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Development and Pilot Evaluation of a Clinical Algorithm to Prioritize Patients in the ICU for Physiotherapy

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List of Abbreviations

ICU	Intensive care unit
ICUs	Intensive care units
KIM	Department of Intensive Care/ Klinik für Intensivmedizin
UKE	University Hospital Eppendorf
AI	Artificial intelligence
ICUAW	Intensive care unit acquired weakness
RASS	Richmond Agitation-Sedation Scale
COVID-19	Coronavirus disease 2019
IMS	ICU Mobility Scale
IPPA	ICU Physiotherapy Prioritization Algorithm
PRISMA	The Preferred Reporting Items for Systematic Reviews and Meta-Analysis
SWiM	Synthesis Without Meta-analysis
GRADE	The Grading of Recommendations Assessment, Development, and Evaluation
ICDSC	Intensive Care Delirium Screening Checklist
I-CVI	Item-Level Content Validity Index
S-CVI/Ave	Scale-Level Content Validity Index
vs.	Versus
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
SUS	System Usability Scale
ICM	Integrated Care Management

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1. Introduction

Patients admitted to the intensive care unit (ICU) with critical conditions frequently experience prolonged periods of immobilization (1–4) resulting in considerable demands on healthcare resources (2,3,5) including the need for early physiotherapy intervention (6–9). When the demand for physiotherapy exceeds the available staffing capacity, the interdisciplinary ICU team often face ethical dilemmas while being held accountable for rationing resources and prioritizing patients for treatment (10–13).

Current physiotherapy prioritization practices, including those in the Department of Intensive Care or "Klinik für Intensivmedizin" (KIM) at the University Medical Center Hamburg-Eppendorf (UKE), Germany, are predominantly based on clinical judgement, which may be subjective and variable, rather than being informed by objective, evidence-based measures (14,15). The availability and use of standardized, objective guidelines or algorithms to support prioritization of patients in the ICU for physiotherapy intervention remain largely underexplored.

1.1 Background and context

Critical care medicine has undergone significant advances over the last two decades, evolving from general treatment approaches to more targeted, patient-centred strategies focused on improving patient outcomes, with the aim of reducing mortality (16,17). Advances in modern intensive care units (ICUs) include, among others, innovations in mechanical ventilation, improved sepsis management, AI (artificial intelligence) -driven predictive analytics, the use of extracorporeal membrane oxygenation (ECMO), and early mobilization strategies (18–22). Improved survival, together with an aging population, has contributed to an increasing number of adult patients requiring intensive care, many of whom experience prolonged ICU stays (23,24). Angus et al. (2000) predicted that this trend would continue to increase in the years to come (25).

Although only a small proportion of total ICU admissions require prolonged stays, these patients occupy approximately 25–45% of available ICU beds (1–3), placing significant demands on healthcare resources (2,3,5), including the provision of early physiotherapy intervention (6–9). Patients with prolonged ICU stays also experience substantially higher in-ICU and in-hospital mortality (26,27), as well as higher one-year mortality rates. For patients who remain in the ICU for 21 or more days, one-year mortality has been reported to be as high as 57.8% (28). In addition, long periods of bed rest and immobilization is associated with short-term complications such as polyneuropathy and/or myopathy known as ICU acquired weakness (ICUAW), delirium, and prolonged duration of mechanical ventilation. These short-term complications in turn significantly affect long-term outcomes, which includes cognitive decline, impaired mobility and reduced quality of life for months or years after discharge from the ICU (29,30).

The role of early physiotherapy intervention, including early mobilization, in adult patients admitted to the ICU is increasingly being recognized as an important component of interdisciplinary ICU care, as it is associated with improved clinical outcomes (8,31–38). This is supported by the findings of Garzon-Serrano et al. (39), who reported that physiotherapists achieved higher levels of patient mobilization in the ICU compared with registered nurses. Studies have also indicated that physiotherapy interventions focusing on early progressive mobilization in mechanically ventilated adult ICU patients are associated with statistically significant and clinically beneficial outcomes, including reduced ICU and hospital lengths of stay (8,40) thereby also reducing healthcare costs (33). Such early interventions may also contribute to a reduction in ICUAW (33,38), the duration and incidence of delirium (41,42), and ultimately a decrease in mortality rates (21,38).

Despite its multiple benefits (43–45), the implementation of early mobilization practices in routine ICU care remains less than ideal, often due to structural constraints such as suboptimal staff-to-patient ratios, among several other factors (46,47). Physiotherapy staffing constraints limit the provision of appropriate interventions to all eligible patients, consequently requiring patients to be prioritized for physiotherapy. Clinical decision-making regarding the identification of ICU patients most likely to derive greater benefit from physiotherapy intervention than

others is often based solely on variable clinical judgement, which may directly affect the quality of patient care (14,15). To reduce bias, improve objectivity, and minimize variability, the use of standardized assessments in healthcare is increasingly recommended to support, rather than replace, clinical expertise and judgement (48–50). Authors, including Stiller, recommend that, in situations of staffing constraints, patient prioritization should be based on objective criteria and the demonstrated benefits of early progressive mobilization (8,51–54). For example, patients recovering from surgery and awaiting discharge, those with delirium (42), acute stroke, pneumonia, and those at risk of deterioration without intensive physiotherapy intervention may warrant higher priority. Likewise, patients with a good prognosis who require assistance to improve functional mobility and reduce ICU length of stay, should be given higher priority. Conversely, patients experiencing hemodynamic, respiratory, neurological, or cognitive instability may not be suitable candidates for early mobilization and physiotherapy treatment. Thus, the prioritization of patients for physiotherapy should ideally be patient-centred and based on safety and eligibility, the likelihood of benefit, and evidence of need determined using objective criteria (16,17,48–50,55,56).

Considering the above recommendations, the challenge lies in determining which patients have the greatest need for, or are most likely to benefit from, physiotherapy intervention. Furthermore, if the number of patients deemed high priority for physiotherapy exceeds the available treatment time, how can clinicians justify a ranked order of priority that is fair to all patients? This challenge faces many ICU clinicians, including staff in the KIM, particularly on weekends and public holidays, when the physiotherapy treatment time available to cover 114 beds across 10 ICUs is considerably less than that available on weekdays. Similar constraints also occur during the week when staffing shortages limit the availability of physiotherapy services.

At present, the prioritization and selection of patients for physiotherapy intervention in the KIM is done by the physician on duty, which is often based on variable clinical judgement, rather than assisted by standardized, evidence-based criteria. In Germany, under Section 28(1) Sentence 2 of the German Social Code, Book V (§ 28

SGB V), licensed physicians are assigned the responsibility for clinical decision-making in patient care, which involves prescribing and delegating appropriate treatment interventions. This inevitably includes selecting and prioritizing ICU patients who are eligible for physiotherapy. Although allied health professionals, such as physiotherapists and nurses, rely on medical referrals, they do play a vital role by contributing valuable insights to interdisciplinary decision-making and patient care (55–57). Several validated tools are used in the ICU to guide clinical decision-making and can indirectly support the prioritization of physiotherapy interventions, particularly in the context of early mobilization. However, evidence in the literature suggest that no standardized assessment scales exist specifically for prioritizing patients in the ICU for physiotherapy interventions (8,14,58).

Several triaging physiotherapy algorithms in non-ICU settings is described in the literature (59–63). These integrate objective patient variables and have been reported to provide a standardized, evidence-based approach to patient selection, assist in ethical decision-making, and facilitate the fair allocation of limited resources (59,60,63). These scoring algorithms are considered as a tool to manage ICU strain, promote unbiased decision-making, and improve patient outcomes. While some algorithms may identify adult ICU patients who benefit most from early physiotherapy and mobilization (31,64–67), and others aid in treatment progression, a notable gap remains: they lack an objective, systematic method for ranking ICU patients according to their priority for physiotherapy.

Therefore, there is a need for an objective algorithm that integrates relevant, established ICU parameters e.g., Richmond Agitation-Sedation Scale (RASS), delirium scores, and ICU Mobility Scale (IMS), to support prioritization and enhance consistency and transparency in clinical decision-making (8,14,68–71). Such an approach may reduce bias and subjective variability, promoting more transparent and patient-centred decisions.

The aim of this PhD thesis was to systematically develop and pilot-evaluate an algorithm designed to prioritize adult ICU patients for physiotherapy intervention.

1.2 Research questions and objectives

To achieve the research aims mentioned in Section 1.1, the following research questions need to be addressed:

1. What is the current evidence in the literature regarding established, validated scoring systems or algorithms used in the ICU to prioritize adult patients for physiotherapy treatment?

2. From the perspective of ICU staff, what are the key components of a scoring algorithm to prioritize patients for physiotherapy treatment?

3. Can an evidence-informed ICU physiotherapy prioritization algorithm be developed to support the prioritization of adult ICU patients eligible for physiotherapy intervention?

4. Is it feasible to use a standardized scoring algorithm to prioritize adult ICU patients for physiotherapy treatment in a ranked order, and what is the level of agreement between algorithm-based and clinical judgement-based approaches to patient prioritization?

To answer each of the above research questions, the research objectives of this thesis were as follows:

1. To conduct a systematic literature review to identify and evaluate existing, validated scoring systems or algorithms used to prioritize adult ICU patients for physiotherapy treatment.

2. To conduct face-to-face, semi-structured interviews with ICU staff to explore perceptions and experiences related to the selection and prioritization of patients eligible for physiotherapy treatment.

3. To develop a clinical scoring algorithm to prioritize adult ICU patients for physiotherapy treatment in a ranked order, based on the findings of the systematic literature review, data obtained from the semi-structured interviews, and expert opinion.

4. To conduct a pilot feasibility study to assess the feasibility, usability, and acceptability of the scoring algorithm within the ICU workflow integration. The internal validation and reliability of the scoring algorithm will also be assessed.

1.2 Thesis outline

This doctoral thesis is structured as follows: Chapter 2 presents a systematic literature review conducted by the me to identify existing ICU physiotherapy prioritization tools and gaps in the current evidence base, ensuring that the research addresses genuine gaps in the literature and avoids redundancy. It provides the foundation and methodological framework to support and justify the subsequent qualitative and experimental mixed-methods research presented in Chapters 3, 4, and 5.

Chapter 3 presents the methodology and results of the qualitative interview study. Chapter 4 outlines the iterative development process of the ICU Physiotherapy Prioritization Algorithm (IPPA) and its corresponding results. Chapter 5 presents the pilot study evaluating the feasibility and reliability of the IPPA, including its findings. Chapter 6 provides an overall discussion of the results including strengths, limitations, and future directions, whilst Chapter 7 outlines overall conclusions.

2. Systematic Literature Review

Current evidence on scoring systems or algorithms used to prioritize adult patients in the ICU for physiotherapy

2.1 Introduction and rationale

In Chapter 1, I addressed the role of early physiotherapy intervention in adult ICU patients to improve outcomes, and the how the demand thereof, which continues to increase, often exceeds the available physiotherapy staffing resources (5,8). I discussed the ethical dilemma facing ICU staff when making patient prioritization decisions (10) and the increasing expectation that clinical decision-making be supported by standardized, objective criteria to ensure a patient-centred approach to the management of critically ill patients (48–50).

Having worked as a physiotherapist in the KIM during the COVID-19 pandemic and personally experiencing these ethical dilemmas and staffing shortages, brought this problem into sharp focus. It became evident that the current prioritization of adult ICU patients for physiotherapy remains the responsibility of the physician on call and is based on variable clinical judgement rather than standardized, evidence-based criteria. This prompted an interest in exploring the patient prioritization approaches adopted in other ICUs, both nationally and internationally.

In view of the above, it became apparent that a review of the existing literature would be beneficial to identify the strategies and approaches available for prioritizing patients for physiotherapy. Accordingly, a systematic literature review was conducted to address the first research question, which aimed to critically evaluate the existing evidence on validated scoring systems or algorithms used to prioritize adult ICU patients for physiotherapy treatment. The aim was to identify gaps in the literature, areas for improvement, and recommendations for future research.

2.2 Methods

2.2.1 Study registration

This review protocol was registered in PROSPERO (CRD42022342415), the International Prospective Register of Systematic Reviews (see Appendix 1), at https://www.crd.york.ac.uk/PROSPERO/ (72). This systematic review was conducted following The Cochrane Handbook and The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (73) and complies with the PRISMA checklist (Appendix 2).

2.2.2 Eligibility criteria

1) Study types: There were no restrictions on study types or designs. Published literature, unpublished studies not reported in peer-reviewed journals, and other sources of grey literature, for example, trial registries, were all included in the review.
2) Population: This was defined as human studies involving adult ICU patients (age ≥18 years).
3) Intervention/ Outcome: This included studies describing scoring systems or algorithms used to prioritize adult ICU patients for physiotherapy treatment, both in ICU and non-ICU clinical settings.

2.2.3 Search strategy and screening

In this systematic review, I was the primary reviewer responsible for selecting the databases, defining the inclusion and exclusion criteria, conducting the electronic database searches, and performing the primary screening, while the external reviewers (ML or JB) independently validated the records to assist in resolving any discrepancies. I searched PubMed, Cochrane Library, PEDro, CINAHL, Google Scholar, BASE, British Library, ClinicalTrials.gov, EU Clinical Trials Register, and Australian Clinical Trials from their inception up to 31 March 2026. Search terms were

appropriately adapted across all databases to ensure maximal inclusion of literature sources (see Appendix 3). The initial 200 results from Google Scholar were screened to supplement the findings from electronic library databases.

To enhance the comprehensiveness of the search strategy, I conducted six distinct searches in PubMed applying diverse keyword combinations. This iterative process aimed to refine the search strategy and capture the widest possible scope of eligible studies. No language or time restrictions were imposed during the search process, thus facilitating the identification of diverse sources of evidence. Reference lists of included studies were manually screened, and the "related articles" feature was used to identify additional relevant studies.

Additionally, the search was expanded to include supplementary sources and personal contacts to identify studies that might not be indexed in the preceding databases. These supplementary sources included the National Institute for Health and Clinical Excellence (NICE) and the Google search engine. In instances where data were unpublished, direct communication with authors was initiated to ensure clarity and obtain additional information – one of the authors were contacted successfully to retrieve further information. This thorough search strategy efforts served to maximize the retrieval of relevant literature, including both published and unpublished studies. The full search strategy for each database is provided in Appendix 3.

Articles underwent a rigorous two-stage screening process conducted by me and ML and JB as the two external reviewers. Following the removal of duplicates, the titles and abstracts were screened to identify potentially relevant articles according to the predefined eligibility criteria. Subsequently, the full-text publications of potentially relevant articles were retrieved and assessed for eligibility by the independent reviewers. Any discrepancies between the reviewers were resolved through discussion until a consensus was reached.

2.2.4 Data extraction and synthesis

The data extracted from the included literature were captured by me and an independent reviewer (JB) using a pre-constructed spreadsheet in Microsoft Word 365, Version 2408, and included the following: source (author, year), study location, language, study design, population, sample size, age, intervention, results. In the event of a discrepancy between the two reviewers, a discussion followed until a consensus was reached.

The scarcity of available evidence and insufficient reporting of data within the included records precluded a meta-analysis. Instead, a narrative synthesis of the extracted data was conducted, adhering to the SWiM (Synthesis Without Meta-analysis) reporting items, to evaluate the efficacy of a scoring system in ranking ICU patients according to their priority for physiotherapy treatment (74). Reported results were documented as raw scores and corresponding percentages. The certainty of evidence for the priority outcome was determined using a modified Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach (75).

2.2.5 Quality assessment

Two external, independent reviewers (MH and TD), who both spoke German as a first language, assessed the methodological quality of the included literature. They used a modified version of the McMaster Critical Review Form for Quantitative Studies (76), which evaluated eight core items to derive a total raw score and a percentage score. In cases of discrepancies between the assessments, a third independent external reviewer (JB) was consulted to reach a consensus through discussion.

2.3 Results

2.3.1 Study selection

Details of the literature search results, study selection process, and the reasons for exclusion, are outlined in the PRISMA flow diagram, Figure 1 (73). The literature search identified a total of 2,777 records, 2,715 sourced from electronic databases and registers, 50 from other sources, and 12 additional records through bibliographic manual searching. After removing 122 duplicates, the remaining 2,655 records were screened by title and abstract. Subsequently, 2,501 irrelevant records were excluded, leaving 154 potentially eligible records for full-text review. Upon full-text review, 152 records were excluded for the following reasons: 40 were deemed inappropriate prediction tools or were conducted in non-ICU settings, and 112 studies lacked scoring systems. Ultimately, two records met the eligibility criteria and were included in this review, one unpublished symposium abstract (77) and one observational study (78).

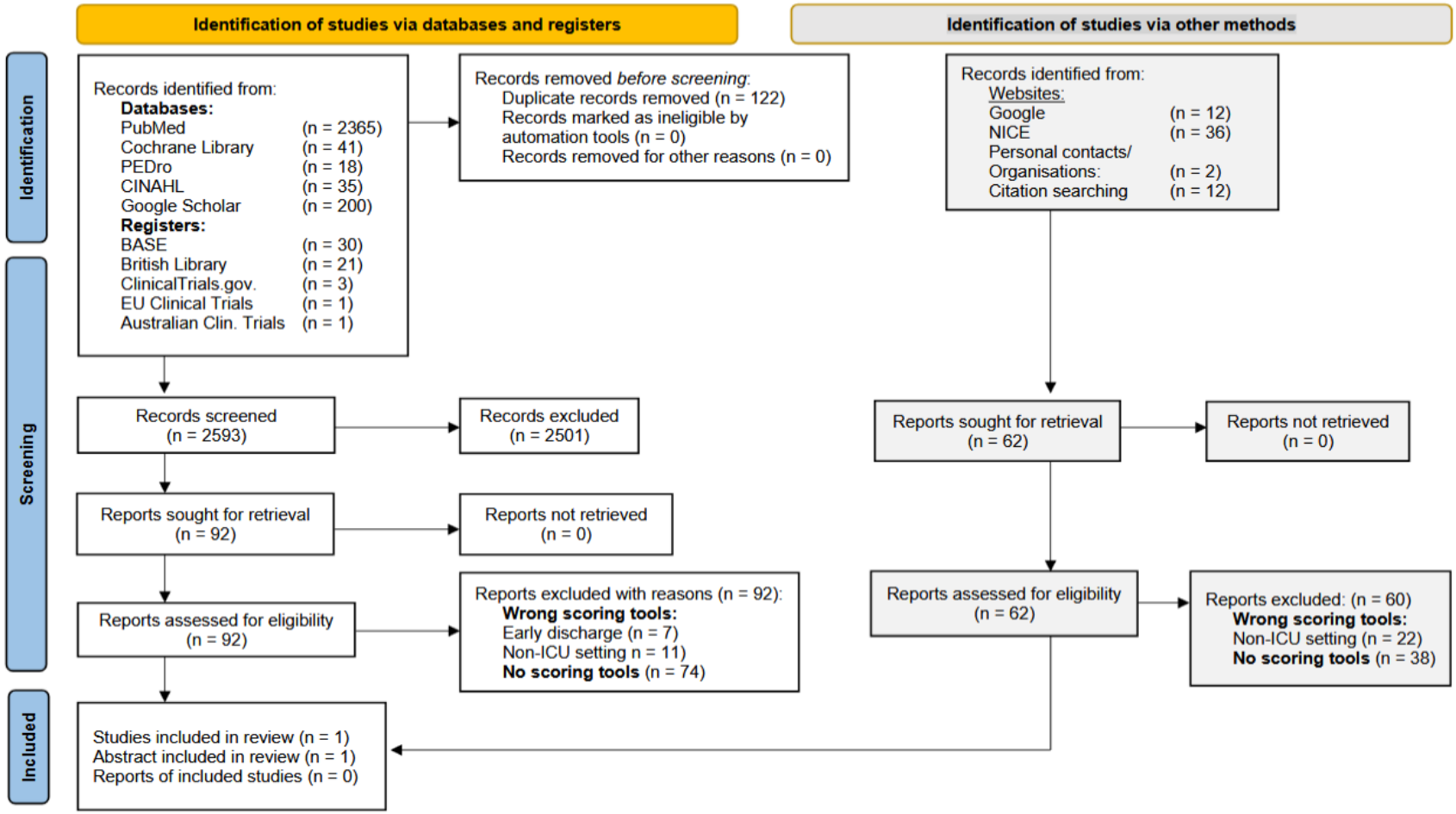


Figure 1. PRISMA flow diagram (Page et al., 2021) of study selection process.

2.3.2 Study characteristics

The study details and participant characteristics are outlined in Table 1. The abstract (77) and the observational study (78) included in the review were published in 2012 and 2015, respectively. These studies provided data from 424 patients across diverse adult ICU wards, including Neurology, Surgical, Internal Medicine, Cardiology, and Cardiac Surgery. The records were reported in German, with the observational study featuring an English abstract.

Scoring algorithm – Symposium abstract, Fründ et al (2012)

This scoring algorithm was developed by a team of physiotherapists at a University Hospital in Bad Oeynhausen, Germany, based on their Quality Management treatment objectives (Appendix 4). Their aim was to establish a more objective method for prioritizing patients in the cardiac and cardiosurgical ICU for weekend physiotherapy treatment. The algorithm underwent testing on 160 patients, followed by adjustments before full implementation. Comprising of two independent sub-scores, the algorithm allows for a maximum total of 14 points. The first sub-score evaluates four vital parameters (secretion, oxygenation, ventilation, and inflammatory pulmonary disease), each assigned a score ranging from 0 (best) to 2 (worst), collectively contributing 8 points to the total. The second sub-score evaluates patient mobility, either with or without therapeutic assistance, with scores ranging from 0 (best) to 5 (worst). An additional point may be added for acute neurological episodes or good adherence and treatment progression. Higher scores reflect poorer vital and mobility statuses, signifying a greater need for physiotherapy intervention. They report the successful implementation of this scoring algorithm which has led reduced controversies and conflicts in patient prioritization. However, no further published work on this algorithm was identified, nor could any relevant information regarding the methodology used to develop the algorithm be obtained from the first author following direct contact.

Observational study, Ketels (2015)

The observational study presents findings from a pilot trial assessing the feasibility and transferability of Fründ's scoring algorithm across four different ICU wards: neurology, surgical, internal medicine, and cardiology/ cardiac surgery. This algorithm was evaluated by trained physiotherapists among a cohort of 264 patients over 11 days (see Table 1). They observed similar scores in vital signs and mobility parameters across patients in internal medicine, cardiology, and cardiac surgical ICUs, enabling the order of prioritization for physiotherapy intervention. Patient scoring and selection for weekend physiotherapy treatment were conducted anonymously alongside the existing clinical judgement-based selection process performed by the treating physician. However, this was purely an observational study, and no comparison with the reference standard prioritization was undertaken. A statistically significant difference in scores was observed among patients in the neurological ICU compared to those in internal medicine, cardiology, and cardiac surgical ICUs. The study did not report on the transferability of the algorithm to the surgical ICU setting.

Table 1. Study Characteristics (Systematic literature review)

Source (author, year)	Study location	Language	Study design	Population (*Adult ICU wards)				Sample size	Age	Intervention	Outcome(s)
				A	B	C	D				
Fründ et al (77), 2012	Bad Oeynhausen, Germany	German	Abstract	0	0	0	160	160	NS	Scoring Algorithm	Predicting order of priority for physiotherapy treatment over weekends, and reducing controversies and conflicts
Ketels & Freiwald (78), 2015	Hamburg, Germany	German, English abstract	Observational	66	66	66	66	264	NS	Scoring Algorithm (Fründ, 2012)	Feasibility and transferability of the scoring algorithm

**Adult ≥ 18 years, ICU* intensive care unit, *A* = Neurology, *B* = Surgical, *C* = Internal, *D* = Cardiology/ Cardiac surgery, *NS* not specified

2.3.3 Risk of bias and certainty of evidence

The results of the methodological quality assessment based on the modified McMaster Critical Review Form for Quantitative Studies are detailed in Table 2 (76). To external reviewers (TD, MH) conducted independent assessments of the observational study and the abstract. Both studies report the efficacy of the scoring system in prioritizing adult patients within internal, cardiology, and cardiac surgical ICUs (77,78), but results yielded inconclusive statistical evidence. Both records were considered at high risk of bias in one or more of the core items, resulting in an overall rating of low quality. The observational study achieved a score of seven out of 15 (46.7%) for methodological rigor, while the abstract scored two out of 15 (13.3%).

The overall certainty of evidence by the GRADE criteria for the outcome of interest was of very low quality. The low level of evidence was further downgraded for both records due to the following limitations: 1) study design - observational study, 2) imprecision - sample size small and not justified, and 3) limited data - only one unpublished symposium abstract, and one observational study based on this unpublished abstract contributing to results (both non-peer-reviewed). The GRADE assessment is presented in Table 3 (75).

TABLE 2. Methodological quality results using modified McMaster Critical Review Form for Quantitative Studies

Core Items	Fründ et al, 2012 (77)	Ketels & Freiwald 2015 (78)
1. Was the purpose stated clearly?	Y	Y
2. Was relevant background literature reviewed?	N	Y
3. Was the study design appropriate?	NAD	Y
4a. Was the sample described in detail?	N	Y
4b. Was sample size justified?	N	N
5a. Were the outcome measures reliable?	NAD	N
5b. Were the outcome measures valid?	NAD	NAD
6a. Intervention was described in detail?	N	N
6b. Contamination was avoided?	NAD	Y
6c. Cointervention was avoided?	NAD	NAD
7a. Results were reported in terms of statistical significance?	N	Y
7b. Were the analysis method(s) appropriate?	NAD	Y
7c. Clinical importance was reported?	Y	NAD
7d. Dropouts were reported?	NAD	N
8. Conclusions were appropriate given study methods and results?	N	N
Total Raw Score	**2/15**	**7/15**
Percentage Score (%)	**13,3%**	**46,7%**

Y = yes = 1 score given, N = no = 0 score given, NAD = not addressed = 0 score given

Table 3. Certainty of evidence based on a modified GRADE Assessment.

Certainty Assessment							Certainty (GRADE)
No. of Studies	**Study Design**	**Risk of Bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other Considerations**	
Prioritization of physiotherapy treatment							
1	Abstract only[a]	serious[b]	not serious	not serious	serious[c]	only an abstract available[d]	⨁◯◯◯ Very low
Transferability of the scoring algorithm							
1	Observational[e]	serious[b]	not serious	not serious	serious[c]	only one study contributed to results[f]	⨁◯◯◯ Very low

Explanations

a. Downgraded one point: abstract only.
b. Downgraded one point: overall poor quality.
c. Downgraded one point: the sample size was not justified.
d. Downgraded one point: only an abstract is available; no external validation of results.
e. Downgraded one point: an observational study.
f. Downgraded one point: only one study contributed to the results.

2.4 Discussion

To the best of my knowledge, this systematic literature review represents the first to evaluate the existing evidence on scoring systems or algorithms used to prioritize adult ICU patients for physiotherapy intervention. The review identified a very limited evidence base, consisting of two eligible grey literature records: one symposium abstract and one non-peer-reviewed observational study, both providing very low-quality evidence. Both records reported the use of the same scoring algorithm (77,78), which was developed by Fründ et al. to identify cardiac and cardiosurgical patients eligible for physiotherapy treatment over the weekend.

Amidst the rising recognition that clinical decision-making in the ICU should best integrate evidence-based guidelines with clinical judgment (14,55,56), the use of scoring algorithms shows potential to support clinical decision-making, improve outcomes, reduce subjective variability, and avoid controversies regarding rationing and resource reallocation, as described in an editorial by Dambha-Miller (63). However, both literature sources exhibited fundamental methodological limitations and provided no evidence to support the use of this scoring algorithm for prioritizing adult ICU patients for physiotherapy. The unpublished abstract, in fact, lacked methodology, i.e., transparency in how the clinical need to develop the algorithm was established, how objective variables were identified, and the justification for its items and weighting. The limited evidence available precluded a meta-analysis; therefore, the data obtained from the two included records were synthesized using alternative methods to report the outcomes (79). Both records included in the review had small sample sizes which lacked justification, absence of clearly defined outcomes or conclusions, and did not establish the variability in the need for physiotherapy treatment across different ICU cohorts, as specified by many authors (6–9).

Furthermore, the limited scope of the ICU population in which this scoring algorithm was developed and tested restricts its generalizability and predictive capacity across other ICU cohorts. Ketels & Freiwald (2015) noted that the scoring algorithm could not be transferred to assess the priority for physiotherapy treatment for neurological patients and attributed this limitation to the heavy weighting of vital parameter items

and the absence of neurological parameters such as cognition, balance, and coordination.

Strengths of this review included the rigorous methods I adopted, including a comprehensive search strategy without language and time restrictions to identify the best evidence available and avoid selection and publication bias. I broadened the scope of my search to include a wider range of healthcare settings and professionals to gather a comprehensive understanding of patient prioritization practices. Prioritization tools, scoring assessments, and strategies employed by physiotherapists in non-ICU contexts (59–62) were included in the Google search engine, and provided valuable insights into alternative strategies for prioritization.

In addition, two external independent reviewers (MH and TD) who spoke German as a first language, were recruited to reduce the risk of bias in the reporting of study quality and to reduce interpretation bias since both records were written in German.

This review also has certain limitations. The main limitation is the considerable lack of eligible studies identified, despite the extensive search strategy. Furthermore, the two records eligible for inclusion are not peer-reviewed, one is an observational pilot investigation lacking interventional evidence, and the other is an abstract lacking transparency.

This systematic literature review reveals a significant gap in the literature regarding the availability and use of standardized and validated scoring systems for ranking adult ICU patients according to their priority for physiotherapy treatment. There is very limited evidence on the use of standardized assessments to assist clinical judgment in the prioritization of patients in the ICU for physiotherapy treatment, despite being highly advised (48–50).

The single scoring algorithm developed by Fründ et al. (2012) is flawed with major methodological limitations, particularly in its lack of transparency in its development and internal validation (77) The importance of tool validation before its implementation has been highlighted in literature, thus the very low certainty of evidence in addition to the lack of external validation of Fründ`s scoring algorithm

limits the clinical applicability and implementation of this algorithm in the ICU workflow (80).

Findings of this review informed the next phase of my research program, which aimed to address my second research question related to the current prioritization strategies employed in the KIM at the UKE. This motivated the conduction of face-to-face interviews of ICU staff to gather their perceptions and experiences regarding patient prioritization for physiotherapy, and to see if any objective variables could be identified which is used in the clinical decision-making and prioritization.

2.5 Research gaps and justification for subsequent research

Based on the evidence gaps identified in Section 2.3.3 (Risk of Bias and Certainty of Evidence) of the systematic literature review, which revealed a very limited evidence base consisting of two grey literature sources, both with very low-certainty evidence, the subsequent phases of this research were guided accordingly.

The research framework of this doctoral thesis was informed by the ongoing ethical challenge of prioritizing ICU patients for physiotherapy in the KIM at UKE, the variability in clinical judgment, and the limited existing evidence regarding the availability of a universal, validated scale for this purpose. A clinical need was identified to develop an evidence-based prioritization algorithm to assist ICU staff in decision-making, thus justifying the qualitative interview study presented in Chapter 3, as well as the development and pilot evaluation of a scoring algorithm for prioritizing adult ICU patients for physiotherapy intervention presented in Chapters 4 and 5, respectively.

3. Qualitative Interview Study

3.1 Chapter outline

In this chapter the aim is to gain insight into the clinical decision-making processes and experiences, from the perspectives of staff in the ICU, related to the allocation and prioritization of physiotherapy care during situations of staff capacity constraints in adult ICU populations. To achieve this, I conducted a qualitative interview study with staff members in the ICU as described in Section 3.2. In Section 3.3 the results are presented. Finally, I also explore whether the interview data could inform the development of an evidence-based algorithm for prioritization of patients in the ICU eligible for physiotherapy intervention.

3.2 Methods

3.2.1 Ethical considerations

Permission to conduct the study was obtained from the UKE "Personalrat für das wissenschaftliche Personal" (WPR) and the "Personalrat für das nichtwissenschaftliche Personal (NPR) (Appendix 5). The study was approved by the "Ethikkommission des Deutschen Verbandes für Physiotherapie an der Physio-Akademie" (Ethikkommissionsvorlagennummer: 2023-08).

All participants were provided with written and verbal information about the interview study. They were also informed that participation was voluntary, without renumeration, and could be withdrawn at any stage prior to, or during the interview, without providing a reason and without consequence. This information was reiterated to all participants before commencing each interview, providing them with an opportunity to withdraw from the study if they so wished.

Interviews were only commenced after written informed consent was obtained from all interview participants. Interviewees were informed that they could request a copy

of their interview transcripts at any time and that the study results would be made available once results had been analyzed and published. The anonymity and confidentiality of all interview participants were ensured throughout the study, and no personal information relating to the participants is disclosed in this thesis. Audio recordings were deleted after the interviews were transcribed and anonymized, for privacy purposes. The signed consent forms are stored securely in the KIM.

3.2.2 Study design, participants and setting

This single-center qualitative study was conducted using interviews based on a semi-structured interview guide. This study is reported in line with the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist (Appendix 6) (81).

The interviews were conducted with staff members working in the KIM at the UKE, Hamburg, Germany. The KIM has 10 ICUs with a total of 114 beds and an interdisciplinary team comprising physicians, nurses, physiotherapists, respiratory therapists, occupational therapists, speech and language therapists, dietitians, and psychologists.

Purposeful sampling was used to select participants with relevant insights or experiences related to the selection and prioritization of adult patients in the ICU eligible for physiotherapy intervention. ICU clinicians from three different professions (i.e., physicians, nurses, and physiotherapists) with more than six months of ICU work experience were recruited across the 10 different wards representing various ICU specialties (e.g., medical, surgical, neurology, neurosurgery, cardiology, cardiothoracic surgery, and cardiovascular surgery). Potential participants were recruited via a notice placed on the bulletin boards of all ICUs, in which I introduced myself as the interviewer and provided information about the interviews (see Appendix 7). The ICU director, the head of nursing, and the head of physiotherapy were informed and approved the recruitment of interview participants. Sample size was determined by data saturation, which was defined as the point at which no new codes were generated in two consecutive interviews. After data saturation was reached, no further interviews were undertaken.

3.2.3 Data collection

Data were collected through face-to-face, semi-structured interviews conducted by me between May and September 2024. I developed an interview guide with semi-structured, open-ended questions in German (Appendix 8) and English (Appendix 9). The German version was verified for translation accuracy by an external native German speaker (AG). In addition to the open-ended questions, information on the participants' profession, as well as the duration and type of their ICU specialty work experience, was collected.

Three pilot interviews were conducted with a physiotherapist, a nurse, and a physician, respectively. During two of the pilot interviews, an observer (AG), with extensive experience in qualitative research, was present to provide feedback and insights regarding the interview technique and the content of the semi-structured interview guide. Following the pilot interviews, minimal adaptations were made to the interview guide. These included revising the wording of Question 3 by removing “Medical, Nursing, or Physiotherapy” to make it more concise, and adding a question about the possible features of a scoring tool.

The pilot interviews were included in the analysis because they did not vary too much from the rest of the interviews. The interviews lasted between 15 and 30 minutes and were conducted in a private room without interruptions, with only the interview participant and me present. Following the pilot interviews, a further 15 interviews were conducted. All interviews were conducted in German language, audio recorded and transcribed verbatim using the f4x transcription software. Audio recordings were deleted after all interview transcripts were finalized to protect participant privacy and reduce data leaks.

3.2.4 Data analysis and rigor

Participant characteristics were documented as absolute and corresponding relative frequencies (i.e., percentages). I checked all transcribed interviews against the audio recordings for accuracy and made corrections where necessary. I began familiarizing

myself with the data by reading and re-reading the transcripts while recording notes and initial thoughts related to coding and theme development. I conducted a reflexive thematic analysis based on Braun and Clarke´s approach (82–85). Inductive, line-by-line coding of the transcribed interview data was done manually in Microsoft Word 365, Version 2408. Each transcribed interview document was divided into two columns, with the raw transcribed interview data presented in the left column and the corresponding codes documented in the right column. The transcript text in the left column and its corresponding codes in the right column were highlighted using matching colors to facilitate the identification of coded segments. Initially, four interview transcripts were manually coded, and all codes were copied and pasted into a separate word document to cluster the codes and for purposes of comparison. This was done to start organizing the codes and to ensure that the code names allocated were consistent within each transcript, as well as across the four transcripts. Similar codes derived from the interview transcripts were merged, whereas broader codes were reorganized into more specific codes.

After this, a thematic framework was developed by grouping codes together in broader themes. Potential themes were defined, and the codes were assigned to the newly defined corresponding themes. Cleaning up the codes was done by counting the number of times a given code appeared under each theme in the data, writing the number in brackets next to the code. Codes appearing more frequent were listed under the corresponding themes at the top, those less frequent were listed further down. In this way, an initial framework of codes or codebook was derived.

This codebook was used to document my interpretations and serve as an audit trail, rather than to assess intercoder reliability. The coded segments and potential themes were compared throughout the analysis of remaining interview transcripts to ensure that the groupings remained relevant. Initial codes and potential themes were adapted and refined through an iterative process involving critical reflection and discussion of interpretations with two external researchers (AG, JB), consistent with reflexive thematic analysis (82,85,86). Subsequently, the codes were revised accordingly within the original interview transcripts, and the Microsoft Word

Comments feature ("Review, New Comment") was used to add themes and subthemes directly related to specific highlighted data extracts and their corresponding codes. In this way, relevant quotes associated with specific codes and their corresponding themes could be easily traced within the Word document. Unused codes were deleted.

I coded all transcripts and a second, external coder (JB) independently coded and reviewed the themes of n = 5 (27.7%) randomly selected transcripts. Double coding was undertaken to enhance trustworthiness, facilitate critical reflection in the reflexive thematic analysis, and support the audit trail, rather than to establish intercoder reliability (82,85,86). As a native English speaker with a high level of proficiency in German, I translated the verbatim quotes from the transcribed interview data presented in Results Section 3.2 from German into English. These semantic translations were verified for accuracy by an external bilingual German-English speaker (HB). The original German verbatim quotes are presented alongside their English translations.

3.2 Results

3.3.1 Participant demographics

In total, 18 ICU staff members, comprising 7 physiotherapists, 6 nurses, and 5 physicians, participated in the semi-structured interviews. Thematic saturation was reached after n = 18 interviews. Most of the interview participants had between 1-5 years of ICU work experience, across various ICU disciplines. Participant demographics are presented in Table 4.

Table 4: Participant demographics (Interview study)

Characteristic	Total n = 18 n *(%)*
Gender	
Male	13 *(72,2)*
Female	5 *(27,8)*
Profession	
Physiotherapist	7 *(38,9)*
Nurse	6 *(33,3)*
Physician	5 *(27,8)*
ICU work experience (years)	
1-5	13 *(72,2)*
6-10	1 *(5,6)*
11-15	1 *(5,6)*
16-20	1 *(5,6)*
>20	2 *(11,1)*
ICU specialties	
Medical	9 *(50)*
Surgical	9 *(50)*
Neurology/ Neurological	3 *(16,7)*
Cardiology	4 *(22,2)*
Cardiosurgical	7 *(38,9)*
Cardiovascular surgery	1 *(5,6)*

3.3.2 Themes and subthemes

Four themes and twelve subthemes were generated from the qualitative data analysis. The themes included:

1) Current decision-making practices
2) Current prioritization criteria
3) Scoring algorithm
4) Suggestions for patient prioritization

Tables 5, 6, 7 and 8 outline the four themes and its corresponding subthemes with verbatim quotes. The code in the bracket appearing after the quote refers to the relevant interview participant.

Theme 1: Current decision-making practices

This theme describes how the ICU organizational processes and workflow, including the barriers encountered, influences resource allocation and prioritization of adult patients in the ICU eligible for physiotherapy intervention. This theme is divided into three subthemes and is presented in Table 5.

Subtheme 1.1: Interdisciplinary collaboration

Here, ICU staff members (physicians, nurses, and physiotherapists) describe the shared responsibility in the decision-making process for selecting patients for physiotherapy treatment. They also report that interdisciplinary decision-making is not always feasible, particularly in situations of time constraints or where staff members are unfamiliar with the ICU ward or the patients. (Table 5, quotes 1-2).

Subtheme 1.2: Physician-centered

This subtheme refers to patient selection and prioritization decisions made exclusively by physicians, including the time taken to make these decisions. These decisions are primarily based on clinical judgment or intuition. It also highlights that

the weekly overview of patients' progress and handover from colleagues, nursing staff, or physiotherapists aid decision-making. (Table 5, quotes 3-5).

Subtheme 1.3: Organizational influences

This subtheme describes how institutional and departmental factors such as staffing capacity, resources, and limited ICU-specific physiotherapy expertise, impacts decision-making. (Table 5, quotes 6-7).

Theme 2: Current prioritization criteria

Theme 2 refers to the prioritization of critically ill patients for physiotherapy intervention based on the frameworks adopted in the ICU. These include the consideration of clinical or non-clinical criteria when determining priority, for e.g., vital signs, standardized assessments, and the appropriateness of care. This theme is divided into three subthemes and is presented in Table 6.

Subtheme 2.1: Explicit exclusion

This subtheme includes factors and situations that automatically rule out patients in the ICU for physiotherapy, as any intervention could be detrimental to the patient's health. For example, this includes patients with hemodynamic or respiratory instability, those in septic shock, or those with contraindications to mobilization. (Table 6, quote 8).

Subtheme 2.2: High priority

This subtheme describes the criteria that justify urgent physiotherapy intervention to avoid an adverse impact on the patient's health status or mortality. Patients in whom impending intubation needs to be prevented, or those with a pending extubation, are given high priority for physiotherapy intervention. Patients with delirium, excessive pulmonary secretions, and an ineffective cough are also considered urgent. Patients with ICUAW and reduced mobility who may deteriorate are also considered for urgent physiotherapy. (Table 6, quotes 9-11).

Subtheme 2.3: Low priority

Interview participants reported factors indicating limited benefit or independent patients as less urgent and, therefore, lower priority for physiotherapy. Heavily sedated patients or those with a poor prognosis were also considered less urgent. (Table 6, quotes 12-13).

Theme 3: Scoring Algorithm

This theme describes how ICU staff perceive the potential use and implementation of a scoring algorithm to prioritize patients. It considers views on its integration into the daily workflow, impact on workload, and its feasibility and validity as compared to clinical judgment. This theme is divided into two subthemes (see Table 7).

Subtheme 3.1: Desired features

This subtheme highlights the attributes interview participants considered essential in a prioritization tool intended to determine the priority of patients for physiotherapy in a ranked order. Considering the already high workloads and staffing constraints in the ICU, participants indicated that such a tool should be user-friendly, numeric, and not too time-consuming. Inclusion of established standardized scores and integration into existing electronic patient records was highlighted (Table 7, quotes 14-16).

Subtheme 3.2: Intended role

Participants gave their views on the purpose a prioritization tool is expected to serve in clinical decision-making and how such a tool can be implemented in an interdisciplinary setting. It was emphasized that such a tool should support, rather than replace, clinical judgment, but that it could be of great benefit to new registrars with less clinical experience starting their ICU rotation. It was also highlighted that, under German law, physicians hold the final responsibility for patient selection, even if a scoring tool is used in an interdisciplinary setting. (Table 7, quotes 17-18).

Theme 4: Suggestions for improving patient prioritization

This theme reflects the opinions and suggestions of ICU staff who are usually not involved in selecting patients for physiotherapy to optimize clinical decision-making in patient selection and prioritization. It is divided into four subthemes and is presented in Table 8.

Subtheme 4.1: Interdisciplinary decision-making

In this subtheme, interview participants present ideas to improve interdisciplinary, collaborative decision-making and patient prioritization. They suggest that prioritization be based on staffing levels or available resources and adjusted accordingly. For example, nursing staff could mobilize the "fitter" patients to free up physiotherapy resources for the more complex mobilization of ECMO patients. (Table 8, quotes 19-20).

Subtheme 4.2: Exclusion criteria

Participants highlighted that they would exclude unstable patients.
(Table 8, quote 21).

Subtheme 4.3: High priority criteria

Participants suggested similar criteria for high treatment priority as in Subtheme 5. (Table 8, quote 22).

Subtheme 4.4: Low priority criteria

Participants suggested similar criteria for low treatment priority as in Subtheme 6. (Table 8, quote 23).

Table 5. Theme 1, Subthemes 1.1 and 1.2 with verbatim quotes

(Q = quote; P = participant; T = translation)

Theme 1: Current decision-making practices ***Subthemes***	**Verbatim quotes**
1.1: Interdisciplinary collaboration	Q1. „Ich mache das inzwischen tatsächlich ganz gerne mit der Pflege zusammen, …; …das ist schon meistens so eine Teamentscheidung.“ (P3) T1. *(Decisions regarding patient prioritization are often made in collaboration with nursing staff and are interdisciplinary.)* Q2. „Meinst du, ob die Ärzte mich fragen? Wenn ich auf meiner Station bin, dann ja. Und wenn ich auf eine andere Station bin, dann eher nicht.“ (P13) T2. *(When I'm working on my own ward, the doctors involve me in the decision-making, but if I'm working in an ICU that is unfamiliar to me, then I'm not involved.)*
1.2: Physician-centered	Q3. „…das Bestimmen ja die Ärzte. Die erstellen im Nachtdienst eine Liste“ (P5) T3. *(…the doctors decide, they prepare a list during the nightshift)* Q4. „…das ist mehr so eine Gefühlsentscheidung. Tatsächlich.“ (P3) T4. *(…it´s more of a gut feeling actually)* Q5. „… aber ich kenne die Patienten genau. Wenn man die Patienten gut kennt, dann hat man so ein Gefühl dafür, was gerade der Fokus ist.“ (P17) T5. *(…if the patients are known to me, then I have an idea where the focus lies)*

Table 5 (continued). Theme 1, Subtheme 1.3 with verbatim quotes

(Q = quote; P = participant; T = translation)

Theme 1: Current decision-making practices ***Subthemes***	**Verbatim quotes**
1.3: Organizational influences	Q6. „…denn es kommt Kollegen, die dann auch nicht immer auf Intensiv arbeiten.“ (P16) T6. *(…there are often colleagues on duty who don´t usually work in the ICU)* Q7. „im Zweifel kann ja auch die Pflegekraft mit denen an die Bettkante und so, also ich glaube, das können die Pflegekräfte covern. Was die halt nicht covern können, ist jemanden an die Bettkante setzen, der eine schwere CIP/ CIM hat und irgendwie seine Arme nicht selbst bewegen kann. Da brauchen wir halt Physiotherapie.” (P17) T7. *(…if necessary, nursing staff can mobilize patients to sit over the edge of the bed, but difficult patients with CIP/ CIM are best treated by the physiotherapists)*

Table 6. Theme 2, Subthemes 2.1 and 2.2

(Q = quote; P = participant; T = translation)

Theme 2: Current prioritization criteria ***Subthemes***	**Verbatim quotes**
2.1: Explicit exclusion criteria	Q8. „…schwerer septischer Schock, wo die sehr instabil sind auf Bewegung und vielleicht auch ja Bewegung eher die in Gefahr bringt. Die würde ich dann eher ausschließen.“ (P17) T8. *(…I would exclude unstable patients with severe septic shock, where mobilization could be detrimental)*
2.2: High priority criteria	Q9. „…bei sehr deliranten Patienten, weil ich da so das Gefühl habe, das orientiert die und das hilft, den Tag über auch so ein bisschen mobil zu sein.“ (P3) T9. *(…patients with severe delirium might become more for orientated if mobilized)* Q10. „…Patienten, die frisch extubiert wurden oder um jemanden noch vor einer Intubation zu retten…“ (P8) T10. *(…recently extubated patients, or to avoid intubation)* Q11. „… akute pneumologische Erkrankungen, zum Beispiel hohe Sekretlast, die entweder ohne Therapie nicht mobilisiert oder trainiert werden kann…“ (P6) T11. *(…acute pulmonary conditions, with excessive secretions, difficult to expel without physiotherapy)*

Table 6 (continued). Theme 2, Subtheme 2.3 with verbatim quotes

(Q = quote; P = participant; T = translation)

Theme 2: Current prioritization criteria ***Subthemes***	**Verbatim quotes**
2.3: Low priority criteria	Q12. „Wenn da jetzt jemand tief sediert, ist, das glaube ich ist für die auch jemand, der eher nach hinten rückt. (P9) T12. *(…heavily sedated patients have low priority)* Q13. „…aber wenn jetzt jemand alt und multimorbide und im künstlichen Koma ist und ich davon ausgehen muss, dass es noch sehr lange dauert und dass er wahrscheinlich keine gute Prognose hat…“ (P16) T13. *(…patients with multimorbidities and poor prognosis have low priority)*

Table 7. Theme 3, Subtheme 3.1with verbatim quotes

(Q = quote; P = participant; T = translation)

Theme 3: Scoring Tool ***Subthemes***	**Verbatim quotes**
3.1: Desired features	Q14. „Es müsste sehr einfach sein.... wenn es zum Beispiel fünf Punkte gäbe, okay so eine fünf Punkte Liste," (P16) T14. *(...must be simple, numeric with list of points)* Q15. „... nicht so ein überdimensional großer zusätzlicher Arbeitsaufwand..., sondern dass man Assessments etabliert, die man dann zusammenfassen könnte, was wir jetzt schon haben zum Beispiel ist die Glasgow Coma Scale, RASS, die ICU Mobility Scale. (P6) T15. *(...should not be too time-consuming and should integrate assessments already available in the documentation)* Q16. „... in verschiedene Areale aufgeteilt ... Vigilanz.... und Kooperationsfähigkeit seitens der Patient:innen sollte sich wiederfinden lassen. Mobilität und motorische Potenziale... Atmung und die Komplikationsrate... Die Diagnosen... auch der nähere prognostische Verlauf." (P6) T16. *(...should include different domains, e.g., vigilance, cognition, mobility status, respiratory status, diagnosis, and prognosis)*

Table 7 (continued). Theme 3, Subthemes 3.2 with verbatim quotes

(Q = quote; P = participant; T = translation)

Theme 3: Scoring Tool ***Subthemes***	**Verbatim quotes**
3.2: Intended role	Q17. „… für junge Kolleg:innen , aber auch für mich eine gewisse Einschätzung. Damit können alle gut arbeiten, ...wenn man das noch in einer Übersicht sehen würde, das ist für alle Berufsgruppen glaube ich schon okay. (P7) T17. *(…for younger colleagues, and for the entire interdisciplinary team to have an overview, including me)* Q18. „… kann ich mir vorstellen, dass man die zu Hilfe nimmt und nutzt. In Absprache trotzdem wieder mit dem Team gemeinsam. Und dass man das auf jeden Fall für alle Beteiligten als deutliche Unterstützung mit dazunehmen kann.“ (P8) T18. *(…I can imagine using it, but in collaboration with the interdisciplinary team)*

Table 8. Theme 4, Subtheme 4.1 with verbatim quotes

(Q = quote; P = participant; T = translation)

Theme 4: Suggestions for improving patient prioritization ***Subthemes***	**Verbatim quotes**
4.1: Interdisciplinary, collaborative decision-making	Q19. „…man könnte uns mit einbeziehen. Was ich manchmal mache, ist gerade fürs Wochenende, dass ich am Freitag, wenn ich meine Übergabeliste mache, dass ich einmal auf die Übergabeliste schon mal schreibe, wer aus meiner Sicht wichtig ist. Also wir geben die Haupt Priorisierung und die Ärzt:innen können Einwände geben **(P9)** T19. *(…one could involve physiotherpay – we could prepare a list of patients we consider as priority for physiotherapy and doctors can raise objections)* Q20. „…die Rücksprache direkt mit den, ähm, mit den Pflegekräften, ja, und dann auch noch mit der Physio, dass wäre optimal.“ **(7)** T20. *(…collaboration and discussion directly with nursing and physiotherapy)*

Table 8 (continued). Theme 4, Subthemes 4.2 to 4.4 with verbatim quotes

(Q = quote; P = participant; T = translation)

Theme 4: Suggestions for improving patient prioritization ***Subthemes***	**Verbatim quotes**
4.2. Exclusion criteria	Q21. „Ich würde entscheiden, nach Krisensituation. Also die, die zu instabil sind, sind raus.“ (P7) T21. *(…I would base my decision to exclude on how unstable they are)*
4.3. High priority	Q22. „…frische Extubation in den letzten 24 Stunden… respiratorische Verschlechterungen.“ (P8) T22. *(…recent extubation in the last 24 hours or respiratory deterioration)*
4.4. Low priority	Q23. “… wenn jemand beatmet ist und ist, sediert, und ist respiratorisch total schlecht, dann habe ich aber das Gefühl, ich kann dort nicht so viel einwirken…“ (P2) T23. *(…I don´t thnk patients who are ventilated, sedated, and with poor respiratory status, have any benefit)*

3.4 Discussion

The aim of this interview study was to gather the perceptions and experiences of ICU staff regarding patient prioritization strategies. Feedback from interviews confirmed the need for a supportive clinical decision tool and several outcomes of interest were identified from the interview data, including neurocognitive, respiratory and mobility status. Many objective prioritization variables across these outcome domains were collected from the interview data, which informed the development framework of the ICU the prioritization algorithm. Participants reported that, should a prioritization tool be developed, it should be simple, user-friendly, and numeric, and should integrate standardized scores already available in electronic healthcare documentation. They also emphasized that such a tool should not replace clinical judgment. They highlighted that if a tool is too complex and time-consuming it risks not being accepted in the ICU workflow. Dambha-Miller et al. (2020) also emphasized the importance of user-friendly, clinically beneficial scoring algorithms to reduce uncertainty without imposing an excessive clinical burden (63).

The main findings were that current patient prioritization in the KIM is primarily based on clinical expertise and intuition of the physician on duty, without the support of evidence-informed objective criteria. This patient prioritization occasionally occurred through interdisciplinary collaboration; however, this was not standard practice. Several participants across all three disciplines expressed the need for interdisciplinary collaboration and decision-making between physicians, nurses and physiotherapists to facilitate patient-centred care. This aligns with the transition and advances in critical care medicine described in the narrative review by Padte et al. (2024), among others, which highlights the impact of interdisciplinary, patient-centred care on improving outcomes for patients in the ICU (16,55).

Participants felt that in a team collaboration, resources could be reallocated more effectively. For e.g., the nurses could mobilize “fitter” patients to free up physiotherapists for more complex ECMO mobilizations. Also, if physiotherapists who were not that confident working in the ICU had weekend duty, complex mobilizations could be replanned.

Of interest, although physicians reported that patient selection was intuition-based, it became apparent that certain objective criteria were subconsciously taken into consideration when making prioritization decisions. For example, cognition and sedation (RASS scores) were considered – patients heavily sedated and unable to interact and cooperate were considered low priority for physiotherapy. These considerations also align with clinical guidelines as reported by in the literature (35,43,51,87,88).

Interview participants also highlighted that patients with reduced mobility, poor respiratory function and delirium were given priority for physiotherapy treatment. Nydahl et al (2023), amongst others, also emphasize the improved outcomes with early mobilization in patients with delirium or reduced mobility (8,41,42,51,52).

In this study, interview participants were recruited through purposive sampling to ensure the inclusion of ICU staff with the experience and expertise to provide valuable insights into the prioritization of ICU patients for physiotherapy, in contrast to non-ICU staff, who would not be able to provide relevant feedback on ICU patient prioritization. This approach is recommended as it aligns well with identifying the target population (89,90). However, as many participants volunteered to take part in the study, there is potential for selection bias, as participation may have been influenced by a high level of motivation. In addition, as I was known to some participants, this may have influenced their responses.

4. Development of physiotherapy prioritization algorithm

4.1 Chapter outline

This chapter addresses my third research question and presents the systematic and iterative development of the ICU Physiotherapy Prioritization Algorithm (IPPA, Version 1.0), incorporating considerations of safety, expected benefit and need. These steps included item generation and reduction, algorithm design, item weighting and pre-pilot testing, followed by modifications to the prioritization algorithm. The IPPA is intended to serve as a clinical decision-support tool that assists and informs, rather than replaces, clinical judgment and expertise when prioritizing ICU patients eligible for physiotherapy intervention. Its intended purpose is not necessarily to speed up the prioritization process but to provide a more objective and standardized approach to patient selection and prioritization. The development process is described in Section 4.2, and the corresponding results are presented in Section 4.3. Pilot evaluation and post-pilot modification of the algorithm are presented in Chapter 5 of this thesis.

4.2 Algorithm development framework

The initial algorithm was developed in multiple steps using a modified two-round Delphi approach and was guided by the COnsensus-based Standards for the Selection of Health Measurement INstruments (COSMIN) recommendations for clinician-administered measurement instruments, specifically those relating to the content validity measurement property, including face validity (Appendix 10) (91). The algorithm was developed by integrating standardized parameters assessing neurocognitive, respiratory, and mobility status to identify ICU patients most likely to benefit from physiotherapy intervention, in a ranked order.

4.2.1 Phase 1: Item generation and reduction

The initial version of the algorithm was developed from an item pool generated from the findings of the systematic literature review presented in Chapter 2 and the data obtained from the semi-structured interviews described in Chapter 3. It was further informed by safety parameter checklists, evidence-based clinical guidelines for early mobilisation and critical care (14,35,43,92,93), ventilator weaning protocols, the Physiotherapy Standards of Practice (SOP 2.3.1) for priority definitions at UKE (Appendix 11), and standardised assessment tools, including the Richmond Agitation–Sedation Scale (RASS), the Intensive Care Delirium Screening Checklist (ICDSC), the Horovitz-Index, and the ICU Mobility Scale (IMS) (14,68–71). These validated assessments form part of the routine patient documentation currently integrated into the electronic health records of ICU patients at UKE.

4.2.2 Phase 2: Modified Delphi (two rounds)

Given pragmatic resource limitations and the intended use of the algorithm across all ICU wards at UKE, a small expert panel comprising medical, physiotherapy, and nursing staff was selected to establish the content validity of the algorithm. This purposive selection was considered appropriate because it was based on the participants' clinical experience and familiarity with the specialized ICU environment. This approach ensured that feedback was obtained from clinicians with direct knowledge of the ICU patient population, clinical workflow, and decision-making processes relevant to patient prioritization. They participated in a modified Delphi process consisting of two anonymous rounds involving controlled feedback, iterative refinement, and data evaluation to achieve consensus. Due to the small expert panel and the adapted use of the Delphi method, the process is described as a modified Delphi approach rather than a formal Delphi study. Strict anonymity of the panel members and their responses was maintained throughout the process. The five ICU staff members independently reviewed the draft clinical decision-support algorithm across two iterative rounds. Feedback was incorporated between rounds to refine

the algorithm content by adding, removing, rephrasing, and repositioning scoring items, while also considering evidence supporting their association with physiotherapy needs and patient outcomes. This modified Delphi process ensured that the items, namely the clinical variables included in the ICU Physiotherapy Prioritisation Algorithm, were expert-verified and supported the algorithm's clinical relevance and content validity.

Round 1:

The initial version of the algorithm was presented to the expert panel for qualitative feedback and to rate the relevance of the individual items. Experts rated the relevance of each item using a 4-point scale (1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = highly relevant) recommended for content validity studies (94,95). Ratings of 3 or 4 are suggested as relevant for content validity and calculating the Item-Level Content Validity Index (I-CVI). The Item-Level Content Validity Index (I-CVI) was calculated for each item and the scale-level CVI (S-CVI/ Ave) was calculated for the scoring algorithm to provide a quantitative measure of the experts´ consensus on the clinical relevance of the scoring items. This was followed by item reduction of the large, comprehensive pool of prioritization assessment factors.

Round 2:

Based on the feedback from Round 1, substantial item reduction and refinement were undertaken. The revised algorithm was subsequently re-evaluated by the expert panel to achieve final consensus on the scoring items. Once consensus had been achieved and an acceptable I-CVI value of 1 had been attained, as recommended for panels of five experts (94), the ICU Physiotherapy Prioritisation Algorithm (IPPA) was created in the form of a landscape flowchart with the online digital tool, Whimsical AI flowchart generator (https://whimsical.com/flowcharts). It included screening items to determine eligibility for prioritization, and scoring components within the neurocognitive, respiratory, and mobility status domains to establish the priority for physiotherapy intervention in ranked order. The individual exclusion items were consolidated into clinically meaningful categories to improve

usability without compromising patient safety. Each exclusion item was accompanied by a detailed explanation in the IPPA user guide to ensure consistent interpretation and application. However, the final decision to exclude or include a patient for physiotherapy prioritization remained at the discretion of the treating physician responsible for prioritizing patients for physiotherapy intervention.

4.2.3 Item scaling and weighting

All scoring items were scaled using a polytomous format, except for the "ICDSC" and "Neurological event" items within the neurocognitive status domain, which were dichotomized into yes/no. Items were weighted according to the ordinal scores or item weightings of the validated assessment tools incorporated within the neurocognitive, respiratory, and mobility status domains of the IPPA. In addition, the weighting assigned to each categorical item was informed by the expert opinion of the panel according to its relative clinical relevance. Each domain contributes to a composite score, which is then summed to generate a total physiotherapy urgency score used to identify patients with the highest priority for physiotherapy intervention. A higher total score indicates a higher priority for physiotherapy intervention.

4.2.4 Pre-pilot testing

The IPPA (Version 1.0) was pre-piloted in an ICU representing the patient population for whom the prioritization algorithm is intended. Following this, minor revisions were made within the respiratory status domain and to the layout of the IMS alignment reference within the mobility status domain to improve clarity.

4.3 Results

4.3.1 Algorithm development

The initial item pool generated as described in the section 4.2.1 above, comprised 29 items. These included 21 exclusion items for initial patient safety and eligibility screening, that is, items used to determine exclusion from prioritization; 1 item for absolute inclusion; and 7 prioritization items with corresponding scoring levels across three clinical domains: neurocognitive, respiratory, and mobility status. Following Round 1 expert feedback and discussion substantial initial item reduction, the draft algorithm included 15 items: 6 screening and 9 scoring components. The 6 screening items were grouped into broader categories, and all exclusion screening variables listed under these categories were removed from the algorithm and incorporated into the accompanying user guide used by the raters in the subsequent study described in Chapter 5 (Appendix 12).

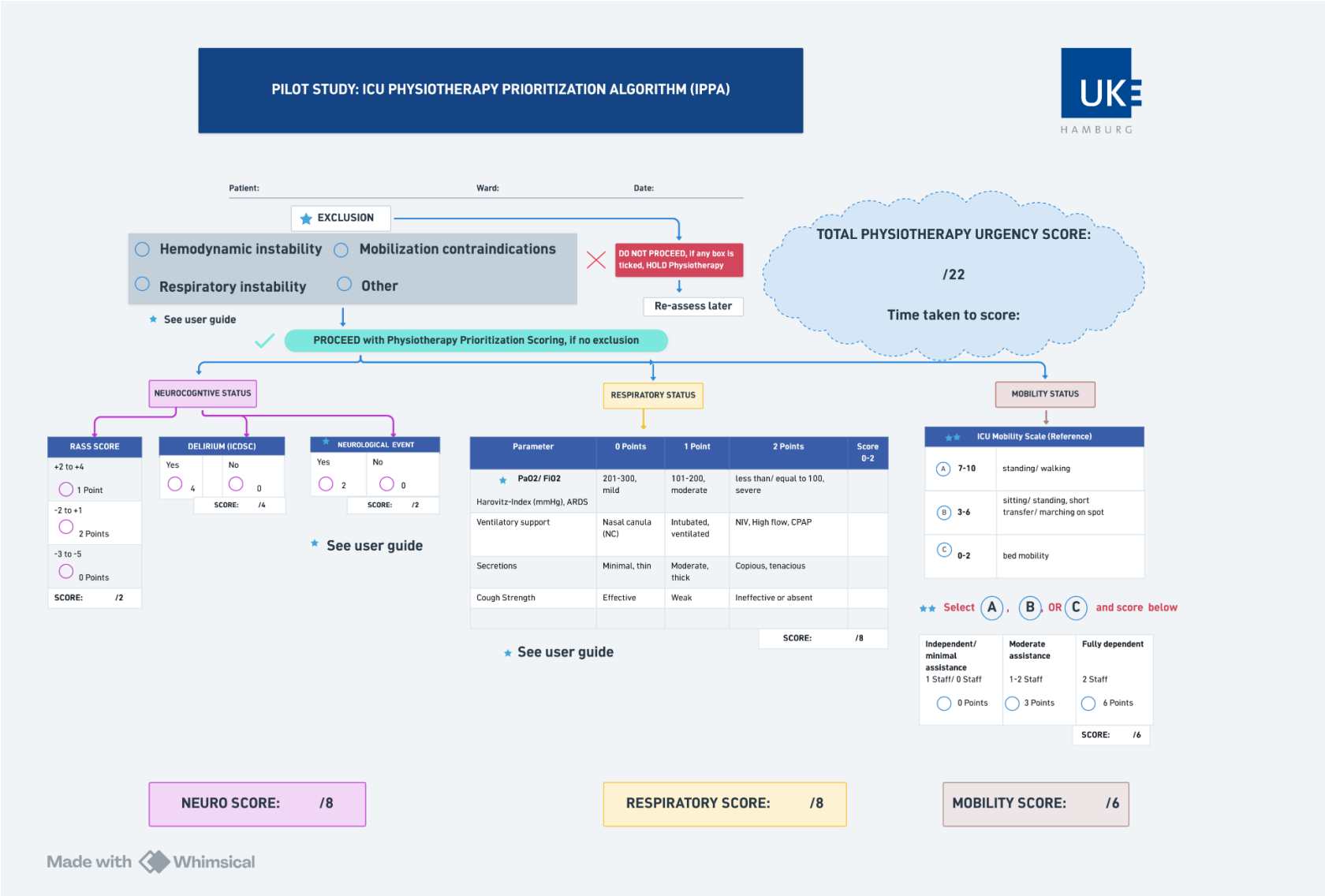
Following consensus in Round 2 of the Delphi process, subsequent revisions and refinement resulted in an algorithm consisting of 12 items: 4 screening items to determine eligibility (i.e., exclusion or inclusion) for physiotherapy intervention and 8 scoring components to prioritize eligible patients across the three clinical domains of neurocognitive, respiratory, and mobility status. After pre-pilot evaluation of the algorithm with four patients, minor revisions of the neurocognitive and respiratory status domains were undertaken. The term “neurodegenerative disorder of consciousness” was renamed to “neurological event” for clarity and more inclusion, and “ventilatory support/ oxygenation” was renamed to “ventilatory support” which also indirectly incorporates provides the opportunity to include oxygenation.

Subsequently, the first version of the ICU Physiotherapy Prioritization Algorithm flowchart (IPPA, Version 1.0) was finalized as presented in Figure 2. The 4 exclusion variables, hemodynamic instability, respiratory instability, mobilization contraindications, and other, were incorporated as an initial screening step to determine eligibility for priority scoring. If any of the exclusion items or variables

were selected, the patient was excluded from physiotherapy prioritization and was not considered eligible for physiotherapy intervention at that time. Physiotherapy was therefore placed on hold, and the patient was not prioritized but was reassessed at a later stage. If none of the exclusion variables were selected, the rater proceeded with the physiotherapy prioritization scoring using the IPPA flowchart to generate a final total physiotherapy urgency score. The 8 scoring variables across three domains included the following: neurocognitive status (RASS, ICDSC score, neurological event), respiratory status (Horovitz-Index, ventilatory support, secretions, cough strength), and mobility status (ICU Mobility Scale reference).

In comparison with the algorithm developed by Fründ et al. (77) the IPPA (Version 1.0) also included respiratory and mobility domains; however, there was similarity in only one variable within the respiratory domain, and the rest of the items including its scaling and weighting, differed completely (see Appendix 4).

Figure 2. IPPA (Version 1.0) Flowchart



4.3.2 Content validity analysis

Five experts participated in the content validation process. The panel comprised two ICU physicians, two physiotherapists, and one nurse, all of whom had more than five years of clinical experience in the ICU. Following the first Delphi round, the I-CVI values ranged from 0.20 to 1, with an average I-CVI (S-CVI/ Average) score of 0.91. The items that were removed or renamed following expert consensus are presented in Table 9. Items with lower agreement, specifically items 10 and 11, with I-CVI values of 0.20 and 0.40, respectively, were revised based on expert feedback and re-assessed during the second Delphi round. Following revision, all 12 items achieved an I-CVI of 1, resulting in an S-CVI/Ave of 1, indicating a high level of agreement with excellent content validity for a panel of five experts, based on the recommendations of Polit and Beck (2006) (94).

Table 9: CVI values for modified Delphi - Round 1 and Round 2

Item	I-CVI[a] Round 1	Action	I-CVI[a] Round 2
Item 4 **Mobilization not required**	1	Removed	1
Item 5 **Respiratory physiotherapy not required**	1	Removed	1
Item 10 **RSBT**	0.2	Removed, add Horovitz-index	1
Item 11 **Oxygenation**	0.4	Renamed, ventilatory support	1
Item 14 **Inflammatory lung disease**	1	Removed	1
Item 15 **IMS reference**	1	Restructure for clarity	1
S-CVI/ Average	**0.91**		**1**

[a]**I-CVI =** Item-Level Content Validity Index

4.4 Discussion

Following two rounds of iterative review, all 12 items of the IPPA (Version 1.0) demonstrated content validity and were considered clinically relevant for the purpose of prioritizing patients in the ICU for physiotherapy. Although the expert panel was small, the participants represented the clinical expertise required for a focused and contextually relevant assessment of the content validity of the algorithm.

Items that received the lowest ratings and subsequently removed or renamed for clarity, were those within the respiratory status domain, specifically the RSBI and oxygenation. The RSBI was considered inappropriate for assessing a patient's overall respiratory status, as it is primarily applicable to intubated patients who are candidates for ventilator weaning. Consequently, the Horovitz Index (PaO_2/FiO_2 ratio) was recommended instead because it provides a more informative measure of pulmonary gas exchange by accounting for the fraction of inspired oxygen (FiO_2).

It therefore offers a better indication of the severity of respiratory impairment and the efficiency of oxygen transfer from the lungs to the blood. In contrast, oxygen saturation may remain within the normal range in patients receiving supplemental oxygen despite the presence of severe pulmonary dysfunction. This is consistent with current critical care guidelines, which support the use of the Horovitz Index as a clinically relevant indicator of respiratory impairment (96).

In addition, the oxygenation item was replaced by a ventilatory support item as the latter was considered to provide more clinically relevant information regarding the patient's respiratory support requirements, including the likelihood of impending extubation or the potential need for intubation. This revision also supported the removal of Item 14, "Inflammatory lung disease," as respiratory impairment was more appropriately captured by the above-mentioned parameters.

Overall, this study systematically developed a clinically relevant algorithm for prioritizing ICU patients for physiotherapy intervention and established initial evidence supporting its content validity. Evaluation of its feasibility and reliability is presented in Chapter 5.

5. Pilot evaluation of physiotherapy prioritization algorithm

5.1 Chapter outline

This chapter presents the small-scale, pilot evaluation that was conducted following the pre-pilot testing and revision of the ICU Physiotherapy Prioritization Algorithm (IPPA), to address my fourth research question. The pilot evaluation methodology is described in Section 5.2 and the Results of the pilot evaluation are presented in Section 5.3. In this pilot evaluation the aim was to evaluate the feasibility and reliability of the IPPA (Version 1.0), specifically its acceptability and usability within the clinical workflow in the ICU. The agreement between the IPPA algorithm-based and clinical judgment-based (reference standard) prioritization was evaluated, as well as the agreement between the two raters conducting the algorithm-based prioritization. Additionally, the pilot feasibility trial served to inform the decision of whether to progress to a large-scale study.

5.2 Methods

5.2.1 Ethical considerations

Permission to conduct the study was obtained by the UKE Personnel Committee Council (WPR and NPR), as well as the Director of the Department of Intensive Care Medicine. The study was approved by the "Ethikkommission des Deutschen Verbandes für Physiotherapie an der Physio-Akademie" (Ethikkommissionsvorlagennummer: 2023-08) and data collection was conducted in accordance with data protection regulations and the approved ethics protocol.

5.2.2 Study design, participants and setting

The pilot evaluation was reported using the Consolidated Standards of Reporting Trials (CONSORT) extension for pilot and feasibility trials (Appendix 13) (97), where applicable, alongside the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) cohort checklist for observational design elements (Appendix 14) (98).

The IPPA (Version 1.0) was evaluated in a prospective, paired, non-randomized, double-blinded, single-center pilot study conducted in two adult ICU wards (mixed-case, multidisciplinary and surgical) at the UKE in northern Germany. Each ICU ward comprised 12 beds. The study was conducted over three consecutive weeks, with assessments performed once weekly on Saturdays on both wards. The algorithm was applied to all adult patients (≥18 years) admitted to the two ICU wards over the three consecutive weeks. Those identified by the screening items as unstable and therefore ineligible for physiotherapy intervention did not proceed to the priority scoring stage. Instead, they were assigned the lowest priority ranking for the purposes of statistical analysis, enabling all patients to be included in the overall ranking analysis. Those patients deemed eligible were scored in the pilot feasibility evaluation.

Patients admitted to the two ICUs were prioritized for weekend physiotherapy intervention over three consecutive weeks under three rater conditions: Ratings 1, Ratings 2, and Ratings 3. Ratings 1 is defined as the clinical judgment-based (reference standard) patient prioritization performed by physicians over three consecutive weeks across the two different ICU wards and, for simplicity, is also referred to as "Rater 1". Ratings 2 and 3 are defined as the algorithm-based patient prioritization performed independently by two different physicians and are also referred to as "Rater 2" and "Rater 3", respectively. From this point onwards, and for the purpose of clarity, the testing days over the three consecutive weeks are referred to as Day 1, Day 2, and Day 3, whilst the multidisciplinary ICU is referred to as ICU 1 and the surgical ICU as ICU 2. Six patient lists were collected across the three testing days, comprising a total of n = 50 patients, each of whom was ranked three times by

different raters (i.e., Raters 1, 2, and 3). Rater 2 re-tested the same two patient lists collected from ICU 1 and ICU 2 on Day 1, for a total of n = 16 patients.

In Ratings 1, the ICU physician on duty for the Friday night shift prioritized patients according to usual clinical judgment for Days 1, 2, and 3 in ICU 1 and ICU 2, and no treatment was withheld. Under current practice in the ICU at the UKE, the physician on duty prepares a list of patients eligible for weekend physiotherapy intervention, in a prioritized, ranked order, for the physiotherapist. In Ratings 2 and 3, prioritization was IPPA-based, using electronic health record data for each patient, and was performed concurrently with Ratings 1. Due to organizational constraints, the physicians working on ICU 1 and ICU 2 could not perform the IPPA-based priority ratings. Therefore, two physicians from a different ICU (Rater 2 and Rater 3) were recruited to evaluate the algorithm. They had no prior clinical knowledge of, or involvement with the patients.

Each patient was scored across the IPPA clinical domains to generate a total composite physiotherapy urgency score, which was then used to rank patients in an order of priority for physiotherapy treatment. The higher the score, the higher the priority for physiotherapy intervention (Figure 2, IPPA, Version 1.0).

These ratings enabled comparison between the clinical judgment-based and IPPA-based priority rankings, as well as assessment of the inter-rater reliability between the IPPA priority rankings assigned by Rater 2 and Rater 3. To assess intra-rater reliability, Rater 2 re-tested a subset of anonymized electronic health record datasets, namely those from Day 1 in ICU 1 and ICU 2. To minimize recall bias, the test–retest was conducted two weeks later using the same IPPA.

On three consecutive Saturday mornings, I collected the Ratings 1, i.e., the ranked patient lists from the night duty ICU physicians from ICU 1 and ICU 2. The algorithm-based patient priority ratings from Raters 2 and 3 were also collected by me.

5.2.3 Sample size calculation and statistical power

The study is exploratory and, accordingly, there is no primary hypothesis with an associated sample size calculation. For reasons of feasibility, it was decided to generate lists three times using the different ratings. This results in at least 48 triple rating pairs (if the same 16 patients are selected for each rating), which is sufficient for a pilot trial (99–101).

5.2.4 Rater training

Training was conducted to ensure that raters were familiar with the algorithm and to minimize variability due to misunderstanding. This included instruction on the items, weighting, scoring scales, interpretation of scores, and identification of relevant information in the electronic health records. A user guide in German language accompanied the ICU algorithm to ensure clarity and transparency of the scored items (Appendix 12). I was available on testing days to assist the raters if necessary, and to answer questions as needed.

5.2.5 Data collection and statistical analysis

The primary outcome was the feasibility of applying the IPPA to prioritize patients in the ICU for physiotherapy intervention in a ranked order. Feasibility was assessed through method comparison between usual clinical judgement (Ratings 1) and IPPA-based prioritization (Ratings 2 and 3). This included the level of agreement in patient rankings between Ratings 1 and Ratings 2, Ratings 1 and Ratings 3, as well as the time required to prioritize patients.

In addition, evaluations of the IPPA's workflow integration, usability, and acceptability involved feedback from Raters 2 and 3, who completed an ad hoc rater feedback questionnaire after applying the IPPA to 50 patients. Availability and completeness of the required electronic health record data was also reported by Raters 2 and 3. Additionally, Rater 2 and Rater 3 completed the validated System Usability Scale (SUS) in week 3, immediately after applying the IPPA. The SUS score

provides a score from 0 to 100, where higher scores indicate better perceived usability. SUS score interpretation is presented in Table 10. No average score was calculated and the individual SUS scores from Raters 2 and 3 were used as a preliminary standardized usability assessment to identify potential usability challenges before conducting a larger-scale study, rather than to establish statistical power (102).

Secondary outcomes to establish internal validation of the IPPA were: (a) agreement between Rater 2 and Rater 3, representing inter-rater reliability; and (b) agreement between the two assessments performed by Rater 2, representing intra-rater reliability. The completion rate was established and reported as the percentage of the 50 patients who were successfully evaluated by Rater 2 and Rater 3 using the IPPA. It was calculated as the proportion of completed IPPA evaluations relative to the total number of planned IPPA evaluations. The frequency and the type of missing data was documented.

Table 10. SUS score interpretation

Score ranges	Interpretation
> 80.3	Excellent
68.0 – 80.2	Above average
51.0 – 67.9	Below average
< 50.0	Unacceptable

The level of agreement between the ordinal patient priority rankings of the three raters (method comparison, inter-rater reliability, and intra-rater reliability) was analyzed in IBM SPSS Statistics Version 29.0.2.0 using the weighted kappa (k_w) statistic with linear weights. Weighted kappa was selected because the priority rankings represent ordinal data, and it considers partial agreement by assigning less weight to disagreements between adjacent categories than to disagreements

between categories that are further apart. The strength of agreement was interpreted according to standard guidelines (103) as defined in Table 11. As all analyses are exploratory, no conclusions regarding statistical significance are drawn. Weighted kappa coefficients were reported with corresponding 95% confidence intervals. However, the p-values are reported as descriptive statistics. Line graphs were generated using Microsoft Excel (Microsoft 365 MSO, Version2408).

Weighted kappa coefficients were calculated separately for the 6 patient lists under 3 Rater conditions:

a) Method comparison - clinical judgment vs. IPPA patient rankings.
   Rater 1 vs. Rater 2
   Rater 1 vs. Rater 3

b) Inter-rater reliability - IPPA patient rankings
   Rater 2 vs. Rater 3

c) Intra-rater reliability – IPPA patient rankings (test-retest)
   Rater 2 vs. Rater 2

Table 11. Interpretation values for strength of agreement between raters for weighted kappa (k_w)

Cohen´s Kappa	Interpretation
< 0 = 1.00	No agreement
010 – 0.20	Slight agreement
0.21 – 0.40	Fair agreement
0.41 – 0.60	Moderate agreement
0.61 – 0.80	Substantial agreement
0.81 – 0.99	Near perfect agreement
< 0	Perfect agreement

5.3 Results

5.3.1 Participant characteristics

A total of n = 50 patients admitted to the two ICU wards were included in the feasibility evaluation of the IPPA. The patients were predominantly male (n = 35, 70%) and admitted under surgical or trauma specialties (n = 42, 84%). Patient characteristics are presented in Table 12.

Table 12: Patient characteristics of pilot study

Characteristic	**Total n = 50** **n = *(%)***
Gender	Male = 35 *(70)* Female = 15 *(30)*
Age, mean (SD)	60.56 (16.34)
Specialty	Surgical/ Trauma = 42 *(84)* Medical = 8 *(16)*

In addition, a total of 8 physicians under 3 different rater conditions agreed to participate in the feasibility study over three consecutive weeks, with 6 different physicians performing Ratings 1 (judgment–based prioritization) and 2 physicians performing Ratings 2 and 3, respectively (IPPA-based prioritization). The 6 physicians performing Rating 1 each assessed patients independently within their respective ICU ward, and each patient was rated only once by the corresponding physician. Four of the physicians performing Ratings 1 had between 6 and 12 months of ICU work experience, while two had between 12 and 18 months of experience. Rater 2 had more than 5 years of ICU work experience, whereas Rater 3 had more than 20 years of ICU experience. A STROBE-style study flow diagram illustrates patient inclusion, prioritization, and analysis across the three rater conditions. (Figure 3) (98).

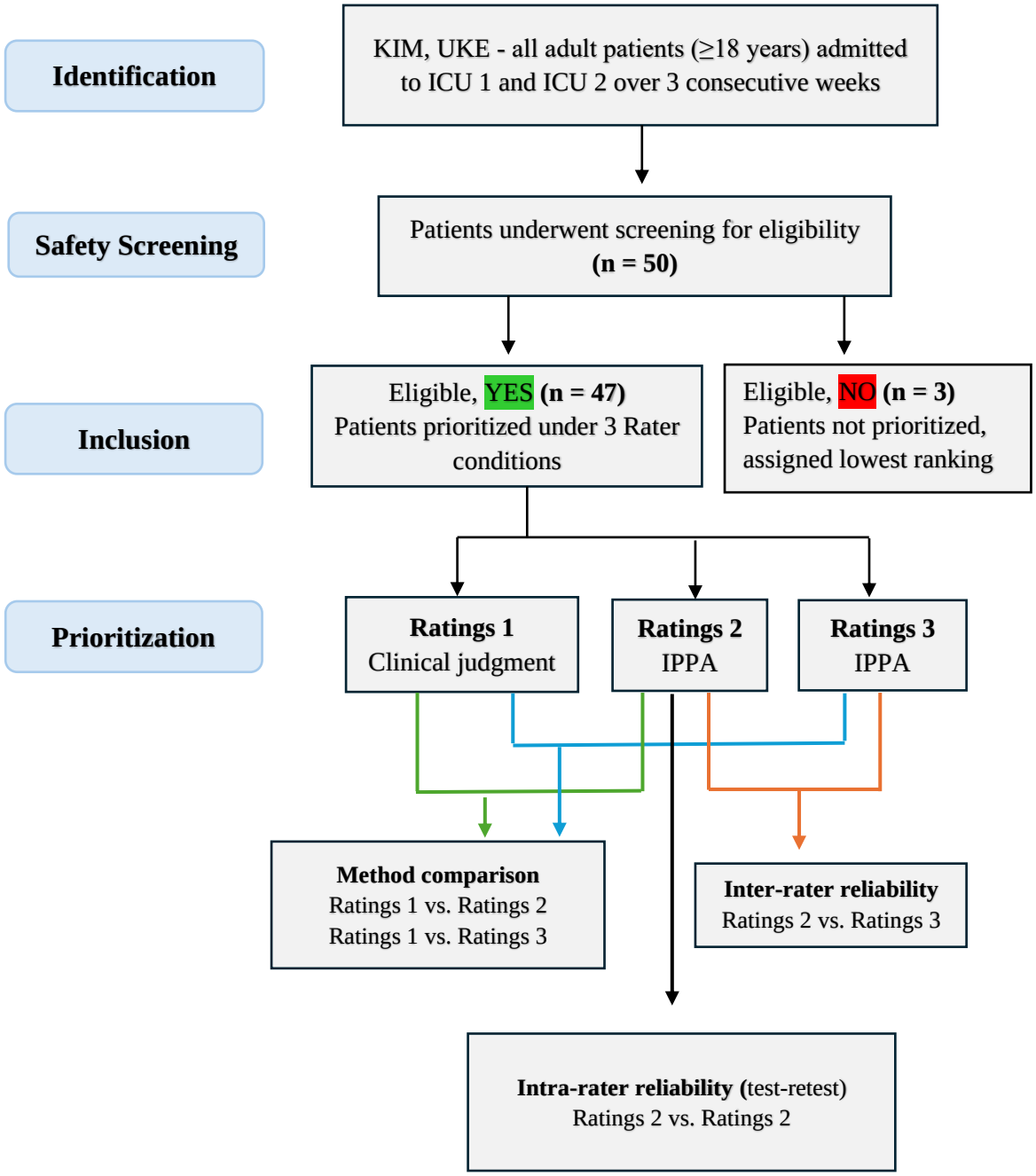


Figure 3. STROBE-style study flow diagram

5.3.2 Feasibility and reliability findings

The IPPA was completed in 50 of 50 patients (100%) for both Rater 2 and Rater 3 (see Section 5.2.2). Total time and time taken to score per patient for Raters 1, 2, and 3 are presented in Table 13. An anonymized example of one of Rater 2's priority ratings is shown in Figure 4.

Table 13: Total priority ranking completion time

Rater	Total time (min.) n = 50	Time per patient (sec./ min.)
[a]**Rater 1**	8	0.16 sec.
[b]**Rater 2**	60	1.2 min.
[c]**Rater 2 (test-retest)**	18 **(n = 16)**	1.12 min
[b]**Rater 3**	87	1.74

[a]*Clinical judgment-based prioritization,* [b]*IPPA-based prioritization,* [c]*time taken for Rater 2 to re-test the same 16 patients from first test day in ICU 1 and ICU 2*

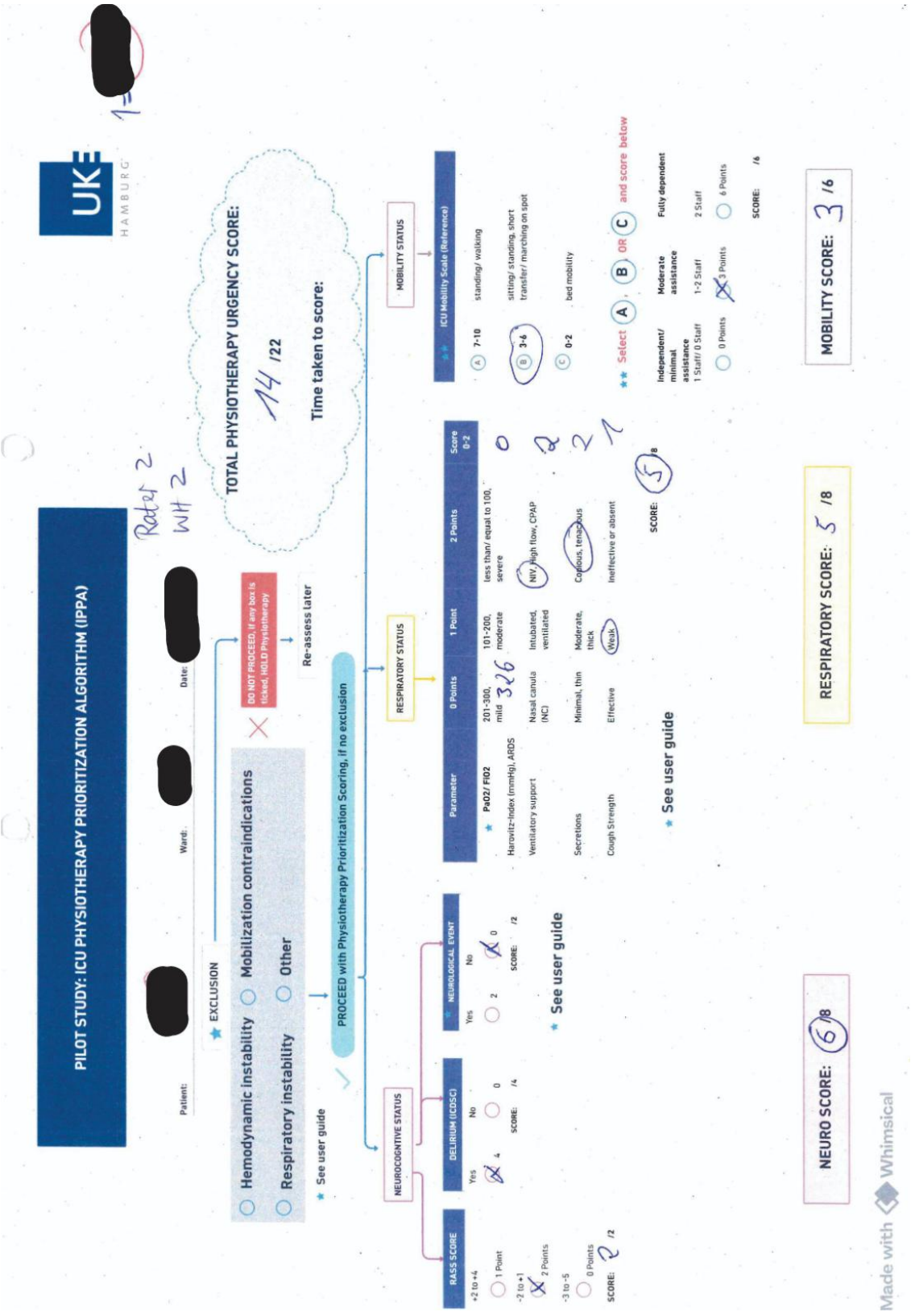


Figure 4. Anonymized example of priority scoring using the IPPA (Version 1.0)

Perceived usability, acceptability, and workflow integration of the IPPA were evaluated by both Raters 2 and 3 through the completion of a SUS questionnaire and an ad hoc feedback questionnaire (Appendix 15) developed by me. Both Raters 2 and 3 had SUS scores of 92.5 indicating excellent usability rating of the IPPA. The results of the SUS questionnaire for the IPPA for Raters 2 and 3 are presented in Table 14.

Both raters reported that the IPPA was very easy to use and required very little training. Regarding acceptance of the IPPA, both raters expressed a willingness to use the tool and considered the algorithm clinically relevant as a quick, objective assessment of priority needs. They also indicated that it could be potentially useful in situations of ICU physiotherapy staff shortages.

High rates of missing delirium scores (ICDSC) were reported (n = 48, 96%). Details of the two patients identified with active delirium were obtained from the physicians' and physiotherapists' documentation. Despite active delirium being documented in the physicians' and physiotherapists' progress notes, it was not recorded in the corresponding nursing documentation under the relevant documentation column.

The ICU Mobility Scale (IMS) also showed high rates of omitted documentation (n = 47, 94%). Again, mobility status and progress were documented by the physiotherapists but not in the relevant column of the nursing documentation. The parameters of "Secretions" and "Cough strength" were not always transparent for Raters 2 and 3 in the physiotherapy documentation. Physiotherapists documented only the presence of secretions and whether the cough was ineffective, but not whether the cough was effective or whether secretions were absent.

Raters 2 and 3 both reported that if they worked in the ICU and the patients were known to them, the IPPA would not only be easier to complete but would most probably require much less time to complete, provided all the required data were available. Both raters were optimistic that the IPPA could realistically be integrated into the routine ICU clinical workflow.

Table 13: System Usability Scale (SUS)

SUS Question	Rater 2 (Raw)	Rater 2 (Adjusted)	Rater 3 (Raw)	Rater 3 (Adjusted)
1. I think that I would like to use this system frequently.	4	3	4	3
2. I found the system unnecessarily complex.	1	4	1	4
3. I thought the system was easy to use.	5	4	5	4
4. I would need the support of a technical person to be able to use this system.	1	4	2	3
5. I found the various functions in this system were well integrated.	3	2	4	3
6. I thought there was too much inconsistency in this system.	1	4	1	4
7. I would imagine that most people would learn to use this system very quickly.	5	4	5	4
8. I found the system very cumbersome to use.	1	4	1	4
9. I felt very confident using the system.	5	4	5	4
10. I needed to learn a lot of things before I could get going with this system.	1	4	1	4
SUM (Adjusted points)	**-**	**37**	**-**	**37**
Final SUS Score	**-**	**37x2.5 = 92.5**	**-**	**37x2.5 = 92.5**

Weighted kappa (k_w) values between priority rankings generated by the IPPA versus clinical judgment, and IPPA versus IPPA, were widely variable, ranging from high to no agreement. Comparison of the clinical judgment-based and IPPA-based priority rankings (i.e., Ratings 1, 2, and 3), revealed that for 2 of the patient lists there was fair agreement, 4 moderate, 1 substantial, 1 near perfect, 3 had poor agreement and 1 had no agreement (Table 15). Of the 6 ranking lists evaluated for the inter-rater reliability of the IPPA between Raters 2 and 3, 2 showed fair agreement in prioritization, 2 moderate, 1 substantial, and 1 near perfect agreement of priority ranking order. (Table 16). Test-retest shows substantial agreement and consistency in using the IPPA over time for Rater 2, in both ICU 1 and ICU 2, with Weighted Kappa k_w = 0.619 (0.35, 0.89) and k_w= 0.820 (95% CI 0.63, 0.99), respectively (Table 17).

Table 15. Method comparison. Correlation between clinical judgment and IPPA priority rankings

Comparison Day, ICU, *n*	Weighted Kappa (k_w)	p -value (2-tailed)	95% CI
Day 1, ICU 1 *(n = 8)*			
Rater 1 versus Rater 2	0.714*	0.002	(0.42, 1.01)
Rater 1 versus Rater 3	0.429	0.064	(-0.01, 0.87)
Day 1, ICU 2 *(n = 8)*			
Rater 1 versus Rater 2	-0.143	0.537	(-0.69, 0.40)
Rater 1 versus Rater 3	-0.429	0.064	(-0.68, -0.18)
Day 2, ICU 1 *(n = 8)*			
Rater 1 versus Rater 2	0.238	0.304	(-0.21, 0.69)
Rater 1 versus Rater 3	0.238	0.304	(-0.31, 0.79)
Day 2, ICU 2 *(n = 9)*			
Rater 1 versus Rater 2	0.850*	<.001	(0.71, 0.99)
Rater 1 versus Rater 3	0.550	0.011	(0.22, 0.88)
Day 3, ICU 1 *(n = 9)*			
Rater 1 versus Rater 2	-0.050	0.817	(-0.50, 0.40)
Rater 1 versus Rater 3	-0.275	0.204	(-0.60, 0.05)
Day 3, ICU 2 *(n = 8)*			
Rater 1 versus Rater 2	0.429	0.064	(-0.06, 0.92)
Rater 1 versus Rater 3	0.619*	0.024	(0.16, 0.89)

Table 16. Inter-rater reliability. Correlation between IPPA priority rankings of Rater 2 and Rater 3

Comparison Day, ICU, *n*	Weighted Kappa (k_w)	p -value (2-tailed)	95% CI
Day 1, ICU 1 *(n = 8)* **Rater 2 versus Rater 3**	0.524	0.024	(0.19, 1.01)
Day 1, ICU 2 *(n = 8)* **Rater 2 versus Rater 3**	0.238	0.304	(-0.27, 0.75)
Day 2, ICU 1 *(n = 8)* **Rater 2 versus Rater 3**	0.429	0.064	(0.04, 0.81)
Day 2, ICU 2 *(n = 9)* **Rater 2 versus Rater 3**	0.625*	0.004	(0.31, 0.94)
Day 3, ICU 1 *(n = 9)* **Rater 2 versus Rater 3**	0.400	0.065	(-0.00, 0.80)
Day 3, ICU 2 *(n = 8)* **Rater 2 versus Rater 3**	0.619*	0.007	(0.29, 0.95)

Table 17. Intra-rater reliability. Correlation between IPPA priority rankings Rater 2 and Rater 3

Comparison (test-retest) Day, ICU, *n*	Weighted Kappa (k_w)	p -value (2-tailed)	95% CI
Day 1, ICU 1 *(n = 8)* **Rater 2 versus Rater 2**	0.619*	0.007	(0.35, 0.89)
Day 1, ICU 2 *(n = 8)* **Rater 2 versus Rater 2**	0.810*	< 0.001	(0.63, 0.99)

Line graphs are presented in Figures 5–10 to compare the priority rankings of the 50 patients ranked by Raters 1, 2, and 3 across the three testing days in both ICUs. In addition, Rater 2's second priority rankings (test–retest) for Day 1, ICU 1 and Day 1, ICU 2 are presented in Figures 5 and 6, respectively.

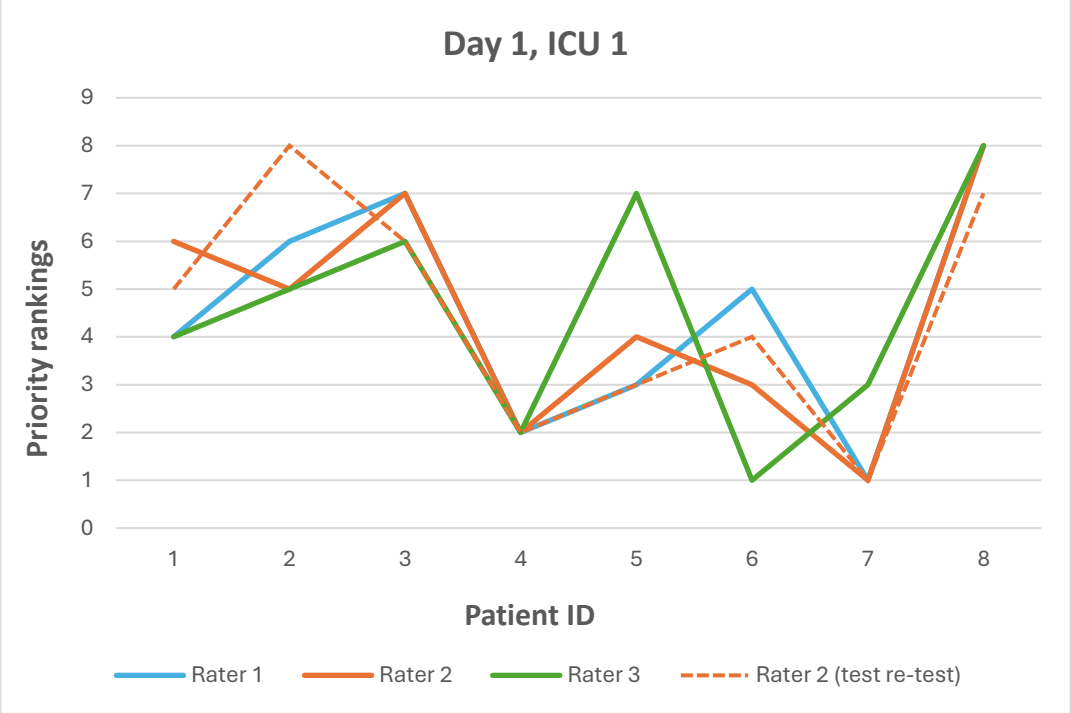


Figure 5. Comparison of priority rankings of Raters 1, 2 and 3 for patients 1 to 8 on the first day of testing in ICU 1, including the 2nd rankings of Rater 2 (test re-test) on the same day for the same ICU patient list.

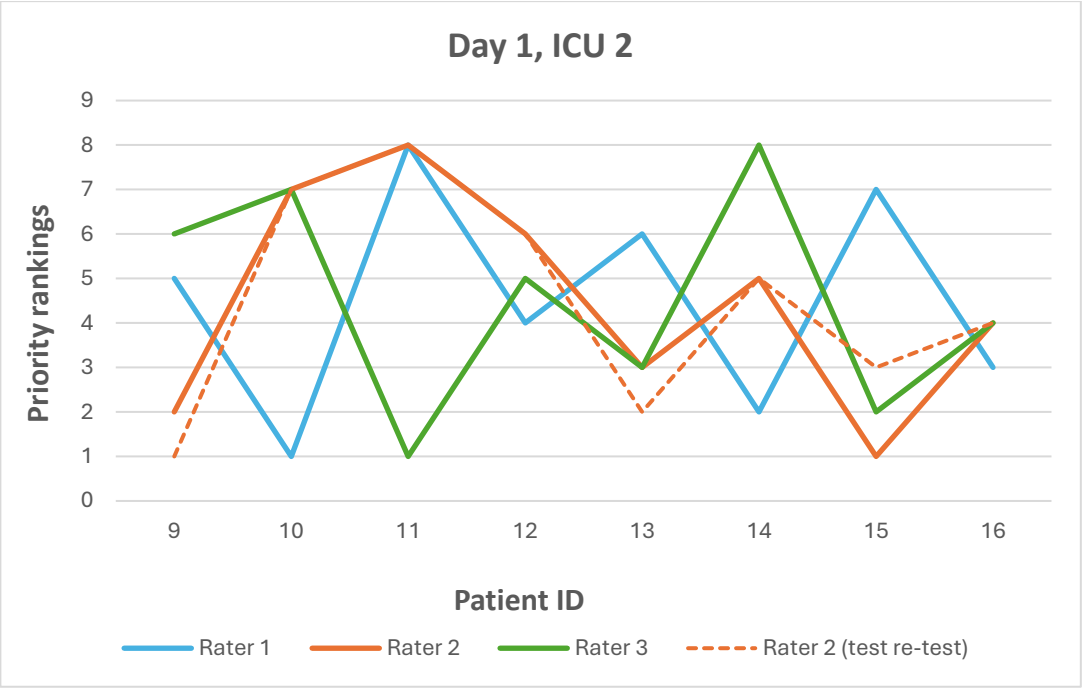


Figure 6. Comparison of priority rankings of Raters 1, 2 and 3 for patients 9 to 16 on the first day of testing in ICU 2, including the 2nd rankings of Rater 2 (test re-test) on the same day for the same ICU patient list.

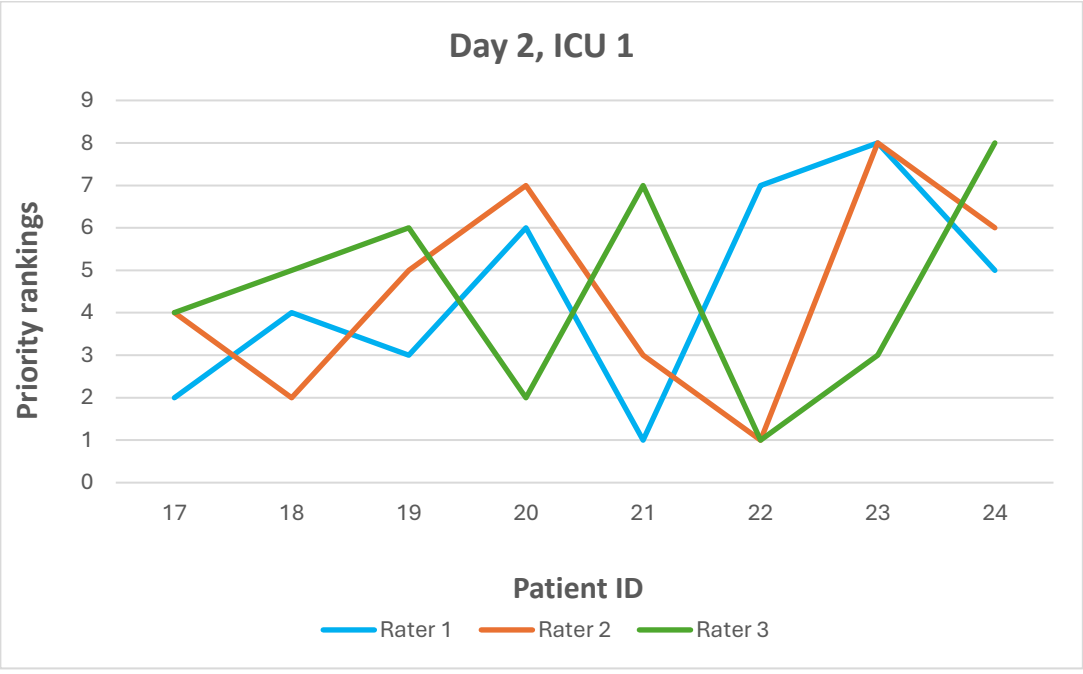


Figure 7. Comparison of priority rankings of Raters 1, 2 and 3 for patients 17 to 24 on the second day of testing in ICU 1

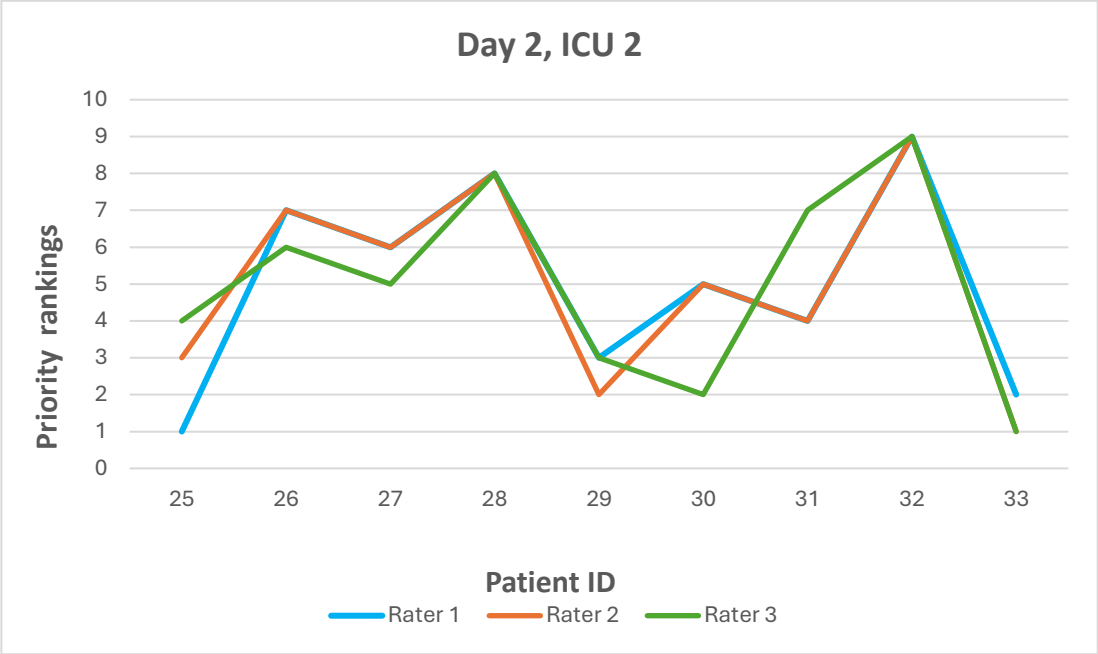


Figure 8. Comparison of priority rankings of Raters 1, 2 and 3 for patients 25 to 33 on the second day of testing in ICU 2

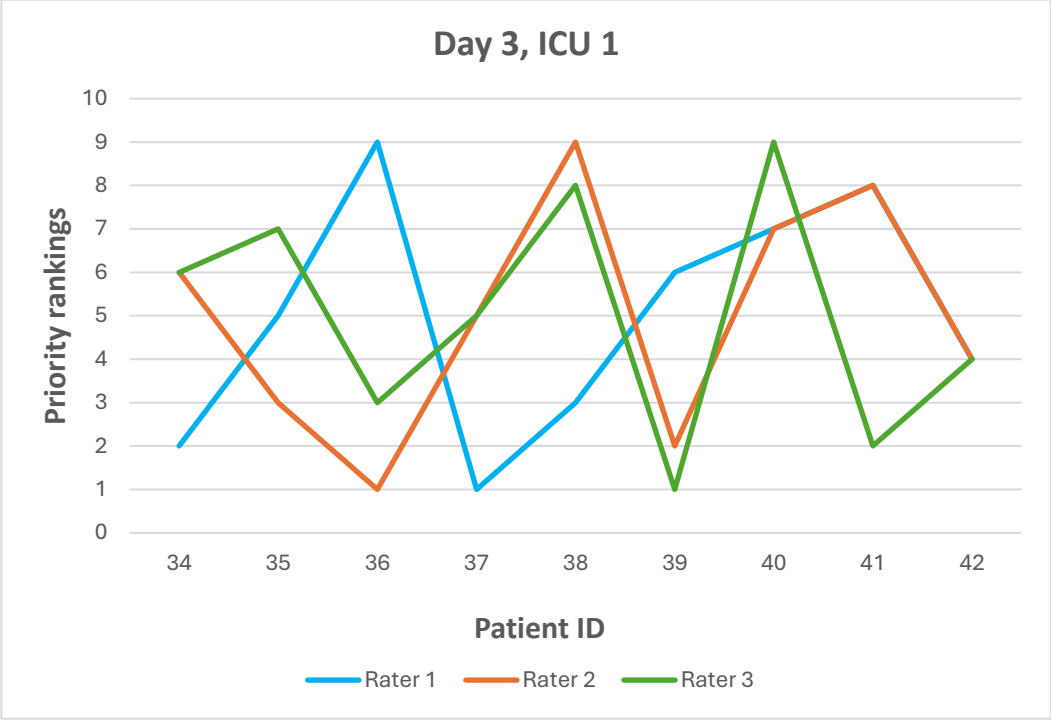


Figure 9. Comparison of priority rankings of Raters 1, 2 and 3 for patients 34 to 42 on the third day of testing in ICU 1

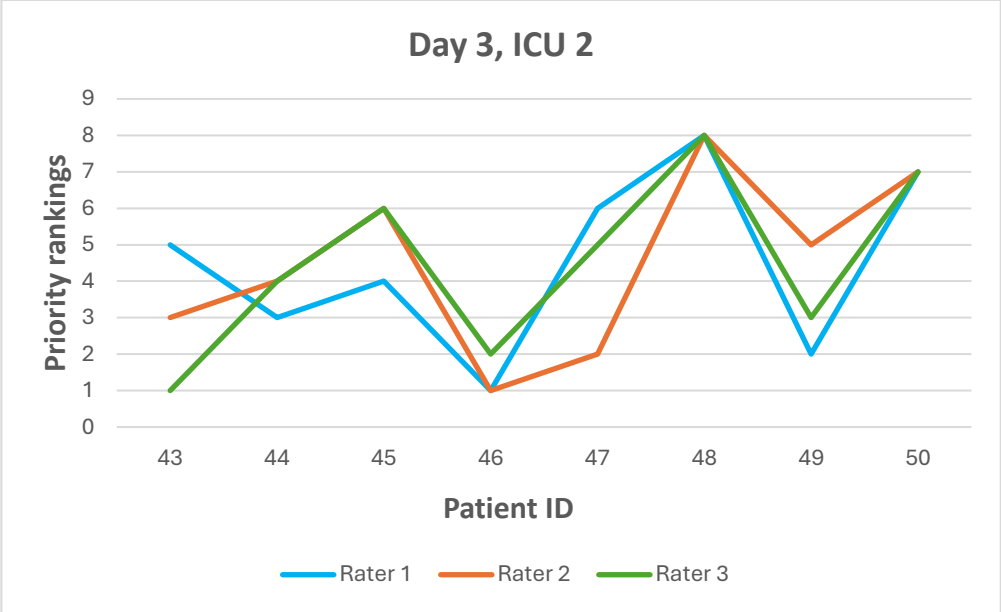


Figure 10. Comparison of priority rankings of Raters 1, 2 and 3 for patients 43 to 50 on the third day of testing in ICU 2

5.4 Discussion

The pilot evaluation of the IPPA (Version 1.0) was conducted to assess its feasibility and reliability within the daily ICU workflow at the KIM, UKE before considering progression to a full-scale study for further validation and implementation. The need for such a standardized algorithm to assist in prioritizing adult ICU patients for physiotherapy was established and described in Chapter 2 of this thesis and coincides with the increasing recommendation to use uniform standards in the ICU to optimize resource allocation and improve patient outcomes (48–50).

Raters 2 and 3 both reported excellent perceived usability and acceptability of the IPPA (Version 1.0), with a SUS score of 92.5. To quantify usability, the two SUS scores were supplemented with feedback from the ad hoc questionnaires, as the small number of raters meant that the SUS scores alone would have been too subjective and unstable for interpretation. The SUS and ad hoc questionnaires were completed immediately after the last day of testing of the IPPA to ensure experiences were still fresh in their minds and to obtain the most reliable feedback regarding the usability and acceptability of the IPPA. Both raters reported that the variables were clinically relevant and easy to rate, and that if the patients and ICU had been familiar to them, scoring would most likely have been easier. Following discussion after completion of the ad hoc questionnaire, the neurocognitive, respiratory and mobility domains of the algorithm were confirmed as clinically relevant. Both raters, however, highlighted the potential to improve the discriminatory ability of two scoring variables (the RASS and IMS scores) to reduce the probability of tied priority rankings for physiotherapy treatment. This is consistent with recommendations regarding the characteristics of good measurement tools (104–106), implicating that the scoring variables of the IPPA should be capable of distinguishing between patients with different physiotherapy priority needs. For this reason, the RASS and IMS variables were redefined in the IPPA to include all the ranking levels, including the appropriate adaption of the weighting assignment of the levels. This still aligns with the current electronic health records in the KIM, as both scores form part of the standardized documentation in the Integrated Care Management (ICM).

Several critical barriers were encountered during the pilot evaluation of the IPPA. Although both raters achieved a 100% completion rate and reported excellent usability and acceptability, the high rate of missing data caused major delays in completing the algorithm-based scoring. The Intensive Care Delirium Screening Checklist (ICDSC) and IMS score were not documented in the relevant nursing charts and were two of the scoring variables creating the biggest barrier. Authors, including Mador et al. (2009) report that workflow and organizational problems could be attributed to incomplete or missing clinical documentation (107–109). While high missing patient documentation was unrelated to the inherent feasibility of the IPPA (Version 1.0), it still negatively affected the performance of the algorithm.

Method comparison between clinical judgment-based and IPPA-based prioritization was also compromised by the missing ICDSC and IMS scores. Raters 2 and 3 required considerably more time to gather the relevant information for scoring from the physicians' and physiotherapists' progress documentation regarding delirium status and mobility. Even in the presence of active delirium, this was not documented in the nursing chart. As the patients were unfamiliar to both raters, they had to make deductions from the written reports, which may not necessarily have been accurate. In the domain of respiratory status, some minor uncertainties were encountered. Generally, documentation regarding secretions and cough strength in physiotherapy progress reports was good. However, when patients experienced no respiratory problems, this was not routinely documented. Again, because the patients were unfamiliar to both raters, it took them some time to deduce that, unless secretions or an ineffective cough were documented, it could be assumed that secretions were absent and the cough was effective, although this was not explicitly documented.

Of interest was the wide variability between the priority rankings generated by the IPPA versus those based on clinical judgement, compared with the variability between the two raters using the IPPA to rank patients, which were closer in agreement. One could hypothesize that this aligns with the concerns highlighted in the literature regarding the subjective variability associated with decision-making based solely on clinical judgement (14,15). Likewise, the high rate of missing data made patient prioritization challenging for Rater 2 and Rater 3, as they had no prior

clinical involvement with the patients and, therefore, could not rely on clinical judgement to compensate for incomplete documentation. This finding supports recommendations that clinical judgement should be used alongside evidence-based criteria in clinical decision-making (48–50).

The underlying reasons for incomplete or missing ICDSC and IMS scores require further investigation, as these may have serious implications for patient outcomes (19,42,110,111). It is possible that nurses observe the presence or absence of delirium but do not document it because of high workloads rather than negligence. This is supported by the literature, which indicates that electronic health record documentation systems may negatively affect users because of the increased documentation burden (112–115). This increased documentation burden often leads to clinician burnout and leaves less time for direct patient care (116,117). Other authors also argue that the quality of electronic health record documentation is not necessarily entirely dependent on clinicians but on the organizational systems and workflow design (118). The aim of introducing the ICM into the KIM at UKE was to provide quicker access to vital parameters, nursing and physiotherapy progress documentation, and other relevant clinical information, while reducing administrative burden and, thereby, freeing up more time for direct patient care. Whether this aim has been achieved is debatable.

The high rates of missing ICDSC and IMS scores also directly affected the inter-rater reliability of the IPPA because of the variable deductions made by Rater 2 and Rater 3 from the written progress reports to complete the algorithm. Intra-rater reliability was established, with Rater 2 showing a higher stability and precision when reproducing the scoring with the IPPA in the ICU 2 dataset (Kappa = 0.810).

These missing scores and the lack of transparency regarding secretions and cough strength made it difficult for the IPPA to deliver reliable priority rankings across raters. Despite excellent perceived usability and acceptability, the current IPPA (Version1.0) together with the critical barriers of missing data implies that it is not fully feasible for progression to a bigger scale study or implementation. It can only be considered operationally ready for implementation if the problem of missing and

incomplete patient documentation of ICDSC and IMS improves. Currently, discussions with physiotherapy, and nursing are underway to address these issues.

Future considerations include the following: The IPPA (Version 1.0) has been updated to IPPA (Version 1.1) to improve discriminatory capability of the RASS and IMS variables in terms of level of scaling and weighting. The next step would be to conduct another pilot evaluation with the IPPA (Version 1.1) provided the missing data issue has been resolved. In addition, the pilot evaluation should be done under different rater conditions: the scoring should be done by physicians working in the ICU and who are familiar with the patients, and preferably with the same ICU work experience.

6. Overall discussion

The aim of this thesis was to develop an evidence-informed algorithm to support the prioritization and selection of adult patients in the ICU eligible for physiotherapy intervention and evaluate its feasibility in a pilot study.

A structured mixed-methods approach was used to develop the ICU Physiotherapy Prioritization Algorithm (IPPA). The systematic literature review identified the existing evidence and informed a qualitative interview study that explored perspectives and clinical experiences related to current ICU physiotherapy prioritization practices, followed by the development and pilot evaluation of the novel IPPA (Versions 1.0 and 1.1).

Overall, the findings demonstrate that it was possible to develop a clinically relevant, evidence-informed ICU Physiotherapy Prioritization Algorithm that integrates well into the routine ICU workflow. The systematic review confirmed the lack of standardized, validated algorithms to prioritize patients in the ICU for physiotherapy, while the qualitative interviews identified clinician perspectives and objective clinical variables considered routinely relevant for patient prioritization. These findings were integrated with clinical practice guidelines for critical care to develop the IPPA, which demonstrated excellent perceived usability and acceptability.

The systematic review confirmed that ICU physiotherapy prioritization is largely dependent on clinician judgement because no standardized, validated prioritization algorithm currently exists. This finding is consistent with the existing literature, which also highlights the lack of standardization in physiotherapy clinical reasoning within the ICU (14,15). Although it appears that clinicians do consider objective parameters during clinical decision-making, these variables are applied informally or subconsciously, rather than through a structured decision-support algorithm. The lack of evidence in existing literature also justified the subsequent qualitative study which in turn identified the objective clinical variables routinely considered by experienced ICU clinicians when prioritizing patients for physiotherapy intervention. Through the development of the IPPA by integrating published evidence, critical care

guidelines, and expert ICU clinician experience and perspectives, this thesis not only addresses an important gap identified in the existing literature but also supports the content validity of the algorithm, as the variables incorporated into the IPPA align with best practice critical care guidelines recommended by several authors, and not on expert opinion alone (14,19,93).

The fact that both raters regarded the IPPA as easy to use and clinically acceptable during the pilot feasibility evaluation indicates that the algorithm integrates well into the routine ICU workflow. However, the feasibility of the IPPA was influenced by organizational barriers rather than by inherent flaws in the algorithm design itself. Both raters encountered high rates of missing delirium and mobility documentation, which substantially increased algorithm completion time and inevitably affected its inter-rater reliability. These findings highlight the influence that ICU work routines and the quality of clinical documentation may have on hindering the implementation of clinical decision-support algorithms, despite their validity and clinician acceptance. This observation is consistent with the literature describing increased documentation burden, workflow interruptions, and electronic health record usability as important factors influencing documentation quality and potential negative user outcomes (112–114,118).

Collectively, the four research studies I conducted as part of my thesis project, contributed to the development of an evidence-informed ICU Physiotherapy Prioritization Algorithm using a structured mixed-methods approach that integrated existing literature, clinical guidelines, and clinician expertise. Although the pilot study confirmed the acceptability and clinical relevance of the IPPA, it also highlighted the impact that organizational factors, particularly missing or incomplete routine clinical documentation, may have on its successful implementation. Consequently, this thesis contributes a novel ICU Physiotherapy Prioritization Algorithm, the IPPA (Version 1.1), while demonstrating that its successful implementation is likely to depend on improving routine clinical documentation.

Implementation of the IPPA may facilitate interdisciplinary, evidence-informed decision-making, especially considering that its domains include the scoring of standardized assessments across all ICU disciplines i.e., physicians, nurses, and

physiotherapists. It may assist rather than replace clinical judgment, improve transparency in prioritization, especially with staff shortages, and support junior staff, as is reported in the literature (59–62). As ICU staff did not want the additional burden of extra documentation, the IPPA was designed to use standardized variables already incorporated into the current ICM electronic health record system in the KIM. This allows the algorithm to be potentially embedded directly within the current ICM system, with the aim of reducing completion time and manual scoring. This would ensure real-time, automated outputs.

Considering the studies were conducted at one institution, these findings may not reflect other ICUs. In addition, the pilot sample was small, limiting generalizability of results. Although missing data was seen as limiting factor with reduced inter-rater reliability, it also revealed an important organizational barrier that future implementation studies should address. The pilot evaluation only had 2 raters which might also have limited findings. It also did not assess clinical outcomes at this stage, only feasibility of the IPPA.

Before implementation of the IPPA can be considered, the issue of missing and incomplete documentation needs to be addressed and resolved. Discussions with nursing and physiotherapy regarding documentation of Delirium score and ICU mobility scale are already underway. Discussions with IT at the UKE regarding incorporating the variables of the prioritization algorithm to compute and generate a total score within ICM is also underway. The RASS and IMS variables of the IPPA (Version 1.0) has been refined (Appendix 16). A repeat feasibility evaluation should follow once documentation issues is resolved, followed by a full-scale study, multi-center validation, and finally, implementation into the electronic health record system. Only thereafter, clinical effectiveness of the IPPA can be evaluated.

Introducing a “team-teaching” approach could also be considered to improve interdisciplinary collaboration and clinical decision-making by educating undergraduate medical students, physicians, and nurses about the role of physiotherapy in the management critically ill patients.

7. Overall conclusions

This thesis addressed an important evidence gap by developing an evidence-informed ICU Physiotherapy Prioritization Algorithm using a structured mixed-methods approach. The findings demonstrate that the IPPA is clinically relevant, acceptable to clinicians, and has the potential to support standardized prioritization of adult ICU patients for physiotherapy intervention. However, its successful implementation in the ICU clinical workflow depends on improvements in routine patient documentation and the organizational context in which it is used.

8. Abstract (English and German)

Evidence indicates that early physiotherapy intervention in adult patients admitted to the intensive care unit (ICU) is associated with improved clinical outcomes. However, physiotherapy staffing constraints in the Department of Intensive Care (KIM) at the UKE, often limit the provision of treatment to all eligible patients, requiring prioritization of patients for treatment that is primarily based on variable clinician judgment, rather than supported by evidence-informed objective criteria.

This thesis contributes a novel mixed-methods approach with the aim to address the evidence gap in prioritizing adult ICU patients for physiotherapy. It comprises a systematic literature review (Chapter 2), which informed a qualitative interview study (Chapter 3), followed by the development of the ICU Physiotherapy Prioritization Algorithm (IPPA) (Chapter 4) and its pilot feasibility evaluation (Chapter 5).

Key findings demonstrate excellent perceived usability and acceptability of the IPPA (Version 1.0). However, high rates of missing delirium and ICU Mobility Scale (IMS) scores caused substantial delays in IPPA completion, indicating that, under the present organizational conditions, progression to a larger-scale study or implementation is not yet fully feasible. Minor modifications to the scaling and weighting of the RASS and IMS objective variables were also suggested.

Future work should include a pilot feasibility evaluation of the modified IPPA (Version 1.1), provided the problem of missing data is resolved. Implementation of the algorithm into the ICM electronic patient health record system in the KIM should be considered only after its feasibility has been established.

Zusammenfassung

Frühzeitige physiotherapeutische Interventionen bei erwachsenen Patient:innen auf der Intensivstation (ICU) sind mit verbesserten klinischen Outcomes verbunden. Die Versorgung aller physiotherapiebedürftigen Patient:innen in der Klinik für Intensivmedizin (KIM) am UKE ist jedoch häufig durch begrenzte personelle Ressourcen eingeschränkt. Die Priorisierung von Patient:innen für eine physiotherapeutische Behandlung beruht daher überwiegend auf dem variablen subjektiven klinischen Urteil des behandelnden ärztlichen Personals, anstatt durch evidenzbasierte, objektive Kriterien unterstützt zu werden.

Diese Dissertation leistet mithilfe eines Mixed-Methods-Ansatzes einen neuen Beitrag mit dem Ziel, die Evidenzlücke hinsichtlich der Priorisierung erwachsener Intensivpatien:innen für physiotherapeutische Interventionen zu schließen. Die Arbeit umfasst eine systematische Literaturübersicht (Kapitel 2) als Grundlage für eine qualitative Interviewstudie (Kapitel 3). Darauf erfolgten die Entwicklung des ICU Physiotherapy Prioritization Algorithm (IPPA) (Kapitel 4) sowie dessen Pilot-Feasibility-Evaluation (Kapitel 5).

Die Ergebnisse zeigen eine hohe wahrgenommene Benutzerfreundlichkeit und Akzeptanz des IPPA (Version 1.0). Gleichzeitig wurden hohe Raten fehlender Delirium- und ICU Mobility Scale (IMS)-Scores identifiziert, die zu Verzögerungen bei der Fertigstellung des IPPA führten. Dies zeigte, dass unter den derzeitigen Routinebedingungen auf der ICU weder eine größere Folgestudie noch eine Implementierung realisierbar sind. Zur Verbesserung der Diskriminierungsfähigkeit wurden geringfügige Anpassungen der Skalierung und Gewichtung der objektiven Variablen RASS und IMS vorgeschlagen.

Zukünftige Arbeiten sollten eine Pilot-Feasibility-Evaluation des modifizierten IPPA (Version 1.1) umfassen, sofern das Problem der fehlenden Daten behoben wird. Eine Implementierung des Algorithmus in das ICM elektronische Patientenaktensystem in der KIM sollte erst nach erfolgreicher Etablierung seiner Durchführbarkeit in Betracht gezogen werden.

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10. Appendices

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Appendix 1: PROSPERO protocol (with amendments)

NIHR | National Institute for Health and Care Research PROSPERO International prospective register of systematic reviews

Scoring systems identifying the priority of a physiotherapy treatment for patients on intensive care unit: a systematic review

Bernadette Bessick, Gesche Ketels, Antonia Zapf, Simon Pecha, Yskert von Kodolitsch, Susanne Klotz

Review methods were amended after registration. Please see the revision notes and previous versions for detail.

To enable PROSPERO to focus on COVID-19 submissions, this registration record has undergone basic automated checks for eligibility and is published exactly as submitted. It has since been amended by the author and the PROSPERO team have checked the record for eligibility. PROSPERO has never provided peer review, and usual checking by the PROSPERO team does not endorse content. Therefore, automatically published records should be treated as any other PROSPERO registration. Further detail is provided here.

Citation 1 change
Bernadette Bessick, Gesche Ketels, Antonia Zapf, Simon Pecha, Yskert von Kodolitsch, Susanne Klotz. Scoring systems identifying the priority of a physiotherapy treatment for patients on intensive care unit: a systematic review. PROSPERO 2024 Available from https://www.crd.york.ac.uk/PROSPERO/view/CRD42022342415

REVIEW TITLE AND BASIC DETAILS

Review title
Scoring systems identifying the priority of a physiotherapy treatment for patients on intensive care unit: a systematic review

Review objectives
Is there evidence in the literature of scoring systems identifying intensive care unit patients in an order of priority for physiotherapy treatment?

Keywords
assessment tools, critical care, ICU, intensive care unit, physical therapy, physiotherapy, priority, scoring, scoring systems, staffing resources

SEARCHING AND SCREENING

Searches
A comprehensive primary search will be conducted in the following electronic databases: PubMed, PEDro, CINAHL, Cochrane Library and Google Scholar. All databases will be searched from January 2000 until June 2022. Studies recruiting adult patients, and published in English or German language, will be eligible for inclusion. The reference lists of all included studies and other sources will be hand screened independently to identify articles missed in the initial search. Unpublished studies will also be included, and primary searches will be re-run prior to the final analysis.

Study design
Inclusion: No restrictions on study design types eligible for inclusion, unpublished studies, symposium/ conference proceedings, thesis dissertations.
Exclusion: None

ELIGIBILITY CRITERIA

Condition or domain being studied
The role of progressive physiotherapy as part of a multidisciplinary approach to patient care in intensive care is unquestionable. Over the last two decades, early mobilisation of intensive care unit patients with a focus on improving functional mobility, has become a standard of care. Current evidence specifies that early mobilisation of mechanically ventilated intensive care patients is safe and feasible. Early mobilisation improves patient outcomes, decreases delirium, weakness and mortality, and can reduce hospital costs due to a decrease in the period of mechanical ventilation and length of stay.
However, one of the challenges of delivering early progressive physiotherapy in intensive care is limited staffing. This imbalance between the increasing demand for early mobilisation of intensive care patients and limited physiotherapy staffing, highlights the need for the prioritisation of patients and staff resource allocation and rationing. Scoring systems identifying intensive care unit patients in an order of priority for physiotherapy treatment could aid in patient selection, prove to be timesaving, and avoid controversies and uncertainties.

Population
Inclusion: Adult intensive care unit patients (18 years and older)
Exclusion: Paediatric and adolescent intensive care unit patients (unders 18 years old)

Intervention(s) or exposure(s)
Scoring systems or assessment tools which benchmarks the priority of a physiotherapy

treatment (evidence-based patient selection).

Comparator(s) or control(s)
Not applicable

OUTCOMES TO BE ANALYSED

Main outcomes
Determination of priority for physiotherapy treatment of intensive care unit patients.
Optimization and rationalization of physiotherapy staff resources in intensive care.

Additional outcomes
None

DATA COLLECTION PROCESS

Data extraction (selection and coding)
Eligible articles will be selected by two independent researches using clearly allocated inclusion-exclusion criteria in a two-part screening process. Initial screening of titles and abstracts will be performed to identify all potentially relevant articles. Thereafter, full-text publications of potential articles will be retrieved and read by two independent reviewers for eligibility of inclusion. If relevant articles cannot be obtained online, authors will be contacted directly. Any disagreement between the two reviewers will be resolved through discussion until consensus is reached.
The following data will be extracted from included literature and captured in a pre-constructed Microsoft Word Version 2209 spreadsheet: source (author, year), study location, language, study design, population, sample size, age, intervention, outcome.

Risk of bias (quality) assessment
Methodological quality of included literature will be assessed by two independent reviewers using a modified McMaster Critical Review Form for Quantitative Studies. Any discrepancies will be resolved through discussion until consensus is reached.

PLANNED DATA SYNTHESIS

Strategy for data synthesis
A formal narrative synthesis will be done. The following data will be extracted from included literature by two independent reviewers for comparison of similarities or differences (clinical and methodological heterogeneity), and captured in a pre-constructed Microsoft Word Version 2209 spreadsheet: source (author, year), study location, language, study design, population, sample size, age, intervention, outcome. The methodological quality (risk of bias) will be assessed by two independent external reviewers using a modified McMaster Critical Review Form for Quantitative Studies. Data extracted from included literature will be synthesized without meta-

analysis to report the outcome/s of scoring systems used to identify the priority of a physiotherapy treatment for patients on intensive care unit. The formal narrative synthesis will be guided by the SWiM (synthesis without meta-analysis) reporting items and reported results will be documented as raw scores (numbers) and percentages. The quality of evidence will be rated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE).

Analysis of subgroups or subsets
None planned.

REVIEW AFFILIATION, FUNDING AND PEER REVIEW

Review team members 1 change

- Ms Bernadette Bessick, Department of Physiotherapy, University Medical Centre Hamburg-Eppendorf, Hamburg
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- Professor Simon Pecha, Department of Cardiovascular Surgery, University Heart & Vascular Center Hamburg
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Funding source
None

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TIMELINE OF THE REVIEW

Review timeline
Start date: 11 July 2022. End date: 30 April 2023

Date of first submission to PROSPERO

11 July 2022

Date of registration in PROSPERO
22 July 2022

CURRENT REVIEW STAGE

Publication of review results
The intention is to publish the review once completed.The review will be published in English

Stage of the review at this submission

Review stage	Started	Completed
Pilot work	✓	✓
Formal searching/study identification	✓	✓
Screening search results against inclusion criteria	✓	✓
Data extraction or receipt of IP	✓	✓
Risk of bias/quality assessment	✓	✓
Data synthesis	✓	✓

Review is currently in the process of being written.

Review status
The review is currently planned or ongoing.

ADDITIONAL INFORMATION

Additional information
Due to limited evidence, grouping of studies and meta-analysis will not be possible. The certainty of evidence of included literature will be rated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE), whilst reported results will be presented in tabular form as raw scores and percentages.

PROSPERO version history

- Version 1.5 published on 30 Apr 2023
- Version 1.4 published on 30 Mar 2023
- Version 1.3 published on 28 Jan 2023
- Version 1.2 published on 16 Jan 2023
- Version 1.1 published on 22 Jul 2022
- Version 1.0 published on 22 Jul 2022

Review conflict of interest

None known

Country
Germany

Medical Subject Headings
Hospital Mortality; Humans; Intensive Care Units; Physical Therapy Modalities

Revision note 1 change
One of the review team members removed from the list due to inability to continue as active team member.

Disclaimer
The content of this record displays the information provided by the review team. PROSPERO does not peer review registration records or endorse their content.

PROSPERO accepts and posts the information provided in good faith; responsibility for record content rests with the review team. The owner of this record has affirmed that the information provided is truthful and that they understand that deliberate provision of inaccurate information may be construed as scientific misconduct.

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Any enquiries about the record should be referred to the named review contact

Appendix 2: PRISMA checklist (na = not applicable)

PRISMA 2020 Checklist (na = not applicable)

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	8-9
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	79-80
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	8
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	8
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	9
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	9-10
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	9-10; Appendix 3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	9-11
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	11
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	11
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	11
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	9-11
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	na
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	na
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	na
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	11
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	11
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	na

PRISMA 2020 Checklist (na = not applicable)

Section and Topic	Item #	Checklist item	Location where item is reported
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	na
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	na
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	11
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	12-13; Fig. 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	na
Study characteristics	17	Cite each included study and present its characteristics.	14-16; Table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	17-18; Table 2
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	na
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	17
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	na
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	na
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	na
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	na
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	17,19; Table 3
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	20-22
	23b	Discuss any limitations of the evidence included in the review.	20-21
	23c	Discuss any limitations of the review processes used.	21
	23d	Discuss implications of the results for practice, policy, and future research.	22
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	9, Appendix 1
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	9
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Appendix 1

PRISMA 2020 Checklist (na = not applicable)

Section and Topic	Item #	Checklist item	Location where item is reported
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	128
Competing interests	26	Declare any competing interests of review authors.	na
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	na

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

Appendix 3: Database search strategies

***PubMed Advanced Search:** Copy and paste the search strategy in plain text without filters in Query Box to reproduce search history. Add relevant filters thereafter.*

Electronic databases and registers

***PubMed - Advanced Search 1:**

("scoring system"[Title/Abstract] OR "functional score"[Title/Abstract] OR "functional status"[MeSH Terms] OR "physical functional performance"[MeSH Terms] OR "functional scales"[All Fields] OR "mobility limitation"[All Fields] OR "activities of daily living"[MeSH Terms]) AND ("intensive care units"[MeSH Terms] NOT "neonatal"[All Fields] OR "respiratory care units"[MeSH Terms] NOT "neonatal"[All Fields] OR "intensive care"[All Fields] NOT "neonatal"[All Fields] OR "icu"[All Fields] NOT "neonatal"[All Fields] OR "critical care unit"[All Fields] NOT "neonatal"[All Fields]) AND ("physical therapy modalities"[MeSH Terms] OR "physiotherapy"[All Fields]) Filters: Humans, Adult: 19+ years, Humans, Adult: 19+ years

***PubMed - Advanced Search 2:**

("scoring system"[Title/Abstract] OR "functional score"[Title/Abstract] OR "functional status"[MeSH Terms] OR "physical functional performance"[MeSH Terms] OR "functional scales"[All Fields] OR "mobility limitation"[All Fields] OR "activities of daily living"[MeSH Terms]) AND ("intensive care units"[MeSH Terms] NOT "neonatal"[All Fields] OR "respiratory care units"[MeSH Terms] NOT "neonatal"[All Fields] OR "intensive care"[All Fields] NOT "neonatal"[All Fields] OR "icu"[All Fields] NOT "neonatal"[All Fields] OR "critical care unit"[All Fields] NOT "neonatal"[All Fields]) Filters: Humans, Adult: 19+ years, Humans, Adult: 19+ years

***PubMed - Advanced Search 3:**

"intensive care units"[MeSH Terms] NOT "neonatal"[All Fields] OR "respiratory care units"[MeSH Terms] NOT "neonatal"[All Fields] OR "intensive care"[All Fields] NOT "neonatal"[All Fields] OR "icu"[All Fields] NOT "neonatal"[All Fields] OR "critical care unit"[All Fields] NOT "neonatal"[All Fields]) AND ("weekend physiotherapy"[All Fields] OR "after hours care"[MeSH Terms] OR "after hours"[All Fields]) Filters: Humans, Adult: 19+ years

PubMed - Advanced Search 4:

("algorithms"[MeSH Terms]) AND ("intensive care units"[MeSH Terms]) NOT ("neonatal"[All Fields]) AND ("physical therapy modalities"[MeSH Terms])

***PubMed - Advanced Search 5:**

"Weekend physiotherapy"[All Fields]

***PubMed - Advanced Search 6:**

("intensive care"[All Fields]) NOT ("neonatal"[All Fields])) OR ("critical care"[All Fields])) NOT ("neonatal"[All Fields])) AND ("rationing"[All Fields]) Filters: Humans, Adult: 19+ years

Cochrane Library - Advanced Search:

ID	Search Hits
#1	MeSH descriptor: [Functional Status] explode all trees
#2	MeSH descriptor: [Physical Functional Performance] explode all trees
#3	("functional status"):ti,ab,kw
#4	("physical functional performance"):ti,ab,kw
#5	#1 OR #2 OR #3 OR #4 (Word variations have been searched)
#6	MeSH descriptor: [Intensive Care Units] explode all trees
#7	MeSH descriptor: [Respiratory Care Units] explode all trees
#8	MeSH descriptor: [Critical Care] explode all trees
#9	("intensive care unit"):ti,ab,kw
#10	("respiratory care unit"):ti,ab,kw
#11	("critical care unit"):ti,ab,kw
#12	#6 OR #7 OR #8 OR #9 OR #10 OR #11 (Word variations have been searched)
#13	MeSH descriptor: [Physical Therapy Modalities] explode all trees
#14	MeSH descriptor: [Physical Therapy Specialty] explode all trees
#15	("physical therapy"):ti,ab,kw
#16	("physical therapy modalities"):ti,ab,kw
#17	("physical therapy specialty"):ti,ab,kw
#18	#13 OR #14 OR #15 OR #16 OR #17 (Word variations have been searched)
#19	#5 AND #12 AND #18 30

PEDro – Advanced search:
Abstract and Title: "functional status" "intensive care"
When Searching: Match all search terms (AND)

CINAHL -Advanced search:
Boolean/Phrase
physiotherapy or physical therapy or physiotherapist or physical therapist (All text)
AND intensive care unit or icu or critical care or critical care unit (Title)
NOT neonatal (All text)

Expanders

- Apply related words
- Also search within the full text of the articles.
- Apply equivalent subjects

Limiters

Age

- all adult

Subject: Major Heading
intensive care units, physical therapy, critically ill patients, critical illness, muscle weakness, early ambulation, length of stay, ventilator weaning, critical care, multidisciplinary care team, .respiratory therapy, treatment outcomes, functional assessment,
functional status

Google Scholar - Advanced Search
with **all** the words: “algorithm” OR “functional status “AND “intensive care” AND “Physical therapy”
with **all** the words: “conference proceedings” OR “symposium” AND “intensive care”

without the words: neonatal
anywhere in the article

<u>Registries:</u>
BASE (Bielefeld Academic Search Engine)
critical illness in adults AND physical therapy AND algorithm
conference proceedings AND physical therapy AND algorithm AND ICU
critical illness in adults AND thesis AND algorithm AND physiotherapy

British Library – Main Catalogue – Advanced search
Show results from – Everything
Query - Any field contains - “Critical illness in adults”
AND – Any field – contains - “physiotherapy”
AND – Any field – contains - “intensive care units”
AND – Any field – contains - “critical care”
AND – Any field – contains - “respiratory care”
AND – Any field – contains - “critically ill patients”
AND – Any field – contains - “early mobilisation”

ClinicalTrials.gov.
“Critical illness” (disease) “algorithm”, “physical therapy” (intervention)

EU Clinical Trials Register
“Critical illness” AND “algorithm”

Australian Clinical Trials
“Critical illness” AND “physiotherapy”

Grey Literature:
NICE (National institute for Health and Care Excellence)
“Critical illness in adults” AND “physical therapy”

Google search engine
scoring system AND physiotherapy
algorithm AND physiotherapy
patient prioritisation AND physiotherapy
intensive care AND rationing AND allied health

Appendix 4: Algorithm, Fründ et al. (2012)

Erstellung eines Algorithmus für die Übergabe von Patienten in einen Wochenenddienst einer kardiologischen/kardiochirurgischen Klinik

Andreas Fründ[1]* ,Serge Fuhrmann[1]*, H. Pupkes[1], Dieter Horstkotte[2], Jan Gummert[3]

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[2] Kardiologische Klinik , HDZ NRW, Ruhr-Universität-Bochum

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* Gleichberechtigte Autoren

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Abteilung Physikalische Therapie
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Phone:+ 49 5731 97-2287, Fax: + 49 5731 97-2887

email: afruend@hdz-nrw.de

Abstract

Ziele:

Der erweiterte physiotherapeutische Wochenenddienst ist für die Aufrechterhaltung einer hohen qualitativen Versorgung kardiologischer und kardiochirurgischer Patienten aus unserem berufspolitischen Selbstverständnis absolut notwendig. Für die Festlegung der Patienten, die in diesem Wochenenddienst therapiert werden sollten, gibt es jedoch häufig unterschiedliche Einschätzungen. Daher erarbeiteten wir einen abteilungsübergreifenden Algorithmus, um diese Patienten zu erkennen.

Methode:

Anhand unserer im QM definierten Behandlungsziele erarbeitete eine Kleingruppe des Physioteams einen Punktekatalog zur Definition dieser Patienten. In einer Versuchsphase wurden diese Definitionen feiner justiert und erprobt. Anfang 2011 wurden dieses Schema implementiert und von der Gesamtheit der Abteilung in Kraft gesetzt.

Standardbeschreibung
Wochenenddienstpatienten

Ärztliche Leitung

Physiotherapieleitung

HDZ NRW
Herz- und Diabeteszentrum
UK RUB

Gültig ab	01.01.2011
Version:	1.0

Punkte	2	1	0
Symptome			
Sekret	viel zäh	mässig	kein
			gut abzusaugen
			gut anzuhusten
Oxy	pO^2 (art)	102-0,33xLebensalter	
	< 85% RL	85-88 RL	> 88 RL
	50% O^2 Beatmung	40% O^2 Beatmung	30% O^2 Beatmung
Ventilation	ATL +2 Pkt Sekretstau	Retraktionsatelektase	Pneu ohne Sog
Entzündl. Pulm	Pneumonie frisch u. nicht beatmet	COPD Symptom	COPD chron. Asymptomatisch
Punkte	8	4	

Bewegungsablauf		Punkte			
Stehen zum Gehen	ohne Hilfe	1	Mit Hilfe	nicht möglich	
Stand	ohne Hilfe	2	Mit Hilfe		Tinetti ?
Sitzen zum stehen	ohne Hilfe	3	Mit Hilfe	nicht möglich	BBS ?
Sitzen	ohne Hilfe	4	Mit Hilfe		
liegen zum sitzen	ohne Hilfe	5	Mit Hilfe	6 nicht möglich	
Gesamt:				6	

* Unterstützung der aktiven neuromuskulären Ressourcen des Patienten durch eine Physiotherapeutische Intervention
** Dokumentierte Behandlungsfortschritte sind aus den letzten drei Behandlungen erkennbar

Schlussfolgerung:

Die Einführung eines Algorithmus zur Einschätzung von Patienten in der Wochenendbetreuung hat sich absolut bewährt, es sind nur noch Anpassungen aufgrund veränderter Patientenstrukuren erforderlich. Zudem hat sich gezeigt, dass der Konsens auch dazu führte, Konfliktpotenzial im Team hinsichtlich der Einschätzung der Patienten zu reduzieren.

Appendix 5: Approval WPR and NPR (UKE)

Schumacher, Ron <r.schumacher@uke.de>

Freitag, 5. Januar 2024 16:05

NPR <npr@uke.de>; Personalrat für das Wissenschaftliche Personal (WPR) <wpr@uke.de>

Cc: Zastrow, Inke <i.zastrow@uke.de>

Betreff: WG: Forschungsprojekt: Scoring-System in der Intensivmedizin zur Bestimmung der physiotherapeutischen Behandlungspriorität

Sehr geehrter Herr Dr. Schultze, sehr geehrter Herr Horn,
sehr geehrte Damen und Herren,

beigefügt finden Sie die Unterlagen für das Ph.D. Forschungsprojekt von Frau Bessick, Bernadette Estelle, die sich mit einem „Scoring-System in der Intensivmedizin zur Bestimmung der physiotherapeutischen Behandlungspriorität“, beschäftigt.

Weitere Informationen zum Forschungsprojekt entnehmen Sie bitte der Anlage.

Als Anlage erhalten Sie das Exposé, das Informationsschreiben mit Datenschutzerklärung, die Einverständniserklärung sowie den Interviewleitfaden.

Die Teilnahme an der Befragung ist freiwillig und kann während der Arbeitszeit erfolgen. Eine Leistungs- oder Verhaltenskontrolle ist nicht beabsichtigt.

Die Koordination erfolgt über Frau Inke Zastrow, DPP, die auch für Rückfragen zur Verfügung steht. Hinweis: Frau Zastrow selbst ist nicht an der Studie beteiligt und ist in diesem Zusammenhang in vermittelnder Funktion tätig.

Die Personalvertretungen werden um wohlwollende Stellungnahme gebeten.

Mit freundlichen Grüßen

Ron Schumacher

_____

Vorstandsbeauftragter
für
Personalratsangelegenhei
ten

Universitätsklinikum Hamburg-Eppendorf

Geschäftsbereich Recht

Personalrat für das Wissenschaftliche Personal (WPR)

Donnerstag, 11. Januar 2024 17:47

Schumacher, Ron

Cc: Zastrow, Inke; NPR; Bessick, Bernadette Estelle; Personalrat für das Wissenschaftliche Personal (WPR)

Betreff: AW: Forschungsprojekt: Scoring-System in der Intensivmedizin zur Bestimmung der physiotherapeutischen Behandlungspriorität

Sehr geehrter Herr Schumacher,

der Personalrat für das Wissenschaftliche Personal (WPR) hat sich in seiner Sitzung am 11.01.2024 mit dem geplanten Forschungsprojekt befasst und stimmt der Durchführung zu.

Im Auftrag der stellvertretenden Vorsitzenden Frau Prof. Dr. Petra Schmage.

Mit freundlichen Grüßen

Marianne Mehl

Sekretariat WPR

Wissen – Forschen – Heilen durch vernetzte Kompetenz – das UKE

Universitätsklinikum Hamburg-Eppendorf

Personalrat für das Wissenschaftliche Personal (WPR)

Zastrow, Inke

Freitag, 19. Januar 2024 13:51

Bessick, Bernadette Estelle

Betreff: Zustimmung NPR

Liebe Frau Bessick,

ich freue mich Ihnen mitteilen zu können, dass auch der NPR Ihrem Vorhaben zugestimmt hat. Sie dürfen nun also starten.

Ich wünsche Ihnen viel Erfolg!

Viele Grüße

Inke Zastrow

Inke Zastrow (M.Sc.N.)

Pflegewissenschaftlerin

Pflegeexpertin

Universitätsklinikum Hamburg-Eppendorf

Direktion für Patienten- und Pflegemanagement (DPP)

Appendix 6: COREQ checklist (81)

COREQ (COnsolidated criteria for REporting Qualitative research) Checklist

A checklist of items that should be included in reports of qualitative research. You must report the page number in your manuscript where you consider each of the items listed in this checklist. If you have not included this information, either revise your manuscript accordingly before submitting or note N/A.

Topic	Item No.	Guide Questions/Description	Reported on Page
Domain 1: Research team and reflexivity			
Personal characteristics			
Interviewer/facilitator	1	Which author/s conducted the interview or focus group?	23-25
Credentials	2	What were the researcher's credentials? E.g. PhD, MD	110, Appendix 7
Occupation	3	What was their occupation at the time of the study?	110, Appendix 7
Gender	4	Was the researcher male or female?	110, Appendix 7
Experience and training	5	What experience or training did the researcher have?	110, Appendix 7
Relationship with participants			
Relationship established	6	Was a relationship established prior to study commencement?	42, Appendix 7
Participant knowledge of the interviewer	7	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	25,42
Interviewer characteristics	8	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	42
Domain 2: Study design			
Theoretical framework			
Methodological orientation and Theory	9	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	24-27
Participant selection			
Sampling	10	How were participants selected? e.g. purposive, convenience, consecutive, snowball	24-25
Method of approach	11	How were participants approached? e.g. face-to-face, telephone, mail, email	25
Sample size	12	How many participants were in the study?	25
Non-participation	13	How many people refused to participate or dropped out? Reasons?	N/A

Setting			
Setting of data collection	14	Where was the data collected? e.g. home, clinic, workplace	24-25
Presence of nonparticipants	15	Was anyone else present besides the participants and researchers?	25
Description of sample	16	What are the important characteristics of the sample? e.g. demographic data, date	24-25
Data collection			
Interview guide	17	Were questions, prompts, guides provided by the authors? Was it pilot tested?	25, Appendix 8 Appendix 9
Repeat interviews	18	Were repeat inter views carried out? If yes, how many?	N/A
Audio/visual recording	19	Did the research use audio or visual recording to collect the data?	25
Field notes	20	Were field notes made during and/or after the interview or focus group?	N/A
Duration	21	What was the duration of the inter views or focus group?	25
Data saturation	22	Was data saturation discussed?	24
Transcripts returned	23	Were transcripts returned to participants for comment and/or correction?	N/A
Topic	**Item No.**	**Guide Questions/Description**	**Reported on Page No.**
Domain 3: analysis and findings			
Data analysis			
Number of data coders	24	How many data coders coded the data?	25-27
Description of the coding tree	25	Did authors provide a description of the coding tree?	25-27
Derivation of themes	26	Were themes identified in advance or derived from the data?	26-27
Software	27	What software, if applicable, was used to manage the data?	25
Participant checking	28	Did participants provide feedback on the findings?	N/A
Reporting			
Quotations presented	29	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	33-40
Data and findings consistent	30	Was there consistency between the data presented and the findings?	29-40
Clarity of major themes	31	Were major themes clearly presented in the findings?	27-40
Clarity of minor themes	32	Is there a description of diverse cases or discussion of minor themes?	N/A

Appendix 7: Recruitment notice – interviews

UKE Klinik für Intensivmedizin / Physiotherapie



Hallo liebe Kolleg:innen in der KIM,

Mein Name ist Bernadette Bessick, einige von Euch / Ihnen kennen mich vielleicht schon als "Bernie". Ich bin Physiotherapeutin am UKE und arbeite derzeit an meiner Promotion (PhD) in der KIM. Das Thema meiner Promotion ist ein Scoring-System zur Bewertung der physiotherapeutischen Behandlungspriorität in der KIM, besonders am Wochenende und Feiertagen.

Der NPR und WPR im UKE sowie die ärztliche und pflegerische Zentrumsleitung in der KIM haben meinem Vorhaben zugestimmt und ich habe auf dem letzten DIVI für mein Vorhaben den Forschungsförderpreis erhalten.

Ich möchte gerne in den nächsten Monaten Interviews mit Euch / Ihnen (Ärzt: innen, Pflegefachpersonen, Physiotherapeut: innen) durchführen. Das Interview hat eine Dauer von ca. 15-20 min. Wenn Ihr länger als 6 Monate in der KIM arbeitet und aus den Berufsgruppen Mediziner, Pflege oder Physiotherapie kommt, würde ich mich sehr über Eure Teilnahme an den Interviews freuen.

Falls ich Euer / Ihr Interesse geweckt habe und Ihr / Sie mich unterstützen möchtet, würde ich mich sehr freuen. Die Teilnahme am Interview ist selbstverständlich freiwillig.

Schreibt mir gerne eine E-Mail an: b.bessick@uke.de (Betreff: KIM-Interviews)

Sobald ich eine UKE-Handynummer habe, leite ich diese auch weiter.

Viele Grüße Bernadette Bessick

Appendix 8: Interview guide - German

02.02.2024

Interview-Leitfaden:

Zur Gewinnung qualitativer Daten über die Wahrnehmungen und Erfahrungen bezüglich der Auswahl und Priorisierung von Patient:innen für die Physiotherapie sowie, ob diese Erkenntnisse zur Entwicklung eines Scoring-Tools beitragen könnten, das die Priorisierung von Patient neben dem „Clinical Judgment" unterstützen könnte.

1. Können Sie mir bitte Ihre Berufsgruppe mitteilen?

Physician/ Gesundheits- und Krankenpflege/ Physiotherapie

2. Können Sie mir bitte Ihre Fachdisziplin mitteilen?

3. Wie lange arbeiten Sie schon in der KIM?

6 - 12 Monate **12 - 24 Monate** **> 24 Monate**

4. Meines Wissens kann am Wochenende/ an den Feiertagen lediglich eine begrenzte Anzahl von Patient:innen physiotherapeutisch behandelt werden. Sind Sie an der Auswahl von Patient:innen beteiligt? **JA** **NEIN** **INDIREKT**

- Wenn **„JA"** zu **Frage 4**, dann weiter zu **Frage 5**
- Wenn „**NEIN**" zu **Frage 4**, dann weiter zu **Frage 6**

5. Wenn „**JA" zu Frage 4**:

5.1 Wie sind Sie dabei involviert? z.B. durch eigenständige Auswahl der Patient: innen oder in Zusammenarbeit mit anderen Teammitgliedern der KIM?

5.2 Welche Kriterien berücksichtigen Sie bei der Auswahl und Priorisierung von Patient:innen?

5.3 Warum verwenden Sie diese Kriterien?

5.4 Welche weiteren Kriterien (objektive oder auch subjektive) könnten bei der Auswahl von Patient:innen berücksichtigt werden?

5.5 Wie viel Zeit verbringen Sie durchschnittlich damit, Patienten: innen in der KIM am Wochenende oder feiertags auszuwählen?

5.6 Wie empfinden Sie den derzeitigen Auswahlprozess in der KIM?

Weiter zu Frage 7

6. Wenn „**NEIN" oder „INDIREKT" zu Frage 4**:

6.1 Wer ist für die Auswahl die Patient:innen an den Wochenenden/ an den Feiertagen zuständig?

6.2 Wie denken Sie werden derzeit die Patienten: innen für Physiotherapie in der KIM am Wochenende oder feiertags ausgewählt?

6.3 Wie lange, denken Sie, benötigen die Ärzt:innen um die Patient:innen zu priorisieren?

6.4 Wie empfinden Sie den derzeitigen Auswahlprozess in der KIM?

6.5 Welche Kriterien würden Sie berücksichtigen, wenn Sie Patienten: innen priorisieren müssten?

6.6 Warum würden Sie diese Kriterien verwenden?

7. Haben Sie Vorschläge zur Verbesserung oder Optimierung der derzeitigen Priorisierung von Patient:innen?

8. Halten Sie ein Scoring-Tool für machbar und sinnvoll, um die Priorisierung von Patient:innen zu unterstützen?

9. Wie sollte ein solches Scoring-Tool Ihrer Meinung nach aussehen?

Appendix 9: Interview guide – English

02.02.2024

Interview Guide:

To collect qualitative data regarding the perceptions and experiences of ICU staff with respect to patient selection and prioritization for physiotherapy, and to determine whether these insights could inform the development of an objective, standardized tool that could be used as an adjunct to clinical judgment to prioritize patients for physiotherapy treatment.

1. Could you please specify your profession?
Physician/ Nursing/ Physiotherapy

2. Could you please specify your area of specialization in the ICU?

3. How many months or years of working experience do you have in the ICU?

6 - 12 months **12 - 24 months** **> 24 months**

4. If I understand correctly, only a limited number of patients can receive physiotherapy treatment in the ICU during weekends and public holidays. Are you involved in selecting these patients?

YES **NO** **INDIRECTLY**

- If **"YES/ INDIRECTLY"** to Question 4, then proceed to Question 5
- If **"NO"** to Question 4, then proceed to Question 6

5. If **"YES/ INDIRECTLY"** to Question 4:

5.1 How are you involved in the patient selection process? e.g., through independent selection of patients or in collaboration with other team members in the ICU?

5.2 What criteria (e.g., inclusion and exclusion) do you consider when prioritizing patients for physiotherapy treatment?

5.3 Why do you use these criteria for patient selection?

5.4 What other criteria (objective or subjective) could be considered when prioritizing patients in the ICU for physiotherapy.

5.5 How much time, on average, do you need to prioritize patients for physiotherapy?

5.6 How do you perceive the current selection and prioritization process?

Proceed to Question 7

6. If **"NO"** to Question 4:

6.1 Who is responsible for the selection and prioritization of patients for physiotherapy on weekends or public holidays?

6.2 How do you think patients are currently prioritized for physiotherapy treatment?

6.3 How would you assess the current patient selection process in the ICU?

6.4 What criteria would you consider if you had to prioritize patients in the ICU for physiotherapy?

6.5 Why would you use these criteria?

7. Do you have any suggestions for improving or optimizing the current patient selection and prioritization process?

8. What is your opinion regarding the feasibility and usability of implementing a scoring tool to be used alongside clinical judgment for patient prioritization?

9. In your opinion, what features should such a scoring tool have?

Appendix 10: COSMIN Checklist (content validity)

Box D. Content validity (including face validity)

	General requirements	yes	no	?
1	Was there an assessment of whether all items refer to relevant aspects of the construct to be measured?	☑	☐	☐
2	Was there an assessment of whether all items are relevant for the study population? (e.g. age, gender, disease characteristics, country, setting)	☑	☐	☐
3	Was there an assessment of whether all items are relevant for the purpose of the measurement instrument? (discriminative, evaluative, and/or predictive)	☑	☐	☐
4	Was there an assessment of whether all items together comprehensively reflect the construct to be measured?	☑	☐	☐
5	Were there any important flaws in the design or methods of the study?	☐	☑	

Appendix 11: Physiotherapy Standards of Practice (SOP)

Prioritätenliste

1 Priorität A

Neben gesetzlichen Vorgaben und Richtlinien werden folgende Systeme/Wirkorte berücksichtigt:
Atmung/Innere Organe, Bewegungsentwicklung, Bewegungsorganisation, Erleben und Verhalten

- Extubation, Atelektasen, Dystelektasen, Weaning, Pat. vor/nach Extubation bei Störung des Gasaustausches, instabile Vitalparameter
- Physiotherapeutische Behandlung am 1. post-Op Tag nach Gelenk Op's
- Patient:innen mit hüftgelenknaher Femurfraktur an 1. post OP Tag
- frische Plegien/Paresen (Stoke Unit -92 Stunden)
- AdL Training z.B. Transfer an die Bettkante und Stand erarbeiten
- zeitnahe postoperative Physiotherapie z.B. nach Herz OP's
- neurologische Ausfälle z. B. frische Querschnitte/Frühreha- Patienten
- Erhalt der Beweglichkeit > nach Arthrolysen
- Endoprothesen > Einsatz von CPM (Motorschiene)
- durch physiotherapeutische Behandlung schnellere Entlassung Verkürzung der Liegezeit > DRG

2 Priorität B

- Lymphdrainage stationär
- Chronisch obstruktive Lungenerkrankungen
- Prävention > Verschlechterung der Vitalwerte verhindern
- Immobilität mit Bettruhe > Kontrolle des Eigenübungsprogrammes z.B. Atemtrainer,
- WOB
- Kontrakturprophylaxe
- große operative Eingriffe ab dem 2. – 3. Tag
- Patienten bei denen sich das Behandlungsergebnis verschlechtern würde
- im Intensivbereich der Transfer an die Bettkante > WOB
- Ziel Teilhabe/Partizipation am tgl. Leben
- manuelle Therapie an Gelenken > Parameter: Schmerz, Mobilität, Bewegung
- akut stationäre Schmerzpatienten

3 Priorität C

- Therapieziel erreicht z.B. bei neurologischen Diagnosen/Erhalt der Funktionen
- Überprüfung des Eigenübungsprogramms
- Entlassungstag
- Prävention

Version	Änderungen gegenüber der letzten Fassung:
07	Anpassung an die Vorlage 2021
08	Anpassung der Prioritäten A und B

Appendix 12: User guide pilot study (German)

Anwendungsleitfaden: ICU-Physiotherapie-Priorisierungsalgorithmus (IPPA)

Abkürzungen:

- **RASS** = Richmond Agitation-Sedation Scale
- **ICDSC** = Intensive Care Delirium Screening Checklist
- **Horovitz-Index** = Lung function, gaseous exchange (ARDS)
- **IMS** = ICU Mobility Scale

***Neurological event**:

Progressive Störung des Bewusstseins und der kognitiven Funktionen. Patient:innen mit tiefer Sedierung bzw. fehlender Erregbarkeit (RASS < −3) werden in der Regel nicht mobilisiert. Eine Ausnahme bilden neurologisch bedingte Bewusstseinsstörungen, bei denen Mobilisation die Wachsamkeit fördern kann. Postoperative neurologische Ereignisse.

RASS Score	Klinische Präsentation
≥ +2 to +4	Unruhig, häufige nicht-zweckmäßige Bewegungen, Zieht Leitungen, stark agitierend
-2 to 0 to +1	Erwacht kurz auf Ansprache, Wach oder leicht schläfrig, ruhig oder leicht unruhig
-3 to –5	Tiefe Sedierung, minimale/keine Reaktion

*AUSSCHLUSS/ EXCLUSION

(The decision to exclude is left up to the discretion of the individual physician)

- **HEMODYNAMISCHE INSTABILITÄT**

  MAP < 60 oder >110 trotz Support, SBP <90 oder >180–200, Eskalierende Vasopressoren/Inotropika, Unkontrollierte Arrhythmie, Tachykardie, Bradykardie, Instabile Hyperthermie >38°C, Instabile Hypothermie <35°C, Aktive kardiale Ischämie, Aktive, unkontrollierte Blutung, Schwere Anorexia nervosa (BMI <14 kg/m²)

- **RESPIRATORISCHE INSTABILITÄT**

FiO_2 >0,8 bei SpO_2 <88%, Schwere Ventilator-Dyssynchronie, Rasche/akute O_2-Desaturierung bei minimaler Belastung

- **KONTRAINDIKATIONEN – MOBILISATION**
  Offenes Abdomen / offene Sternotomie, nicht erweckbar (RASS –5), Instabile Frakturen / Polytrauma, Instabile Wirbelsäulenverletzung, Instabiler ICP (Intrakranieller Druck)

- **SONSTIGES**
  Neurologische Instabilität - akute neurologische Verschlechterung, frischer Schlaganfall oder intrakranielle Blutung mit klinischer Instabilität, unkontrollierte Krampfanfälle sowie fehlende Kooperationsfähigkeit.

PARAMETER	Wo finde ich das in der ICM-Dokumentation
Horovitz-Index, ARDS (PaO2/FiO2)	Tageskurve: Vitalparameter
Ventilation	Tageskurve: Beatmung
Oxygenierung	Tageskurve: Abschnitt Vitalparameter
Sekretlast	Physiotherapiedokumentation: Abschnitt Atmung
Hustenkraft	Physiotherapiedokumentation
ICU Mobility Scale	Pflegedokumentation Physiotherapiedokumentation: Abschnitt Mobilisation
Delir (ICDSC)	Pflegedokumentation Physiotherapiedokumentation: Abschnitt Mobilisation Ärztliche Verlaufsdokumentation
„Neurological Event“	Ärztliche Verlaufsdokumentation

CONSORT 2010 checklist of information to include when reporting a pilot or feasibility trial

Section/Topic	Item No	Checklist item (na = not applicable)	Reported on page No
Title and abstract			
	1a	Identification as a pilot or feasibility randomised trial in the title	53-54
	1b	Structured summary of pilot trial design, methods, results, and conclusions (for specific guidance see CONSORT abstract extension for pilot trials)	54-55
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale for future definitive trial, and reasons for randomised pilot trial	na
	2b	Specific objectives or research questions for pilot trial	53
Methods			
Trial design	3a	Description of pilot trial design (such as parallel, factorial) including allocation ratio	54
	3b	Important changes to methods after pilot trial commencement (such as eligibility criteria), with reasons	na
Participants	4a	Eligibility criteria for participants	54-55
	4b	Settings and locations where the data were collected	54-55
	4c	How participants were identified and consented	54-55
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	54-58
Outcomes	6a	Completely defined prespecified assessments or measurements to address each pilot trial objective specified in 2b, including how and when they were assessed	56-58
	6b	Any changes to pilot trial assessments or measurements after the pilot trial commenced, with reasons	na
	6c	If applicable, prespecified criteria used to judge whether, or how, to proceed with future definitive trial	na
Sample size	7a	Rationale for numbers in the pilot trial	56
	7b	When applicable, explanation of any interim analyses and stopping guidelines	na
Randomisation:			na
Sequence generation	8a	Method used to generate the random allocation sequence	na
	8b	Type of randomisation(s); details of any restriction (such as blocking and block size)	na
Allocation concealment mech.	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	na

Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	na
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	na
	11b	If relevant, description of the similarity of interventions	na
Statistical methods	12	Methods used to address each pilot trial objective whether qualitative or quantitative	56-58
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were approached and/or assessed for eligibility, randomly assigned, received intended treatment, and were assessed for each objective	59-62
	13b	For each group, losses and exclusions after randomisation, together with reasons	na
Recruitment	14a	Dates defining the periods of recruitment and follow-up	na
	14b	Why the pilot trial ended or was stopped	na
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	59
Numbers analysed	16	For each objective, number of participants (denominator) included in each analysis. If relevant, these numbers should be by randomised group	na
Outcomes and estimation	17	For each objective, results including expressions of uncertainty (such as 95% confidence interval) for any estimates. If relevant, these results should be by randomised group	na
Ancillary analyses	18	Results of any other analyses performed that could be used to inform the future definitive trial	61-70
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	na
	19a	If relevant, other important unintended consequences	na
Discussion			
Limitations	20	Pilot trial limitations, addressing sources of potential bias and remaining uncertainty about feasibility	71-74
Generalisability	21	Generalisability (applicability) of pilot trial methods and findings to future definitive trial and other studies	76-77
Interpretation	22	Interpretation consistent with pilot trial objectives and findings, balancing potential benefits and harms, and considering other relevant evidence	na
	22a	Implications for progression from pilot to future definitive trial, including any proposed amendments	77-78
Other information			
Registration	23	Registration number for pilot trial and name of trial registry	na
Protocol	24	Where the pilot trial protocol can be accessed, if available	na
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	na
	26	Ethical approval or approval by research review committee, confirmed with reference number	53

Appendix 14: STROBE checklist (na = not applicable)

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	53-54
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	79-80
Objectives	3	State specific objectives, including any prespecified hypotheses	53
Methods			
Study design	4	Present key elements of study design early in the paper	54
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	54-55
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	54-55 na
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	55-58
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	56-58
Bias	9	Describe any efforts to address potential sources of bias	na
Study size	10	Explain how the study size was arrived at	56
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	56-58
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	56-58 na na na na
Results			
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	59-70 na 60, Fig.3
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	na na na
Outcome data	15	Report numbers of outcome events or summary measures over time	na

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	na
		(*b*) Report category boundaries when continuous variables were categorized	na
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	na
Discussion			
Key results	18	Summarise key results with reference to study objectives	71-74
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	71-74, 75-77
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	77
Generalisability	21	Discuss the generalisability (external validity) of the study results	77
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	na

Appendix 15: Ad hoc feedback questionnaire pilot study

Pilot Studie IPPA - KIM

Bemerkungen

1. **Zeitaufwand** in Minuten:

2. **Workflow:**

   Lässt sich der IPPA in den klinischen Ablauf integrieren?

3. **Akzeptanz:**

   a) Würden Sie den Algorithmus regelmäßig im ICU-Alltag anwenden?
   b) Halten Sie den IPPA für klinisch relevant und potenziell nützlich?

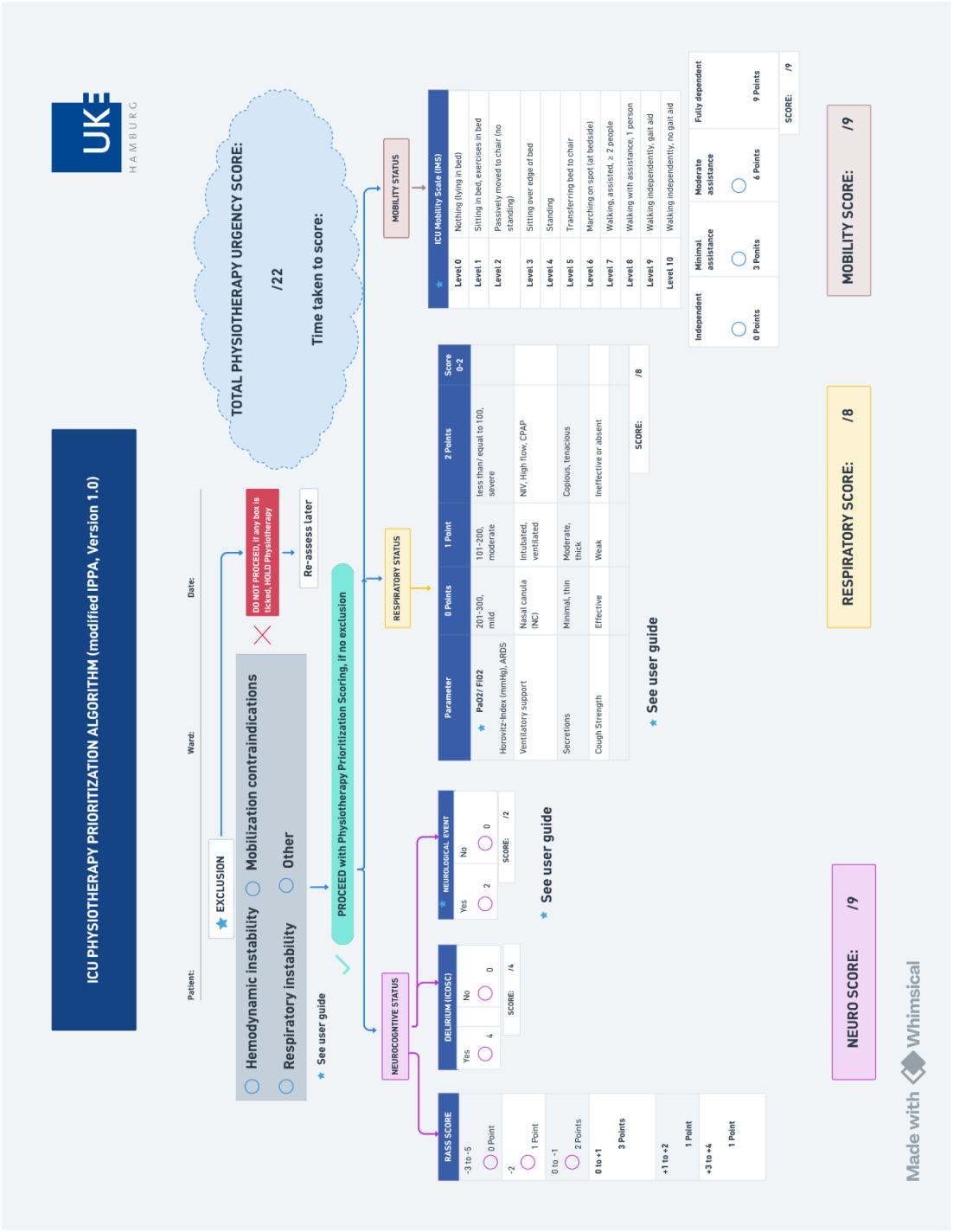
4. **Datenverfügbarkeit („Missing data rate"):**

   Sind alle relevanter Daten aus den elektronischen Gesundheitsakten im klinischen Alltag verfügbar?

5. **Usability (Benutzerfreundlichkeit):**

   Bitte verwenden Sie die angehängte System Usability Scale (SUS)

Appendix 16: Modified IPPA (Version 1.0)



Appendix 17: Author contributions / AI tools

I was responsible for conducting all four of my research studies comprising my PhD thesis. This included the following: **Conceptualization, planning, methodology, conduction of study, data collection, analysis including quality assessments, and writing of the research studies**.

My contributions to my PhD thesis are listed in tabular form below. For simplification, I, the main author of this doctoral thesis will be listed as BB.

In addition, I have added the role of external reviewers.

Research task	Person/ Source
Systematic literature - screening databases, selection articles, extraction, quality assessment, writing	BB
- Advice with initial conceptualization	Thesis committee
- 2nd reviewer in screening proportion of databases and articles for consensus	ML, JB
- Opinions from external reviewers regarding quality assessment for consensus on included sources	TD, MH
- Editing	BB, Thesis committee
Qualitative interview study – completing written, informed consent forms, recruitment, interview guide in English and German, conducting interviews, transcribing, coding, developing themes, subthemes	BB
- Advice interview guide and translational accuracies	AG
- Consensus checking themes, subthemes	AG, JB
- Transcription assist	f4X transcript
- Check for translational accuracies of semantic verbatim quotes	HB

Development ICU Physiotherapy Prioritization Algorithm – item generation, item reduction, design, weighting, scaling, content validity calculation, pre-piloting	BB
- Expert panel opinion: items, content validity	LS, JS, TK, JBi
- IPPA Flowchart design	BB, Whimsical AI Flowchart tool
Pilot evaluation of ICU Algorithm (IPPA) – rater recruitment, development rater guide, ad hoc questionnaire, rater training, collection patient electronic data and lists, statistical analysis	BB
- Advice on statistical analysis	Doctoral supervisor, GS
Entire doctoral thesis – grammar and language check, formatting	BB, Thesis committee
Entire doctoral thesis document – AI grammar and language check with following Prompt: *"Please correct the text grammatically, correct spelling and punctuation, and remove redundancies to make more coherent, but keep my text scientific, keep my content and context, and keep very close to my original text without borrowing phrasing from other literature sources"*	ChatGPT Plus
References	Mendeley reference manager

Appendix 18: Conference poster presentations

Preliminary results of parts of this doctoral thesis have been presented as a poster at scientific conferences. These include:

1. Bernadette Bessick, Gesche Ketels, Yskert von Kodolitsch, Simon Pecha, Antonia Zapf, Friederike Grube, Susanne Klotz. *Scoring systems in intensive care to benchmark the priority of physiotherapy treatment: A systematic review*. In: Center For Health Care Research and Public Health (CHCRPH): Junior Researcher´s Day, June 8, UKE, Hamburg, *Germany, 2023.*
2. B. Bessick, G. Ketels, A. Zapf, S. Pecha, Y. von Kodolitsch, F. Grube, S. Klotz, A. Gerlach. *Scoring System in der Intensivmedizin zur Bestimmung physiotherapeutischen Behandlungspriorität.* In: DIVI-Kongress, November 29, CCH Hamburg, Germany, 2023
3. B. Bessick, A. Zapf, S.Kluge, A. Zapfe, Y. von Kodolitsch, S. Klotz, A. Gerlach. *Kriterien zur Festlegung der physiotherapeutischen Behandlungspriorität von Intensivpatient:innen an einem deutschen Universitätsklinikum: Eine qualitative Interviewstudie.* In: DIVI-Kongress, December 5, CCH Hamburg, Germany, 2024

11. Acknowledgements

This PhD dissertation is the result of considerable hard work, but this achievement would not have been possible through my efforts alone. Throughout the highs and lows of this journey, I was fortunate to receive the support of many incredible people.

My warm and heartfelt gratitude go to:

First and foremost, my doctoral advisor, Professor Dr. Antonia Zapf, for her patience, encouragement, expertise guidance, and advice in statistical analysis, all of which helped me maintain the direction and calm I needed.

All thesis committee members, Simon Pecha, Susanne Klotz, and Yskert von Kodolitisch, for their insights and constructive feedback throughout the various phases of this project.

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Melanie Lemke (ML), Till Demal (TD) and Minettchen Herchenröder (MH), and Jens Brickwedel (JB) for their role as external reviewers in the systematic literature review and/or qualitative study.

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Gerhard Schön from the Institute of Medical Biometry and Epidemiology for his consultation in the statistical analysis.

Family and friends – thank you for the encouraging words when it was needed most.

My mother, a woman with so much wisdom - thank you for teaching me to always persevere, have faith, and that education empowers.

Last, but not least, my husband, Jens, and our daughters Hannah and Leah, I drew strength from your unconditional support and constant encouragement during many of the stressful episodes of this journey – thank you!

12. Declaration under oath (Eidesstattliche Versicherung)

Ich versichere ausdrücklich, dass ich die Arbeit selbständig und ohne fremde Hilfe, insbesondere ohne entgeltliche Hilfe von Vermittlungs- und Beratungsdiensten, verfasst, andere als die von mir angegebenen Quellen und Hilfsmittel nicht benutzt und die aus den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen einzeln nach Ausgabe (Auflage und Jahr des Erscheinens), Band und Seite des benutzten Werkes kenntlich gemacht habe. Das gilt insbesondere auch für alle Informationen aus Internetquellen.

Soweit beim Verfassen der Dissertation KI-basierte Tools („Chatbots“) verwendet wurden, versichere ich ausdrücklich, den daraus generierten Anteil deutlich kenntlich gemacht zu haben. Die „Stellungnahme des Präsidiums der Deutschen Forschungsgemeinschaft (DFG) zum Einfluss generativer Modelle für die Text- und Bilderstellung auf die Wissenschaften und das Förderhandeln der DFG“ aus September 2023 wurde dabei beachtet.

Ferner versichere ich, dass ich die Dissertation bisher nicht einem Fachvertreter an einer anderen Hochschule zur Überprüfung vorgelegt oder mich anderweitig um Zulassung zur Promotion beworben habe.

Ich erkläre mich damit einverstanden, dass meine Dissertation vom Dekanat der Medizinischen Fakultät mit einer gängigen Software zur Erkennung von Plagiaten überprüft werden kann.

Datum, 16.08.2026 Unterschrift, 