non-respiratory and specialist respiratory physiotherapists illustrates the significance of training and proficiency of non-respiratory on-call physiotherapists, particularly in delivering physiotherapy treatments in the critical care environment.[7] Inferring from these ideas, it is therefore only sensible to establish the minimum standards of clinical practice relevant to the local critical care settings. Furthermore, there are currently no standardised local training guidelines to acquaint physiotherapists with this highly specialised domain. The lack of local consensuses, such as "Oncall Position Statement and Recommendation: Association of Chartered Physiotherapists in Respiratory Care" in the United Kingdom (UK),[8] further hinders benchmarking of local practice with global standards. The different individual in-house induction programmes for entry-level physiotherapists often vary in the content and duration of training. Senior physiotherapy staff usually define competency standards, often subjective and informal, with varying hospital requirements. Unsurprisingly, this results in a wide disparity of skillset and expertise levels among ICU physiotherapists. This difference in expertise level could translate into differing patient outcomes due to inconsistencies in the clinical decision-making process.[9] Experience-informed practice is common among ICU clinicians, thus resulting in variations in clinical practice on the choice of physiotherapy techniques and the interventions provided.[10,11] This highlights the potentially detrimental influence on patient outcomes.[12]

An international drive has emerged in Australia and New Zealand (AUS-NZ),[11] South Africa,[10] the UK[13] and Japan,[14] acknowledging the importance of standardising the expectations of clinical practice of ICU physiotherapists. Skinner et al.[11] (2016) utilised a modified Delphi technique to examine the minimum standards of skills and knowledge needed for physiotherapists working in Australia and New Zealand intensive care settings. The study recruited 50 highly experienced ICU physiotherapists, who completed three rounds of questionnaires each over a maximal 8 week period. This study concluded that 132 items out of 222 items (2 items were omitted from the original 224 items during the modified Delphi survey) were deemed essential and were included in the final framework. Twose et al. (2019) adopted a similar protocol but recruited a larger panel of 114 physiotherapists, and the study deemed 107 items essential for the minimum standards for ICU physiotherapists in the UK. More recently, Takahashi et al. (2020) further contributed to the Japanese minimum standards, with 188 items established as essential for the practice of physiotherapy in the ICU in Japan.[14] Noteworthily, the Japanese physiotherapists included more essential items than physiotherapists from western countries.[11,13] A similar initiative in South Africa took place with van Aswegen et al. (2017) exploring the topic in South Africa ICU.[10] Unlike the studies mentioned earlier, these investigators used the nominal group technique as their approach to determine consensus, with their cohort of 25 experienced clinicians concluding that three main themes were necessary for the practice of physiotherapy in the ICU - integrated medical knowledge, physiotherapy practice components, and multidisciplinary teamwork.

These studies established the minimum standards of ICU physiotherapists in their respective countries. Such results could inform the practice standards of physiotherapy and corroborate the curriculum for entry-level physiotherapy programmes. However, there are anecdotal differences across countries, such as the varied role of ICU physiotherapists, the discrepancy in the scope of patient referrals, levels of professional autonomy, intervention preferences, and resources available. These determine the entry-level curriculum, length of training, and job demands,[9,15] thus it may not be feasible to generalise and apply international results to Singapore's context. Therefore, this study aimed to establish the minimum standards of clinical practice for physiotherapists working in ICU in Singapore. The results will formulate an initial framework to support curriculum development to cater to the training needs of physiotherapists at various career junctures. More importantly, this local initiative will enhance the consistency of clinical practice of the physiotherapists in the ICU in Singapore and enable international comparison.

Methods

Ethics

The University Institutional Review Board granted ethical approval (Project Number: 2020073) for this study. Potential participants received the project information via work email addresses of their affiliated hospitals. The return of the completed questionnaire assumed implied consent in each round of the modified Delphi survey. This study took place between March 2020 and January 2021.

Study design

Guided by the Recommendation for the Conducting and Reporting of Delphi Studies (CREDES),[16] this study adopted a modified Delphi survey technique to obtain the consensus.

Participants and sampling method

A purposive snowball recruitment strategy was employed to recruit participants for this study. Invitation emails were sent to professional networks and the physiotherapy departments of local acute hospitals with ICU to seek potential participants. A screening questionnaire that sought information such as consent to participate in the modified Delphi survey, years of clinical and ICU experience, and the current working ICU settings were sent to each potential participant individually. Additionally, we actively asked the potential participants for their referral of individuals who may be eligible to participate in the study by providing the referees' workplace email addresses. The screening questionnaire filtered

their willingness to participate and the inclusion and exclusion criteria. The inclusion criteria for this study were: (1) physiotherapists fully registered with the Allied Health Professions Council, Singapore[17]; (2) physiotherapists who are currently working in any Singapore adult ICU and have been for at least 6 months in the last 12 months. There was no pre-determined sample size, as there is no local census on the number of physiotherapists working in the ICU. Similarly, our inclusion criteria of 6 months minimum ICU experience was low compared to the 3 years required in the AUS-NZ or the UK reports.[11,13] This mechanism in the inclusion criteria could potentially include rotating junior physiotherapists seriously considering future specialisation in critical care, as it is otherwise uncommon for uninterested therapists to stay beyond a typical 6-months rotation. Participants were excluded if they: (1) did not fulfil the inclusion criteria; (2) did not provide sufficient personal and contact information; and (3) wished to remain anonymous, as follow-up was essential for the modified Delphi survey design. Following the similar methodology of Skinner et al. (2016), we aimed to recruit a minimum of 30 participants for all three modified Delphi rounds. Mechanisms to invite additional participants to participate were in place to account for attrition throughout the three modified Delphi surveys.

Modified Delphi survey questionnaire

With permission from the original authors, the questionnaire used in this study was based on the final 222-item list developed by Skinner et al. (2016).[11] It defined the comprehensive role of physiotherapy in the ICU based on existing empirical resources, ICU competency checklists, and current entry-level academic materials from AUS-NZ. Minor modifications of language and medical terminology were made to ensure its relevance to the Singapore context, such as the inclusion of ETT as the abbreviation for endotracheal tube, and ETCO2 to represent end-tidal carbon dioxide. The questionnaire contained 222 items, categorised under assessment, condition and treatment. For each item, participants had three response options: "Yes, it is essential", "No, it is not essential", and "I am not sure". An open comments section was available in rounds 1 and 2 for participants to submit any additional items that may be absent from the questionnaire. The questionnaire was piloted by three investigators who previously worked in the ICU but were not members of the Delphi panel before the full-scale modified Delphi survey began to assess the clarity of the questions and estimate time commitments to complete the questionnaire. The three investigators combined had approximately 35 years of local ICU and 50 years of local clinical experience. The final results did not contain any pilot data.

Data collection procedure

The questionnaire was posted on an online survey platform (Qualtrics^{XM} 2020, Provo, UT, USA) and disseminated through an email link. The modified Delphi survey consisted of three rounds of questionnaires, and participants were given a maximum of 5 weeks to complete each round. Due to the lengthy nature of the questionnaire, the "save" function enabled participants to store their responses intermittently if they experienced response fatigue.[18] Participants had the option to resume the survey when they were ready. Email reminders were sent to non-respondents on the second and fourth week during each cycle. A comparison of individual and group quantitative results was provided to each participant at the end of every cycle. The current modified Delphi survey did not include any focus group discussion.

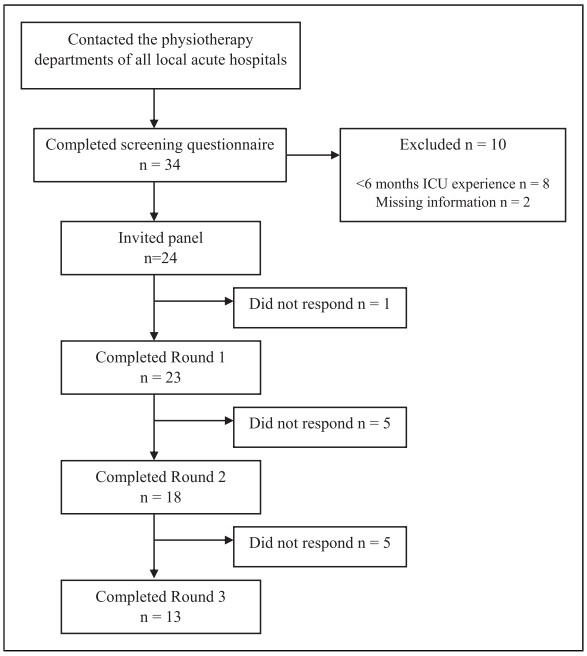

Figure 1. Panel selection and completion rates.

Data analysis

Results from the questionnaires were exported from Qualtrics^{XM} and analysed on Microsoft Excel™. Consistent with the earlier studies[11,13] and literature recommendation,[19] items were deemed essential or non-essential if they achieved >70% consensus for essential or non-essential accordingly. Any items that attained a >70% response as essential would have their status established and removed from the subsequent survey cycle. Additionally, items that attained >70% as non-essential were considered non-essential and excluded from subsequent rounds. Items that received less than 70% response rate for 'Yes, it is essential' or 'No, it is not essential' were brought forward to the subsequent round as they did not attain any consensus. Furthermore, items with "I am not sure" as their primary response were also brought to the next round

Results

Twenty-four physiotherapists who met the inclusion criteria consented to participate. Figure 1 depicts the process of panel selection and the response rate at each modified Delphi survey. 10 potential participants were excluded due to inadequate ICU experience or missing information. One recruited participant was never initiated in the modified Delphi

Table 1. Comparison of variables between Singapore, AUS-NZ, the UK and Japan.

	Singapore	AUS-NZ Mean (SD)	United Kingdom	Japan Median (IQR)
Sample size (*n*)	23	50	114	54
General clinical experience (years)				
Median (IQR)	10 (6.5–15.5)	17.4 (9.1)	16.6	13.5 (11–17)
Mean (SD)	10.7 (5.2)			
ICU clinical experience (years)				
Median (IQR)	7.0 (4.3–9.8)	11.6 (7.1)	15.0	9.0 (6–12)
Mean (SD)	7.2 (4.1)			
Clinical setting				
Public hospital – round 1 (n)	20			
Private hospital – round 1 (n)	3			
Public hospital – round 3 (n)	12			
Private hospital – round 3 (n)	1			
Retention rate (%)[a]	57.0	90.0	80.7	96
Items				
Number of essential items (%)	163 (73%)	132 (59%)	107 (50%)	161 (73%)
Number of non-essential items (%)	21 (10%)	67 (30%)	73 (34%)	42 (15.5%)
Number of no consensus items (%)	38 (17%)	25 (11%)	33 (16%)	31 (11.5%)

[a]Retention rate defined as the percentage of participants who remained until the end of the study. SD: standard deviation; IQR: interquartile range.

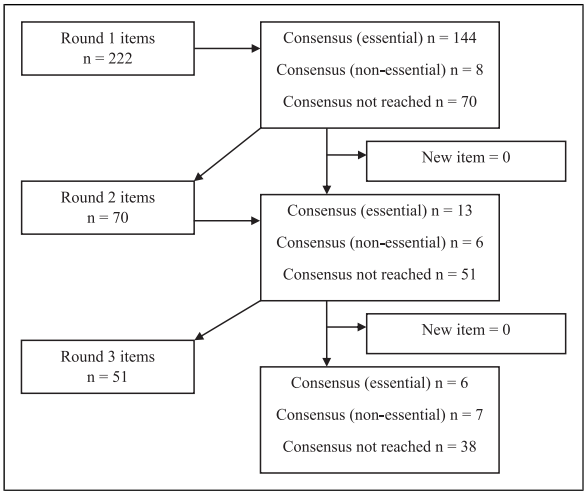

Figure 2. Flow of items through the modified Delphi rounds.

survey, resulting in the initial sample size of 23 participants who completed the first round of the modified Delphi survey. 10 participants were lost in rounds 2 and 3 of the modified Delphi survey; 18 participants (78%) completed round 2, and 13 participants (57%) completed all three rounds. The investigators did not manage to recruit additional participants during rounds 2 and 3 of the survey.

Table 1 presents the characteristics of the participants and in comparison with the AUS-NZ, UK, and Japan studies.[11,13,14] The initial 23 participants were practising in 12 of the 15 public and 4 private hospitals with ICU in Singapore. 20 of the 23 participants represented the restructured hospitals, while 3 participants were working in private hospitals. The participants were working in the cardiac or coronary care ICU, cardiothoracic ICU, medical ICU, multidisciplinary ICU, neurological ICU, and surgical ICU. The mean (standard deviation (SD)) years of ICU experience was 7.2 (4.1), while the median (interquatile range (IQR)) was 7.0 (4.2–9.8) years. The current study reported the lowest participant retention rate of 57% compared to the other reports,[11,13,14] but within the commonly reported sample size of 11–31 participants.[16]

Figure 2 depicts the inclusion and exclusion numbers of the 222 items through the three rounds of the modified Delphi survey, and Table 2 elaborates on the modified Delphi survey results. Twenty-one items were deemed non-essential (Table 3), and no consensus was reached for 38 items (Table 4). The participants suggested no new items via the open comment option throughout the modified Delphi process.

Discussion

This report established the minimum standards of clinical practice for physiotherapy to ensure safe and independent practice in Singapore ICU. The overall consensus was reached on 163 items across the categories of knowledge and skill to conduct a holistic assessment on an ICU patient, knowledge of medical conditions to enhance clinical reasoning, and knowledge of physiotherapy treatment. The 163 items identified as essential to the minimum competency standards of clinical practice of ICU physiotherapists in Singapore are substantially higher than the AUS-NZ and UK studies, which deemed only 132 and 107 items essential, respectively, but similar to the Japanese results (Table 1 161items). It is difficult to pinpoint a reason for this based on this study alone, but one possible reason could be the wide variety of conditions, such as the general medical, surgical, neuro-surgical, and cardiothoracic cases that a typical ICU physiotherapist would have to cover routinely in Singapore. This results from the population-dense city-state with major general hospitals and specialised centres located within proximity to provide highly integrated healthcare. Each specialty requires a relatively distinct set of knowledge and skills, translating into more items being deemed essential in this study. For example, items considered essential in our

Table 2. Items determined as essential, where consensus is defined as >70% of participants agreed. The percentages are as shown in each round. (n = 163).

Item	Singapore Round					
Assessment	1 %	2 %	3 %	AUS-NZ	United Kingdom	Japan
As a minimum standard, a physiotherapist can perform and accurately interpret the results of common respiratory examinations, including						
1. Observation of respiratory rate (RR)	100			*	*	*
2. Patterns of breathing	100			*	*	*
3. Palpate the chest wall	87			*	*	*
4. Auscultation	100			*	*	*
As a minimum standard, a physiotherapist can understand equipment (including recognition of equipment), use/safely apply or handle equipment, and understand the implications for physiotherapy of						
5. Oxygen therapy devices	100			*	*	*
6. Endotracheal tube (ETT) and tracheostomy	100			*	*	*
7. Central venous catheters	91			*	*	*
8. Arterial lines	96			*	*	*
9. Intercostal catheters	91			*	*	*
10. Wound drains	96			*	*	*
11. Indwelling urinary catheter	91			*	*	*
12. Vascath/haemodialysis catheter/continuous veno-venous haemofiltration	96			*	*	*
13. Nasogastric tube (NGT)	100			*	*	*
14. Intra-aortic balloon pump (IABP)	91			NRC	NE	*
15. Extracorporeal membrane oxygenation (ECMO)	78			NE	NE	*
16. Intracranial pressure (ICP) monitors and extra-ventricular drains (EVD)	100			*	NE	*
As a minimum standard, a physiotherapist can accurately interpret readings from clinical monitoring, including						
17. Body temperature	96			*	*	*
18. Heart rate (HR)	100			*	*	*
19. Blood pressure (BP)	100			*	*	*
20. Basic electrocardiogram (ECG)	96			*	*	*
21. Peripheral capillary oxygen saturation (SpO2)/pulse oximetry	100			*	*	*
22. End-tidal carbon dioxide (ETCO2)	78			*	*	*
23. Fluid intake and output	83			*	*	*
24. Central venous pressure (CVP)	74			*	NRC	*
As a minimum standard, a physiotherapist can accurately interpret findings from laboratory investigations, including						
25. Haemoglobin (Hb)	91			*	*	*
26. Platelets, Activated partial thromboplastin time (APTT), International normalised ratio (INR)	87			*	*	*
27. Troponins	100			*	*	*
28. White cell count	83			*	*	*
29. C-reactive Protein	83			NRC	*	*
30. Blood glucose levels	96			*	*	*
31. Creatinine kinase (CK)	78			NRC	NE	*
32. Neutrophil count	74			NRC	NE	*
33. Albumin	74			NE	NE	*
34. Liver function tests	83			NE	NE	*
35. Renal function tests, e.g. urea and creatinine	74			*	NRC	*
As a minimum standard, a physiotherapist is aware of the actions and implications for physiotherapy of the following medications						
36. Vasopressors/Inotropes	91			*	*	*
37. Common electrolyte replenishment	91			N/A	N/A	N/A
38. Anti-hypertensives	78			*	*	*
39. Anti-arrhythmic drugs/agents	87			*	*	*
40. Sedation and neuromuscular paralysing agents	91			*	*	*
41. Bronchodilators	91			*	*	*
42. Mucolytics	87			*	*	NRC
43. Calcium channel blockers, cerebral diuretics, hypertonic saline	78			NRC	NE	*
As a minimum standard, a physiotherapist can independently interpret findings from imaging investigations (excluding the imaging report), including:						
44. Chest radiograph	91			*	*	*

(continued)

Table 2. (continued)

Item	Singapore Round					
Assessment	1 %	2 %	3 %	AUS-NZ	United Kingdom	Japan
45. Skeletal X-ray	78			NRC	NE	*
As a minimum standard, a physiotherapist can interpret the results from neurological equipment/examinations and functional tests, including						
46. An ability to interpret a glasgow coma score (GCS)	96			*	*	*
47. An ability to perform a glasgow coma dcore (GCS)	87			NRC	NE	*
48. An ability to assess sedation levels	65	78		NE	NE	*
49. An ability to interpret an assessment of cranial nerve function	71			NRC	NE	*
50. An ability to perform a delirium assessment	60	61	77	NE	NE	*
51. Intracranial pressure (ICP) monitors (intra-parenchymal and intra-ventricular) and cerebral perfusion pressure (CPP)	87			*	NRC	*
52. An ability to interpret an assessment of sedation levels (e.g. Ramsey sedation scale, riker, richmond agitation-sedation scale)	87			*	NRC	*
53. An ability to perform a neurological examination of motor and sensory functions (e.g. light touch, pain), e.g. ASIA score	91			*	NRC	*
As a minimum standard, a physiotherapist understands the key principles of providing the following different modes of mechanical/assisted ventilation including						
54. Continuous positive airway pressure (CPAP)	91			*	*	*
55. Positive end-expiratory pressure (PEEP)/expiratory positive airway pressure (EPAP)	91			*	*	*
56. Pressure support (PS)/inspiratory positive airway pressure (IPAP)	96			*	*	*
57. Synchronised intermittent mandatory ventilation (SIMV)(volume)/(pressure)	96			*	*	*
58. Bilevel	96			*	*	*
59. Assist-control (AC)	91			*	NRC	*
60. Airway pressure release ventilation (APRV)	74			NE	NE	*
61. Weaning protocols	87			*	NRC	*
As a minimum standard, a physiotherapist can assess and interpret mechanical ventilation settings/measurements, including						
62. Respiratory rate (RR)	100			*	*	*
63. Tidal volume (TV)	96			*	*	*
64. Breath types (spontaneous, mandatory, assisted)	96			*	*	*
65. The levels of fraction of inspired oxygen (FiO2)	96			*	*	*
66. The levels of positive end-expiratory pressure (PEEP)	91			*	*	*
67. The levels of pressure support (PS)	100			*	*	*
68. Peak inspiratory pressure (PIP)	87			*	*	*
69. Inspiration: Expiration (IE) ratio	83			N/A	*	N/A
70. Static and/or dynamic lung compliance measurements	78			NE	NE	*
71. Maximum expiratory pressure (MEP) measurements	52	67	85	NE	NE	NRC
As a minimum standard, a physiotherapist can						
72. Assess the effectiveness/quality of a patient's cough	96			*	*	*
73. Record and interpret observations from physical clinical examination	87			N/A	*	N/A
74. Interpret the rapid shallow breathing index	60	72		NE	NE	NRC
75. Interpret respiratory function tests [e.g. for measurements of forced expiratory volume (FEV), forced vital capacity (FVC), peak expiratory flow (PEF)]	83			*	NRC	*
As a minimum standard, a physiotherapist can interpret indices from blood-gas measurement, including						
76. pH	91			*	*	*
77. The partial pressure of carbon dioxide (PaCO2)	91			*	*	*
78. The partial pressure of arterial oxygen (PaO2), SpO2, arterial oxygen saturation (SaO2)	96			*	*	*
79. Bicarbonate (HCO3)	91			*	*	*
80. Base excess	96			*	*	*
81. PaO2/FiO2 ratio	87			*	NE	*
82. Lactate	74			NE	NRC	*
A physiotherapist can complete musculoskeletal and/or functional assessments including						
83. Manual muscle testing	91			*	*	*
84. Range of motion	91			*	*	*
85. Deep-vein thrombosis screening	78			*	*	*
86. Peripheral oedema	87			*	*	*
87. Dynamometry	60	78		NRC	NE	*
88. Objective measures of physical function	87			*	NE	*
89. Perform and Interpret chelsea critical care physical assessment tool	65	67	85	N/A	NE	N/A
90. Objective measures of cardiopulmonary exercise tolerance	71			NRC	NE	*

(continued)

Table 2. (continued)

Item	Singapore Round					
Assessment	1 %	2 %	3 %	AUS-NZ	United Kingdom	Japan
91. Ability to assess tone (e.g. utilising a modified ashworth scale) and reflexes	91			*	NRC	*
As a minimum standard, a physiotherapist has knowledge of methods for advanced haemodynamic monitoring, can interpret the measurements and understands the implication of these for physiotherapists:						
92. Implanted or external pacemakers and determine the presence of pacing on electrocardiogram (ECG)	74			*	NRC	*
As a minimum standard, a physiotherapist is aware						
93. Of key literature that guides evidence-based physiotherapy practice in critical care settings	87			*	NRC	*
Conditions	Round			AUS-NZ	UK	JAP
	1 %	2 %	3 %			
As a minimum standard, a physiotherapist understands the pathophysiology and presenting features, likely medical management and implications for physiotherapy for a range of conditions, including						
94. Respiratory failure types I and II	91			*	*	*
95. Community-acquired/nosocomial/hospital-acquired pneumonia	96			*	*	*
96. Pleural effusion	96			*	*	*
97. Obstructive respiratory diseases	96			*	*	*
98. Restrictive respiratory diseases	96			*	*	*
99. Suppurative lung diseases	87			*	*	*
100. Acute lung injury (ALI) /acute respiratory distress syndrome (ARDS)	100			*	*	*
101. Acute coronary syndrome (ACS)	100			*	*	*
102. Shock (cardiogenic)	96			*	*	*
103. Heart failure	91			*	*	*
104. Post-abdominal surgery	91			*	*	*
105. Renal failure: acute and chronic	87			*	*	*
106. Immunocompromise	91			*	*	*
107. Systemic inflammatory response syndrome (SIRS)	83			*	*	*
108. Shock (septic)	87			*	*	*
109. Multi-organ failure	83			*	*	*
110. ICU-acquired weakness (ICU-AW)	87			*	*	*
111. Guillain-barre syndrome (GBS)	74			*	*	*
112. Thromboembolic disease	83			*	*	*
113. Intracerebral haemorrhage (ICH)/subarachnoid haemorrhage (SAH)	91			*	*	*
114. Traumatic brain injury (TBI)	83			*	*	*
115. Chest trauma	78			*	*	*
116. Spinal cord injury (SCI)	78			*	*	*
117. Neuromuscular disease (NMD)	78			N/A	*	N/A
118. Pancreatitis	65	89		*	NRC	*
119. Hepatitis	65	83		NRC	NE	*
120. Organ transplantation	65	83		NE	NE	NRC
121. Burns	65	67	77	NRC	NE	*
122. Post-cardiac surgery	87			*	NRC	*
123. Post-thoracic surgery	78			*	NRC	*
124. Metabolic disturbances	65	100		*	NRC	*
125. Electrolyte disturbances	83			*	NRC	*
126. Multi-trauma	71			*	NRC	*
127. Sleep-disordered breathing (e.g. obstructive sleep apnoea, hypoventilation)	78			N/A	NRC	N/A
Treatment	Round			AUS-NZ	UK	JAP
	1 %	2 %	3 %			
As a minimum standard, a physiotherapist can provide the following techniques, including an understanding of indications, contraindications, evidence for the technique and progressions						
128. Oxygen therapy, including initiation and titration of oxygen therapy	91			*	*	NRC

(continued)

Table 2. (continued)

Item	Singapore Round					
Assessment	1 %	2 %	3 %	AUS-NZ	United Kingdom	Japan
129. Humidification	91			*	*	*
130. Active cycle of breathing technique (ACBT)	96			*	*	*
131. Manual airway clearance techniques – percussion, vibration, chest shaking	100			*	*	NE
132. Intermittent positive pressure breathing	74			*	*	NE
133. Mechanical insufflation-exsufflation (MI-E)	78			N/A	*	N/A
134. Supported coughing	96			*	*	*
135. Directed coughing/instructing the patient to cough effectively	96			*	*	*
136. Assisted coughing – chest wall	96			*	*	*
137. Cough stimulation – oropharyngeal catheter stimulation	71			*	*	NE
138. Manual hyperinflation via an endotracheal tube or tracheostomy	87			*	*	NE
139. Nasopharyngeal (NP) airway suctioning, including the insertion of NP airway	83			*	*	NE
140. Oropharyngeal (OP) airway suctioning, including the insertion of OP airway	96			*	*	NE
141. Suction via a tracheal tube (ETT, tracheostomy, mini-tracheostomy)	100			*	*	*
142. Instillation of normal saline into the endotracheal tube (ETT)	65	83		NRC	*	NE
143. Patient positioning for respiratory care – including use of side lie, sitting, upright, postural drainage (modified or with head-down tilt)	91			*	*	*
144. Patient positioning for the prevention of pressure ulcers, management of tone, maintenance of musculoskeletal function	96			*	*	*
145. Mobilisation of the non-ventilated patient	91			*	*	*
146. Mobilisation of the ventilated patient	74			*	*	*
147. Bed exercises	91			*	*	*
148. Nasal high flow	74			N/A	*	N/A
149. Non-invasive ventilation (NIV)/bilevel positive airway pressure (BiPAP) - for use during exercise or mobilisation, including initiation and titration of	71			NRC	NE	*
150. Cough stimulation - tracheal rub	74			*	NE	NE
151. Inspiratory muscle training	78			NE	NE	*
152. Fitting of collars	61	72		NRC	NE	NRC
153. Fitting of braces	65	83		NE	NE	*
154. Electrical stimulation (e.g. for isolated muscle activation to prevent muscle wasting, such as neuromuscular/functional electrical stimulation)	65	83		NE	NE	*
155. Exercise prescriptions with treadmill, cycle ergometry or stationary bike	87			NRC	NE	*
156. Positive pressure devices for airway clearance (e.g. AstraPEP, PariPEP, TheraPEP, or oscillating expiratory pressure devices like acapella, flutter)	83			*	NRC	NE
157. NIV/BiPAP – intermittent, short term applications during physiotherapy to assist secretion mobilisation techniques or lung recruitment, including initiation and titration of	61	61	77	NRC	NRC	NE
158. Assisted coughing - subcostal thrusts for spinal cord injuries	87			*	NRC	*
As a minimum standard, a physiotherapist can appropriately request/coordinate the following						
159. Titration of sedation to achieve physiotherapy goals	74			N/A	*	N/A
160. Titration of analgesia to achieve physiotherapy goals	74			*	*	NE
161. Titration of inotropes to achieve physiotherapy goals	61	61	85	N/A	NRC	N/A
As a minimum standard, a physiotherapist can						
162. Determine the appropriateness of a patient for tracheostomy decannulation	61	78		NRC	NRC	NE
163. Determine the appropriateness of a patient for extubation	65	78		NRC	NRC	*

*; Essential, NRC: did not reach a consensus, NE: not essential, N/A: not available.

study and the Japanese report, but not in AUS-NZ or the UK, included many cardiovascular and neurosurgical items such as having an understanding of the extra-ventricular drain (EVD), actions and implications of pharmacological agents and delirium assessments (Table 2, item 16, 36–43, 50). The ICU physiotherapists in Singapore unanimously agreed that knowledge of EVD is essential as post-neurosurgery patients are common across most ICU in Singapore. This was also deemed essential in Japan (91%) but did not meet the essential status in AUS-NZ and the UK. Similarly, knowledge of actions and implications of pharmacological agents and delirium assessment were deemed highly essential. This could be due to the prominent role of ICU physiotherapists in Singapore in facilitating early mobilisation in critically ill patients, proven for its effectiveness to prevent the onset or reduce the severity of ICU-acquired weakness.[20–24]

Furthermore, Takahashi and colleagues (2020) suggested that identifying more items could be the result of the rapid development of the advancing role of physiotherapists in the Japanese ICU, leading physiotherapists to realise the need for a broader range of knowledge and skills to practise in the multidisciplinary patient-centred care ICU setting.[12] While

Table 3. Items determined as non-essential, with consensus defined as >70% Non-Essential (n = 21). The non-essential ranking percentages are as shown in each round.

Item	Singapore Round					
Assessment	1 %	2 %	3 %	AUS-NZ	United Kingdom	Japan
As a minimum standard, a physiotherapist can understand equipment (including recognition of equipment), use/safely apply or handle equipment, understand the implications for physiotherapy of						
1. Sengstaken-blakemore/Minnesota tubes	48	11	8	NE	NE	NE
As a minimum standard, a physiotherapist is aware of the actions and implications for physiotherapy of the following medications						
2. Prostacyclin	17	16		NE	NE	NE
As a minimum standard, a physiotherapist can independently interpret findings from imaging investigations (excluding the imaging report) including						
3. CT – Brain	17	11	23	NE	NE	*
4. CT – Spine	17	11	23	NE	NE	NRC
5. MRI – Brain	17	11	23	NE	NE	*
6. MRI - Spine	17	11	23	NE	NE	NRC
As a minimum standard, a physiotherapist can interpret the results from neurological equipment/examinations and functional tests including						
7. Electroencephalograms (EEG)	17	11	23	NE	NE	NE
As a minimum standard, a physiotherapist can						
8. Perform a spontaneous breathing trial	22			NE	NE	NRC
9. Perform a swallow assessment	13			NE	NE	NE
As a minimum standard, a physiotherapist can interpret indices from blood-gas measurement including						
10. P50	17	22		NE	NE	NE
11. Anion gap	17	22		NE	NE	NRC
A physiotherapist can complete musculoskeletal and/or functional assessments including						
12. Bioimpedence testing of body composition	13	11		NE	NE	NE
Conditions						
Treatment	Round 1 %	Round 2 %	Round 3 %	AUS-NZ	UK	JAP
As a minimum standard, a physiotherapist can provide the following techniques, including an understanding of indications, contraindications, evidence for the technique and progressions						
13. Feldenkreis	4			NE	NE	NE
14. Performing bronchoscopy independently	4			NE	NE	NE
15. Assisting bronchoscopy via delivery of secretion mobilisation techniques during the procedure	39	22	15	NE	NE	NE
16. Splinting and/or casting for the upper limbs and lower limbs	13	11		NE	NE	NE
As a minimum standard, a physiotherapist can						
17. Intubate a patient	9			NE	NE	NE
18. Extubate a patient	17			NE	NE	NE
19. Lead the coordination of speaking valve trials	13	16		NE	NE	NE
20. Decannulate a tracheostomy	17			NE	NE	NE
21. Tracheostomy exchange	4			NE	NE	NE

*; Essential, NRC: did not reach a consensus, NE: not essential, N/A: not available.

this does not imply that physiotherapists in AUS-NZ or the UK do not have the same level of knowledge, rather it highlights the difference in perception of what physiotherapists feel is important in their ICU culture. This further emphasises the need for minimum standards that are unique to the local healthcare practice.

Airway secretion clearance management forms another significant role of ICU physiotherapists in Singapore. Hence, it is not surprising that knowledge of manual airway clearance techniques, manual hyperinflation via an endotracheal tube or tracheostomy, and airway suctioning (Table 2, item 131, 138–141) were deemed essential. This finding is similar to our AUS-NZ and UK counterparts. Notably, Japanese physiotherapists are not permitted to perform these interventions and thus resulted in the non-essential status of these items. This variation, therefore, reflects differences in physiotherapist roles and professional autonomy guided by local regulations.

Singaporean physiotherapists did not consider the interpretation knowledge for nutritional status or imaging investigation, particularly for CT and MRI scans (Table 3, item 3–6; Table 4, item 2, 7–9) as essential, which were items that were established essential only in the Japanese study.[14] One possible reason is that dietitians are a well-defined part of the

Table 4. Items not reaching consensus (n = 38). The essential ranking percentages are as shown in each round.

Item	Singapore Round					
Assessment	1 %	2 %	3 %	AUS-NZ[6]	United Kingdom[8]	Japan[9]
As a minimum standard, a physiotherapist can accurately interpret readings from clinical monitoring including						
1. Advanced ECG's	48	50	54	NE	NRC	*
2. Nutritional status including feed administration, volume and type	39	39	38	NE	NE	*
As a minimum standard, a physiotherapist can accurately interpret findings from laboratory investigations including:						
3. Haematocrit	61	61	54	NE	NE	*
4. Procalcitonin	57	44	46	NE	NE	NRC
5. Sputum cultures	61	67	62	*	NRC	NRC
As a minimum standard, a physiotherapist is aware of the actions and implications for physiotherapy of the following medications						
6. Nitric oxide	57	50	54	NRC	NE	NRC
As a minimum standard, a physiotherapist can independently interpret findings from imaging investigations (excluding the imaging report) including						
7. CT – chest	52	39	38	NE	NE	*
8. MRI – chest	48	33	31	NE	NE	NRC
9. Ultrasound - chest	35	39	38	NE	NE	*
As a minimum standard, a physiotherapist can interpret the results from neurological equipment/examinations and functional tests including						
10. An ability to perform an assessment of cranial nerve function	35	56	54	NE	NE	*
As a minimum standard, a physiotherapist understands the key principles of providing the following differing modes of mechanical/assisted ventilation including						
11. High frequency oscillatory ventilation	65	67	69	NE	NE	NRC
As a minimum standard, a physiotherapist can assess and interpret mechanical ventilation settings/measurements including						
12. Upper and lower inflection points of P-V curves	26	39	46	NE	NE	NRC
13. Maximum expiratory pressure (MEP) measurements	43	61	69	NE	NE	NRC
As a minimum standard, a physiotherapist can						
14. Perform respiratory function tests (e.g. for measurements of FEV1, FVC, PEF)	43	44	38	*	NE	NRC
15. Perform and interpret percussion note	57	50	46	N/A	NE	N/A
16. Measure peak cough flow on or off mechanical ventilation	52	56	69	NE	NE	NRC
17. Measure peak inspiratory flow rate: Peak Expiratory Flow	52	56	69	N/A	NE	N/A
18. Perform a cuff volume and/or pressure test on an endotracheal tube or tracheostomy	48	44	38	NRC	NRC	NE
As a minimum standard, a physiotherapist can interpret indices from blood-gas measurement including						
19. A-a gradient	43	56	62	NE	NE	*
20. Oxygen content (CaO2)	43	50	46	NE	NE	NRC
21. Venous blood gas interpretation (including venous oxygen saturation)	48	44	46	NRC	NE	*
A physiotherapist can complete musculoskeletal and/or functional assessments including:						
22. Objective measures of quality of life	52	56	69	NE	NE	*
As a minimum standard, a physiotherapist has knowledge of methods for advanced haemodynamic monitoring, can interpret the measurements and understands the implication of these for physiotherapists						
23. Pulmonary arterial catheter measurements	52	56	46	NE	NE	*
24. PiCCO measurements	35	33	46	NE	NE	*
Conditions	Round 1 %	Round 2 %	Round 3 %	AUS-NZ	UK	JAP
As a minimum standard, a physiotherapist understands pathophysiology and presenting features, likely medical management and implications for physiotherapy for a range of conditions including						
25. Fat embolism	43	50	31	*	NRC	NRC
26. Brain death and organ procurement	43	50	46	NRC	NRC	NE

(continued)

Table 4. (continued)

Item Assessment	Singapore Round 1 % 2 % 3 %	AUS-NZ[6]	United Kingdom[8]	Japan[9]
Treatment	Round 1 % 2 % 3 %	AUS-NZ	UK	JAP
As a minimum standard, a physiotherapist can provide the following techniques, including an understanding of indications, contraindications, evidence for the technique and progressions				
27. Glottal stacking (frog breathing)	35 56 69	NE	NE	NE
28. Other breathing techniques	26 67 62	NE	NE	NE
29. Autogenic drainage	39 56 62	NE	NE	NRC
30. Recruitment manoeuvres e.g. staircase manoeuvres	30 39 38	NE	NE	NRC
31. Bronchial Lavage	39 44 62	NE	NE	NE
32. Patient prone positioning in severe respiratory failure/acute lung injury	48 67 46	NRC	NRC	*
33. Additional rehabilitation techniques (e.g. hydrotherapy, Wii)	43 56 46	NE	NE	NE
34. Periodic/intermittent CPAP (non-invasive via mask) including initiation and titration of	61 50 31	NRC	NRC	NE
35. NIV/BiPAP – for Type I or Type II respiratory failure, initiation and titration of e.g. COPD exacerbation with hypercapnia	57 50 46	NE	NRC	NE
36. Ventilator hyperinflation (VHI) via an endotracheal tube or tracheostomy	35 50 62	NRC	NRC	NE
As a minimum standard, a physiotherapist can				
37. Lead the coordination of weaning protocols	52 50 69	NE	NE	NE
38. Lead the coordination of cuff deflation trials	39 44 69	NE	NE	NE

* Essential, NRC: did not reach a consensus, NE: not essential, N/A: not available.

intensive care team in Singapore, AUS-NZ, and the UK. Dietitians in the ICU team are prominent with a strong interest in nutrition management in intensive care medicine in our local settings.[25] This claim is evident from the subsequent representation in establishing the consensus on nutritional therapy for the critically ill.[26] In the same way, while chest radiograph and skeletal X-ray (Table 2, items 44 and 45) were deemed essential, diagnostic radiologists and the timely availability of imaging reports form the cornerstone of intensive care in Singapore, hence CT and MRI interpretations were considered non-essential by the participants.

The role of ICU physiotherapy differs significantly from other disciplines of physiotherapy. Physiotherapists play a crucial and growing role in the multidisciplinary team approach to patient management and rehabilitation in ICU.[2,3,5,20,27] The emerging emphasis on improving health-related quality of life and functional outcomes of survivors of critical illness prompts effective physiotherapy treatment to boost patient outcomes in ICU.[28] In such a complex setting like the ICU, this propels health care professionals to describe the minimum standards in clinical practice in order to provide optimal care for patients during their ICU stay. The specific focus on cardiorespiratory health, the acute precarious nature of the patient's condition, and the higher likelihood of significant adverse events as a result of inadequate clinical decision-making and intervention all warrant physiotherapists to be equipped with sound knowledge and high proficiency in clinical decision-making skills.[9,10] It is, therefore, essential to establish minimum standards of competency required to ensure a safe and effective clinical practice. As evident in the results of this study, physiotherapy practice in ICU may vary across countries due to specific local regulations, variance in scope of patient referrals, and disparity in professional autonomy. Hence, it is essential to establish the minimum standards of clinical practice for physiotherapists specific to the local context.

Establishing such minimum standards of competency would aid the formulation of a standardised training framework for physiotherapists to function proficiently in the intensive care setting. This could reduce the variability in the quality of treatment, hence improving patient health outcomes.[29] In addition, the role of the ICU physiotherapist is currently not clearly defined in Singapore and may overlap with the job scope of other healthcare professionals, such as respiratory therapists. This similar struggle is shared with our AUS-NZ counterparts.[27] Hence, developing a framework would strengthen the definition and integration of physiotherapists in the intensive care setting.[11] Skinner et al.[11] (2016) posited that such a framework can enhance the credibility of ICU physiotherapists and the physiotherapy profession as a whole.

Furthermore, such minimum clinical competency standards may inform the planning, design, and implementation of the local entry-level physiotherapy curriculum. Of the surveyed 222 items, 182 items are taught in the local physiotherapy programme, including the 163 items deemed essential by the respondents of this study. This finding reassures that the current curriculum is congruent with national standards. Moreover, as local curriculum has recently eased into an entrustable professional activities (EPA) model,[30] the essential items identified in this study can be used as a basis for EPA assessment in physiotherapy ICU trainees.

Some limitations in this study should be considered. Participants in this study possessed fewer years of clinical and ICU experience compared to other studies (Table 1). The

average age of the physiotherapists in Singapore is predominantly younger than our counterparts, evident by Singapore's Allied Health Professions Council[31] Annual Report 2019 that up to 75.6% of physiotherapists in Singapore are 39 years old and younger. This would inevitably influence the average ICU experience and could also account for the larger number of items deemed essential. As one can postulate, the mastery of knowledge and skills can compensate for the shortfall of experience. Additionally, several physiotherapists working in ICU at the time of the study were mainly junior rotating physiotherapists who only commenced their ICU rotation with less than 6 months of ICU experience. Hence, they failed to meet the inclusion criteria despite being identified as potential participants. The sample size and retention rate in this study were also low compared to the Japan, AUS-NZ, and UK studies. This is likely due to the fact that as a small city-state, Singapore has fewer ICU and hospitals. Consequently, the initial 23 participants recruited in this study represented 12 of the 15 local hospitals with ICU, and may be viewed as the leading authority representing the key opinions relevant to the practice of ICU physiotherapy in Singapore, who are qualified to deliver valid and relevant viewpoints regarding critical care rehabilitation. Although the absolute attrition number ($n = 10$) was significantly lower than in other studies, which ranged from 16 to 50 participants,[9,11] only 13 out of the initial 23 participants completed all survey cycles eventually, translating to a low retention rate (57%) in our study. The survey length might have resulted in fatigue, causing the high attrition. Most importantly, the study was conducted during the peak COVID-19 pandemic in Singapore when there was a sudden surge in survey studies. This might further explain the low retention of the participants, in addition to the strained manpower situation among frontline healthcare workers, especially those in the critical care settings.

Nevertheless, the information gleaned from this study appears valid and relevant to our local context, as previously discussed. This serves as an important basis for how local physiotherapy training should be modelled to prepare therapists for managing patients in this complex and highly specialised setting.

Conclusion

This study identified 163 items of knowledge and skills essential as a minimum standard for clinical practice for ICU physiotherapists in Singapore. The challenge now is to integrate this newly established framework into clinical teaching, position statements and performance management so as to reduce variability in clinical practice.

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Author contributions

BXL was involved in drafting the manuscript, participant recruitment, data collection and data analysis.
JCT and JGL were involved in participant recruitment, data collection and analysis.
DS, CCY, SP and MYC contributed to the conception of the project, reviewed and edited the manuscript.
MTY contributed to the conception of the project, reviewed and approved the final version of the manuscript.

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Ethical approval

(include full name of committee approving the research and if available mention reference number of that approval) Ethical approval for this study was obtained from the Singapore Institute of Technology Institutional Review Board (Approval number 2020073).

Informed consent

Consent is Implied when Participants Return the Completed Delphi Survey

Availability of data

The data sets generated and/or analysed during the current study are available from BXL and MTY upon reasonable request.

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Supplemental Material

Supplemental material for this article is available online.

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