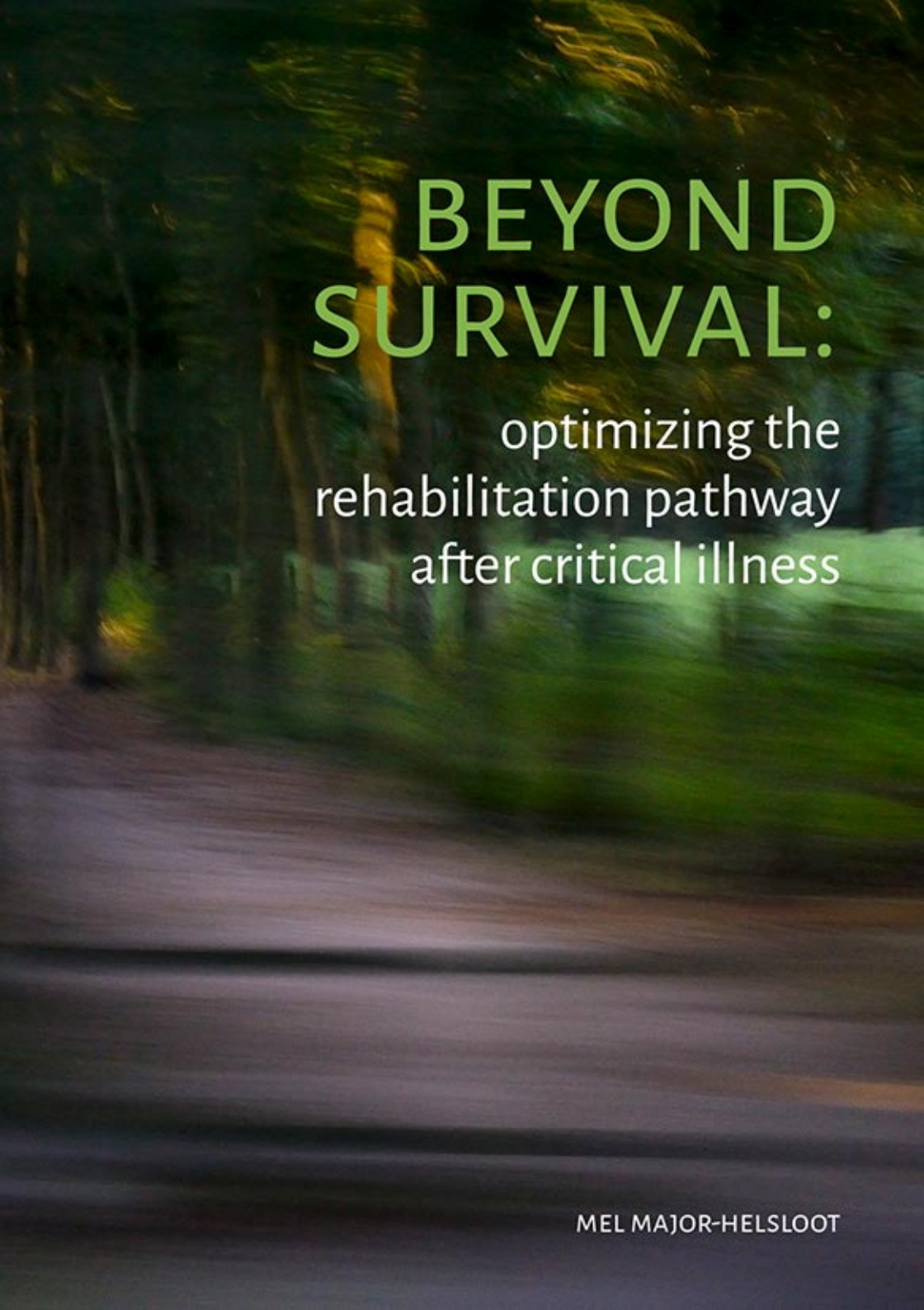

BEYOND SURVIVAL:

optimizing the rehabilitation pathway after critical illness

MEL MAJOR-HELSLOOT

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BEYOND SURVIVAL:

optimizing the rehabilitation pathway after critical illness

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. ir. K.I.J. Maex

ten overstaan van een door het College voor
Promoties ingestelde commissie,
in het openbaar te verdedigen in de Aula der Universiteit
op Vrijdag 8 April 2022, te 11:00 uur
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"They said to take it easy for 6 weeks, but did not tell me about the consequences of sepsis and what I realized later, was the result of that time in ICU. That still happens to me to this day: nobody connects my problems with my time in ICU."

SOPHIA, 47, 9 DAYS IN ICU

CHAPTER 1
General introduction

Annually, 70.000 – 80.000 patients are admitted to an intensive care unit (ICU) in the Netherlands.[1] A distinction can be made between planned and unplanned ICU admissions, where unplanned admissions are often characterized by complex interventions because of medical complications, longer ICU length of stay (LOS), high risk of mortality and long-term morbidity.[2-5] Planned admissions commonly include short stay patients after surgical interventions, i.e., for post-operative monitoring. Mortality rates for patients with critical illness vary from 16%-51% (in the ICU), 22%-76% (in hospital) and 32-41% (1-5 year after discharge), but large variations between populations, countries, and hospitals are observed.[4-8]

Due to technological developments and advancements in medical care, a growing number of patients survive critical illness.[9,10] An increasing amount of evidence has emerged over the last decade, depicting the long-term consequences of critical illness and associated medical interventions. First, the underlying critical illness and the subsequent catabolic inflammatory process may lead to muscle dysfunction and general deconditioning.[11-14] Next, common pharmacological interventions in the ICU, such as the use of sedatives and opioid analgesics, may influence patients' psychological and cognitive state, and subsequently – aggravated by the concurrent immobilization – lead to physical deconditioning.[15,16] In patients receiving mechanical ventilation,

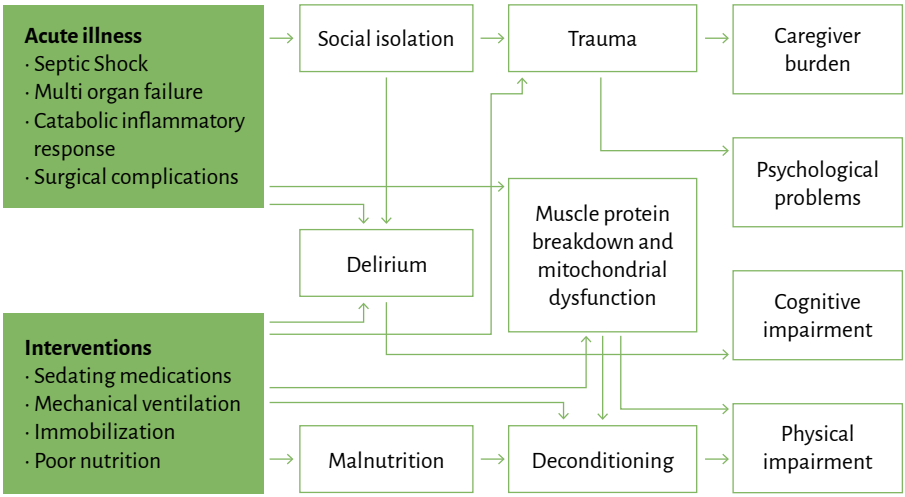


Figure 1: Contributors of critical illness to long-term outcomes (based on Mikkelsen et al, 2020)[23]

respiratory muscle weakness is reportedly present as early as 24 hours after initiation,[17] increasing the risk of weaning failure and mortality. Last, the experience in ICU is often traumatic for patients and their relatives and may lead to anxiety, depression, decreased quality of life and post-traumatic stress disorder[18-22] (Figure 1). Survival of the critical illness, therefore, coincides with the start of a challenging recovery trajectory for patients and their relatives, involving many rehabilitation professionals, such as physical therapists (PTs), occupational therapists (PTs), dietitians (DTs), psychologists and speech and language therapists (SLTs).

Recovery from critical illness

Challenges in recovery after critical illness are increasingly being recognized since the Society of Critical Care Medicine (SCCM) proposed the term 'Post-Intensive Care Syndrome' (PICS) in 2012.[9] PICS is defined by the SCCM as "new or worsening problems in physical, cognitive or mental health status arising after a critical illness and persisting beyond acute care hospitalization" and can occur in both patient and family members (PICS-F) (Figure 2).

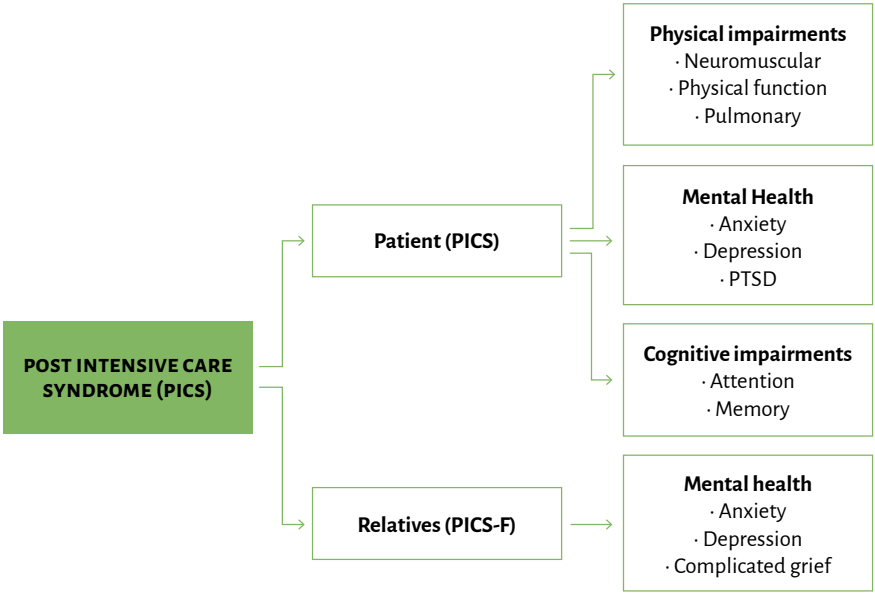


Figure 2: The PICS-conceptual diagram developed by the SCCM[9]
PICS(-F): Post-Intensive Care Syndrome (-Family), PTSD: Post Traumatic Stress Disorder

With the conceptualization of PICS and PICS-F, the impact of critical illness and its long-term consequences on patient outcomes have become major research topics in critical care medicine. Several landmark studies conducted in the last decade have shown long-term mental health problems such as anxiety and depression, and decreased quality of life, occurring in both patients and relatives and affecting their daily functioning.[18-22] ICU delirium, which is associated with long-term cognitive impairments, presents in up to 80% of mechanically ventilated patients, resulting in a large percentage of survivors reporting cognitive problems after hospital discharge.[24-26] Physical impairments are reported to occur in about 70% of survivors.[27] Commonly reported physical problems are muscle weakness (ICU-acquired weakness, ICU-AW), decreased exercise capacity and pulmonary function, and restrictions in the activities of daily living (ADL). ICU-AW presents in 25-50% of patients recovering from critical illness and is associated with poor 5-year outcomes.[11,28-31]

The complexity and variety of problems associated with PICS may lead to new morbidity, increased healthcare costs,[32] and - in almost 50% of the patients - to problems with return to work.[33,34]

Strategies to deal with PICS along the rehabilitation pathway: prevention and treatment

Preventing long-term impairments related to PICS, starts in the ICU. As evidence emerged on the negative effects of deep sedation and immobilization, rehabilitation interventions within the ICU increasingly focused on prevention of detrimental effects through early mobilization.[35-37] Physical therapists (PTs) are often the first professionals providing rehabilitation interventions to critically ill patients, aimed to facilitate mobilization and prevent (further) physical deconditioning. Due to the unique characteristics of the ICU environment PTs require specific competencies for clinical practice.[38-40] Undergraduate students and professionals who are new to the ICU, generally advance their clinical performance with patients with high complexity through a specific learning process. First, specific knowledge is obtained, after which basic skills are applied under supervision, progressing gradually towards independent practice. Ideally, physical therapy competencies are achieved through a combination of theoretical and practical learning. Blended learning methods (a combination of online and face-to-face teaching) are advantageous in that they are flexible for students (accessible at any time and place) and (clinical) teaching staff (easily updated with new material).[41,42] E-learning modules, containing online interactive teaching material on practical

challenges related to ICU-PT, could help prepare undergraduate students and PTs new to the critical care field, for clinical work in the ICU - potentially reducing the on-the-job teaching load for clinicians. However, until now it is not yet known if this teaching method sufficiently prepares students for their clinical responsibilities.

After ICU discharge, patients transition to the hospital ward, where – dependent on the patient's level of functioning - hospital discharge planning is initiated. Careful discharge planning for survivors of critical illness should consist of a thorough needs assessment, education and information on recovery and investigation (and if necessary, arrangement) of support.[43,44] Active engagement of the patient and their relatives during discharge planning is recommended.[45] Research shows that information needs are not always met at time of hospital discharge and continuity of care is lacking, possibly attributing to inadequate discharge planning.[24,46,47] Understanding the transition experience patients and family members go through after the intensive care has ceased and identifying their needs, can help improve the quality of the care provided.[23] Hence, exploring the experiences of survivors and relatives around hospital discharge, and identifying barriers and enablers related to a positively perceived transition, can help increase the understanding of that experience and potentially change discharge processes.

Some of the functional problems patients with PICS experience are well described, but not all underlying mechanisms of long-term functional problems, are currently understood. The long-term effect of common medical interventions, such as mechanical ventilation, on respiratory muscle function has not been investigated. Studies investigating the prevalence and impact of respiratory muscle weakness (RMW) in critically ill patients are often limited to the period within the ICU, surrounding ventilator weaning trials.[48] Continued assessment of inspiratory and expiratory muscle strength in the period after extubation and extending beyond ICU- and hospital discharge, is not commonly performed. While outcomes of patients with RMW in combination with ICU-AW are worse when compared to patients with ICU-AW alone,[49,50] the long-term impact of mechanical ventilation on respiratory muscle strength and its association with other physical outcomes remain unclear.

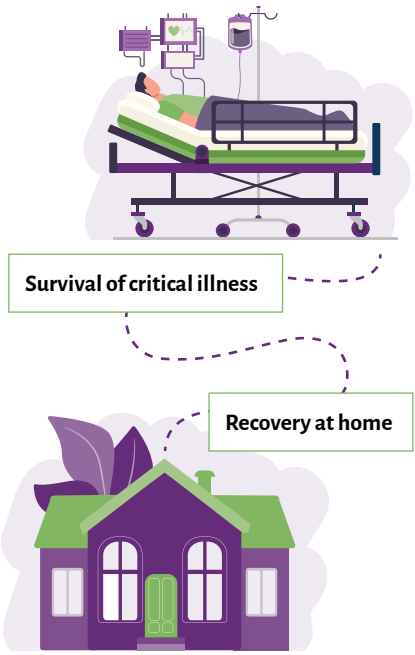
While systematic follow-up of survivors of critical illness and their relatives is recommended, a structured and evidence-based rehabilitation pathway does not exist for this population.[24] In general, recommendations on ICU aftercare revolve around hospital-based follow-up clinics but lack information on how best to address rehabilitation needs after hospital discharge.[9,44] Similarly,

consistency in the use of outcome measures assessing rehabilitation needs, i.e., a core outcome set (COS), is recommended, to improve uniformity in clinical practice and generalizability in research study results.[51-53]

To address impairments in all health domains encompassed within PICS, interventions might be needed from several professional disciplines, such as physical therapists, occupational therapists, dietitians, psychologists and speech and language therapists.[54] Interdisciplinary collaboration is essential to provide the appropriate form of care at the right time, and to provide rehabilitation programs which fit individual needs throughout the recovery trajectory. As post-critical illness sequelae present with large inter-individual variability and heterogeneity, using patient-centered outcome measures to explore the effect (or feasibility) of rehabilitation interventions is recommended.[55] As physical problems are likely to be at the forefront at the time of hospital discharge, physical therapy is often indicated to start as soon as possible.[24, 27, 33] To date, (feasibility) trials investigating effectiveness of PT programs for survivors of critical illness show inconsistent results, mostly attributed to poor participant adherence. Poor adherence was often caused by the fact that interventions were provided in outpatient departments of local hospitals, creating a barrier for severely deconditioned or less motivated patients to attend these sessions.[56-58] As an alternative, the feasibility of home-based, interdisciplinary physical rehabilitation programs for patients with PICS could be further explored.[59,60] Figure 3 shows the knowledge and practice gaps along the critical illness rehabilitation pathway as identified and addressed in this thesis.

Aim and outline of the thesis

The general aim of this thesis is to describe, within the context of professional practice, scientific research, and related education what characterizes survival of critical illness and how physical therapists can support patients in the different stages of the rehabilitation pathway. This thesis follows the chronological journey of the patient recovering from critical illness: from preparing students and professionals for the clinical setting in the Intensive Care Unit (part 1) to understanding patients and relatives' experiences and (physical) needs after ICU discharge (part 2) and lastly to the provision of state-of-the-art interdisciplinary rehabilitation interventions after hospital discharge (part 3).



KNOWLEDGE & PRACTICE GAPS

How can we prepare (newly graduated) physical therapists for tasks and responsibilities in the Intensive Care Unit?

How do patients and relatives experience the transition from hospital to home? What are their needs and preferences?

What are the long-term consequences of mechanical ventilation on the respiratory muscles?

What are essential elements of a physical therapy program for survivors of critical illness who are discharged home?

Figure 3: Beyond survival: knowledge and practice gaps along the rehabilitation pathway

Part 1: the Intensive Care Unit
Chapter 2 describes a mixed method, proof of concept study among undergraduate physical therapy students and ICU physical therapists, on the feasibility of e-learning in preparation for clinical work in the intensive care unit.

Part 2: Understanding survivorship
Chapter 3 describes a qualitative study on the experiences of survivors of critical illness and their relatives and perceived barriers and enablers with regards to a positively perceived transition from hospital to home.
Chapter 4 reports on a prospective cohort study investigating the 6-month recovery of respiratory muscle strength and its associations with functional exercise capacity and handgrip strength in survivors of critical illness.

Part 3: Recommendations for state-of-the-art rehabilitation interventions after hospital discharge

Chapter 5: describes an international Delphi study on a core outcome set for clinical practice and recommendations for physical therapy interventions for survivors of critical illness, who are discharged home.

Chapter 6: presents a Delphi study conducted among rehabilitation professionals in the Netherlands, exploring recommendations for a core outcome set and physical therapy interventions in the context of the Dutch healthcare system.

Chapter 7: reports the results of a mixed methods, non-randomized pilot study investigating the feasibility of a PT-led, interdisciplinary home-based rehabilitation program for patients with post-intensive care syndrome in comparison with patients receiving usual care (the REACH study).

Chapter 8: discusses the main findings, strengths, limitations, clinical implications, and recommendations for future research.

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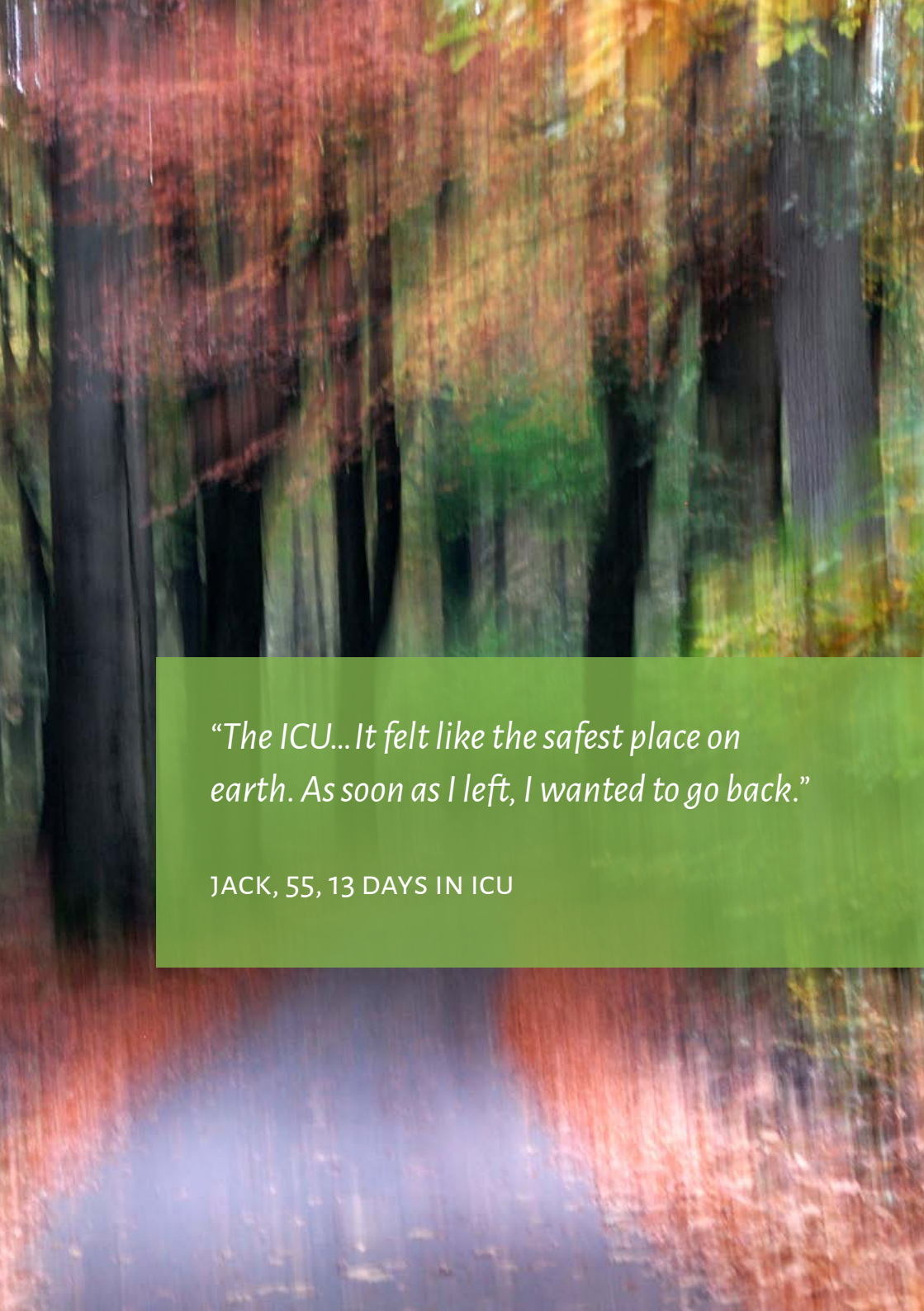
PART 1

The intensive care unit



"The ICU... It felt like the safest place on earth. As soon as I left, I wanted to go back."

JACK, 55, 13 DAYS IN ICU

CHAPTER 2 Preparing undergraduate students for clinical work in a complex environment; evaluation of an e-learning module on physiotherapy in the intensive care unit

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R.H.H. Engelbert
M. van der Schaaf

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ABSTRACT

Background: Intensive Care Units (ICUs) are daunting environments for physiotherapy (PT) students performing clinical rotations. To prepare students for this environment, a newly developed evidence-based e-learning module was designed and implemented in the undergraduate curriculum. The aim of this study was to investigate whether e-learning is a feasible method in preparing PT students for clinical work in complex ICU environments, as perceived by students and experts.

Methods: A mixed methods proof of concept study was undertaken. Participants were final-year students of an international curriculum, and experts from didactic and clinical fields. An e-learning module consisting of 7 separate chapters based on latest scientific evidence and clinical expertise was developed, piloted and incorporated into the undergraduate curriculum as a compulsory course to be completed prior to clinical ICU rotations. Data were collected through 3 focus group meetings and 5 semi-structured interviews, audio recorded, transcribed verbatim and analyzed.

Results: The study sample comprised of 14 students and 5 experts. Thematic analysis revealed three themes: *expected competencies of PT students in ICU, feeling prepared for ICU clinical work and dealing with local variety.* The e-learning module enabled students to anticipate clinical situations and PT tasks in the ICU. Higher level clinical reasoning skills, handling of lines and wires and dealing with out-of-textbook situations could not be achieved with the e-learning module alone.

Conclusions: An e-learning module can sufficiently prepare PT students for their clinical tasks in ICU, as long as it is integrated with, or closely connected to, the students' clinical placement.

BACKGROUND

Developments in intensive care medicine over the past decades have led to both an increase in complexity as well as in the number of patients surviving critical illness, resulting in prolonged intensive care unit (ICU) stay.[1,2] Evidence on the effects of prolonged immobility in these vulnerable patients is abundant[2-6] and multidisciplinary interventions directed to early mobilization of ICU patients are globally implemented.[7-10] Physiotherapists, as part of a rehabilitation team, are essential to ICUs.

Recent studies have identified physiotherapy (PT) competencies required for the ICU setting and recommendations have been made to define a professional profile for ICU physiotherapists (ICU-PTs).[1,11-15] Across these studies, consensus exists on the necessity for ICU-PTs to have knowledge and understanding of medication interaction, pathophysiology, ICU equipment (including mechanical ventilation modes), laboratory testing and imaging investigations. ICU-PTs should also be familiar with practicing PT within safety parameters and based on sound clinical reasoning.[12-16]

Undergraduate PT curricula need to be adaptive to constantly changing clinical environments and requirements, but also include authentic learning experiences to optimally prepare graduates for the profession.[17,18] Teaching methods currently applied in preparation for the ICU include theoretical classes, classroom and in-hospital simulations with computerized manikins and compulsory clinical rotations.[19-22] Despite having had preparational classes or simulation scenarios, PT students are often overwhelmed by the ICU environment and lack confidence in the execution of clinical tasks involving (sedated) patients dependent on mechanical ventilation.[23,24]

E-learning modules use a variety of interactive teaching methods, such as real-life videos, which can be helpful in transferring knowledge and reasoning skills and preparing students for complex environments. It has been shown to be an effective and flexible teaching tool in undergraduate medical and allied health education.[25-29] With internet-based courses being accessible anywhere in the world and on any electronic device,[30,31] an e-learning module on ICU-PT could be a convenient teaching method for an internationally oriented curriculum. Therefore, the aim of this study was to develop, implement and evaluate an e-learning module on evidence-based physiotherapy in the ICU and to investigate its feasibility with regards to preparing undergraduate PT students for clinical work in ICUs worldwide.

METHODS

A mixed method, proof of concept study was undertaken in the period of June 2016 until January 2018. Figure 1 shows an overview of the different study phases.

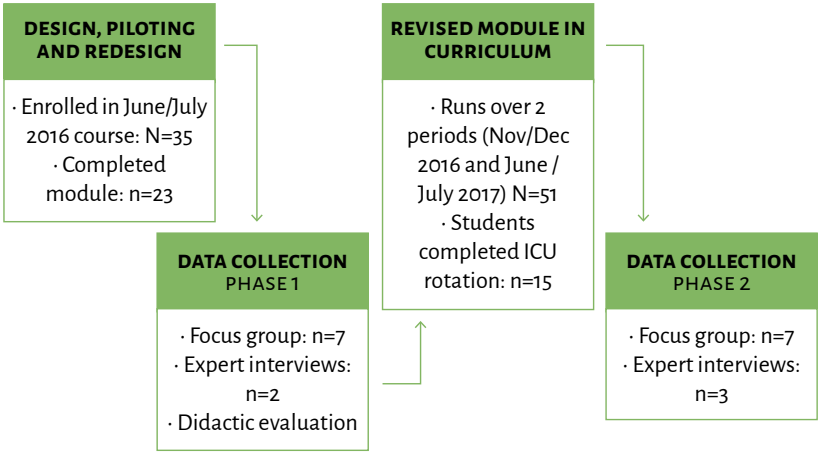

Figure 1: Phases of study: design and evaluation

Context

In 2016 the undergraduate curriculum of the European School of Physiotherapy (ESP), Amsterdam University of Applied Sciences (AUAS), did not contain a course specific to PT responsibilities in the ICU. Relevant content, such as cardiorespiratory physiotherapy and pathophysiology were embedded within different parts of the curriculum, instead of being focused in one course module. Undergraduate students in the ESP program are required to conduct 4 clinical rotations, each lasting 10 weeks. The last two clinical rotations are commonly conducted within rehabilitation facilities, a hospital stroke unit and/or ICU. As these rotations can take place anywhere in the world, students are provided with an internationally oriented course content. Evaluation results led to the decision to design an e-learning module, 'Physiotherapy in the ICU', to be completed before students' practical ICU placements.

Design of the e-learning module

Clinical, didactic and research experts provided input to the e-learning module.

Core topics, competencies and learning objectives, according to Bloom's revised taxonomy,[32] were identified (Table 1). Content decisions were based on recent medical and allied health research evidence for physiotherapy in the ICU and aimed to provide a general introduction into the topic. Videos were recorded at the ICUs at the Amsterdam University Medical Centers (Amsterdam UMC) and informed consent for recording was obtained from patients and clinicians.

Table 1: Learning objectives e-learning module 'Physiotherapy in the ICU'

Objectives	Bloom's revised taxonomy
1. Has insight in safety criteria in the ICU setting and can determine and justify a GO or NO GO for physiotherapy	Remembering, Understanding, Applying
2. Has understanding of the place and content of physiotherapeutic screening and assessment within the ICU	Understanding
3. Has insight in evidence-based physiotherapeutic interventions in the ICU for both conscious and unconscious patients	Understanding
4. Applies clinical reasoning skills within the complex environment of the ICU patient	Understanding, Applying
5. Understands the importance of multidisciplinary collaboration with regards to the ICU patient	Understanding

Key features of the e-learning module

The final module contained 7 chapters: *general introduction to ICU, the impact of ICU admission on patient and family, introduction to ICU rehabilitation, physiotherapeutic assessment, physiotherapeutic interventions, the post-surgical patient and reporting and interprofessional collaboration.* A variety of teaching materials was incorporated in the e-learning module to facilitate student learning and motivation: interactive assignments, background literature and short quizzes, self-developed and online videos (patient-testimonials, patient and PT observations, skills-modelling videos), and text presented in presentation slide format, narrated by a native English speaker. Each module finished with a quiz and direct feedback was provided. An online community supported the e-learning module, operating as a forum between lecturer and students where additional material, as well as content and technical questions could be posted.

A 25 question, multiple choice online exam consisting of 3-answer options was developed as a means to test students on obtained knowledge and reasoning skills related to the learning objectives and predetermined exam matrix. A passing mark was required before being allowed to start the clinical rotation. After the clinical rotation, students submitted a mandatory case report about one of the ICU patients that they had observed during their placement. The mark received for the case report determined the final ICU course grade.

Technical details of the e-learning system

In 2015, a trial version of the e-learning module was developed in Articulate Storyline© (version 2015) by a trainee developer of the Institute Information Communication Technology and Education (ICTO) of the Amsterdam UMC. Microsoft PowerPoint presentations supported by audio files, videos and interactive assignments formed the content of this trial version. The module was accessed through Google Sites. ICU clinicians and a small sample of students ($n = 8$) provided feedback on content accuracy, user-friendliness and overall look and feel of the module.

In 2017, the final version of the e-learning module was incorporated in GSuite from Google Cloud©, with additional interactive assignments created in Adobe Activate©. The main reason for the transition to GSuite was the flexibility of the system, enabling easy content updates as new evidence on physiotherapy practices in the ICU emerged.

Data collection phase 1

The aim of this study phase was to evaluate the e-learning module on user-friendliness, level of complexity, didactic alignment, and accessibility. Between June and October 2016, the e-learning module was piloted among a group of undergraduate students ($n = 23$, male: 5, female: 18) for whom the module was not a compulsory part of the BSc curriculum. Information obtained through focus group (FG) sessions, semi-structured interviews, and exam analysis led to technical changes to improve user-friendliness while the key features of the course remained unchanged.

Data collection phase 2

The course was implemented in the curriculum of the academic year 2016-2017. It ran twice for a period of 6 weeks and was evaluated during data collection phase 2. Participants were recruited via e-mail; only students who had completed both the e-learning module and a clinical rotation between

Table 2: Interview guide and topic list expert interviews and focus groups

Method	Topic	Example question
Interview	**Current role of the expert in ICU** · Tasks and responsibilities · Clinical practice hours	*Can you start by describing what your daily tasks and responsibilities within the ICU are?*
	Expectations of PT students on clinical rotations · Knowledge · Skills · Common mistakes	*What knowledge do you feel a PT student should have when doing a rotation in ICU?*
	Evaluation of e-learning module's content · Agreement · Disagreement · Suggestions for improvement	*How did you perceive the information presented in the ICU online course?*
	Specifics to expert's ICU context · International differences / diversity · Skills/Knowledge	*Are there distinct skills a PT student should possess when doing a rotation in the ICU department at your hospital?*
Focus Group	**Evaluation of e-learning module's content** · Positive/negative · Points for improvement	*What did you like best about the e-learning module's content? And what did you not like?*
	Experience of ICU rotation · Supervision · Matching content e-learning module and real-life situation · Specific experience that stood out	*How did you feel during the rotation in ICU?* *How much do you think the e-learning module prepared you for the ICU environment?*

November 2016 and July 2017 were included. Clinical experts were purposefully sampled through the faculty's international network. Students and experts were provided with information explaining the aim of the study. Participating experts received PDF files containing the e-learning module's content in preparation for the interview.

Interview guides were set up for FG meetings and semi-structured interviews (Table 2). Interviews were conducted by a research assistant, either face-to-face or via Skype©, and had a duration of 30-60 minutes. FG sessions, lasting approximately one hour per session, took place at the Faculty of Health, AUAS, in Amsterdam. Sessions were moderated by one of the research assistants and monitored by the main investigator.

Data analysis

Interviews and FG sessions were audio- or video recorded and transcribed verbatim. Initial line-by-line coding was followed by focused coding, in order to identify categories and transcendent themes from the data. Regular feedback sessions were scheduled with the complete research team to discuss data analysis and to facilitate a thorough categorization, interpretation of the data and establishment of data saturation. MAXQDA12 was used for qualitative data analysis. The online exam was analyzed for estimated internal consistency reliability (Cronbach's Alpha) between questions, proportions of correct answers, and standard measurement error. P-values (difficulty index) corrected for chance score (expressed as *Pc*), point-biserial correlations (item discrimination index) and distractor efficiency (DE) were calculated for the exam. Individual exam scores were checked to reveal deviant response patterns. If indicated by the exam statistics, the content of a question was reviewed to establish its validity. No questions were removed from the exam.

Ethics

Ethical approval has been obtained from the ethical review board of the Netherlands Association for Medical Education (NVMO-ERB) file number 728. Written, informed consent was obtained from each participant.

RESULTS

In total 14 international bachelor students participated in three FG sessions during study phases 1 and 2. The mean age was 25.3 (SD ± 3.2) and 93% ($n = 13$) of the students were female. Compared to gender distribution in the ESP

program (female 59%, male 41%, 2019-2020 data), the proportion of females in this study was high. This can be explained by the higher amount of females volunteering to participate in the 2016 pilot (19 out of 23) and more female students having completed the ICU rotation at time of recruitment. Therefore, more females met the eligibility criteria for participation. All participating students were in their 3rd or 4th year of study. Purposive sampling of didactic and clinical experts led to participation of 5 experts in total (60% female, mean age 37, SD ± 7.8) (Table 3).

Table 3: Participant characteristics

Phase	Pilot: FG	Pilot: EI	Implementation: FG	Implementation: EI
Total N	7	2	7	3
Gender	Female: 6 (86%)	Male: 2 (100%)	Female: 7 (100%)	Female: 3 (100%)
Nationality	Italy (1) Ireland (1) Netherlands (1) Romania (1) Lithuania (1) Germany (1) South Africa (1)	Germany (1) Israel (1)	UK (1) Singapore (1) Greece (1) Germany (2) Netherlands (1) France (1)	South Africa (1) Ireland (1) Greece (1)
Role	Bachelor student (7)	Lecturer (1) Web developer (1)	Bachelor student (7)	ICU physiotherapist and clinical tutor (3) PhD student (1) Postdoctoral research fellow (1)
Mean age	26 (SD ± 4.0)	32.5 (SD ± 7.7)	25.7 (SD ± 2.75)	40 (SD ± 7.5)
Years of clinical experience	N/A	N/A	N/A	Mean: 17 (SD ± 9.2)

FG: Focus Group EI: Expert Interview N/A: Not Applicable

Results data collection phase 1

Qualitative analysis of transcripts of data collected in phase 1 showed that the content of the e-learning module was perceived positively with regards to: accessibility, degree of difficulty, variation in study assignments,

encouragement of further learning and triggering curiosity, and transparency of the module's learning objectives.

Didactic alignment was assessed as the alignment between the course objectives and the content of the online exam. Analysis showed the exam did not align well; only 11 out of 25 questions corresponded with the course objectives. Feedback included the suggestion to add case-based exam questions, which was done for the revised version. The learning objectives and testing matrix were finetuned and after revision, the exam construct and the didactic alignment improved (18 out of 25 corresponded precisely with the learning objectives). Analysis showed high internal consistency (Cronbach's alpha: 0.84) with a tendency towards questions being too easy (*Pc*= 0.86).

Results data collection phase 2: thematic analysis

The following themes were identified: *expected competencies of PT students in ICU, feeling prepared for ICU clinical work and dealing with local variety.*

Expected competencies of PT students in ICU

Participants' perceptions regarding competencies expected of PT students in ICU revolved around understanding theory, clinical performance, communication and clinical reasoning. With regards to theoretical knowledge, participants mentioned the understanding of physiological processes, interpretation of patient data and understanding of the ICU environment and equipment were the most important:

> "*So, I think the main thing that would be good [is] if students had a good grip on [..] physiology and the theoretical…[..] [because] it is a pain to teach them the theoretical underpinnings [in] here.*" (Amy, Irish clinical expert)

> "*I expect them [..] to have a good knowledge of the assessment [..] so looking at all systems so they can adequately clinically reason what they need to do [..]*" (Wendy, South African clinical expert)

> "*He must have knowledge of the environment [..] and the difference between the ICU and the wards ..uhm.. mechanical ventilation.*" (Alexandra, Greek clinical expert)

With regards to clinical performance, participants agreed that (understanding of) cardiopulmonary assessment and interventions were required competencies.

> *"[my clinical site] heavily focuses also on respiratory management [..] So they were like 'oh, you don't know how to do auscultation as an assessment?' [..] so there's like a whole system of respiratory physio that I had no idea about… [Have] Auscultated maybe once in school…"* (Student: Grace)

Being able to connect with the (unconscious) patient and communicate with patient, family member and ICU staff, was found an essential competency by both clinical experts and students.

> *"Communication I guess with the patient, especially if they've altered consciousness [..]. But even so, even when English is their first language, they can use medical jargon when communicating with patients."* (Amy, Irish clinical expert)

> *"And they need to [..] be able to be effective communicators in terms of, cause that's part of, part of working in the ICU[..]"* (Wendy, South African clinical expert)

> *"..talking to them [the patient] or finding a way to connect to them, ask them about their night or their family or something and actually have a personal relationship with them because for them this is their life for this period of time and they're confined in this place which can be very dehumanizing… I think I realized that it is so, so, so important."* (Student: Sarah)

Clinical reasoning skills related to being able to apply the theoretical information in context (i.e. the choice of interventions):

> *"…uhm, yeah difficulty prioritizing what is important for that patient at that time. So yeah, individualizing the treatment specific to the patient and their problems, rather than having a general sort of recipe - all ICU patients need this package of care, whatever."* (Wendy, South African clinical expert)

Feeling prepared for ICU clinical work

FG participants expressed feelings of being overwhelmed by the ICU environment at the start of their clinical rotations, despite having completed the theoretical e-learning module. This was related to specific clinical situations for which they were not prepared, such as wires becoming undetached, alarms going off, or having to deal with an emergency situation in ICU.

> "He suddenly ripped out his mechanical ventilation [..] And I didn't know how to put it back in like properly, and where I could touch it, and hold it and oh god that was horrible." (Student: Leah)

Clinical experts also experienced undergraduate students feeling anxious and at times, being overly cautious when handling connections to equipment:

> "*..in terms of tubes and lines, they're scared to handle [laughs]. I mean yeah [..] they probably err on the side of caution and don't handle as much as they should*." (Wendy, South African clinical expert)

> "*...possibly to pay too much attention to the equipment. So, if, alarms are going off, looking at the equipment rather than looking at the patient [..] They are very awkward handling the equipment, now they do improve, it's a learning curve*." (Amy, Irish clinical expert)

In the clinical environment, students discovered the reality of the theoretical content covered in the course:

> "*First thing I noticed was how common delirium is [..] I was reading about it in the course but I'm like okay, that's a weird thing that might happen, but no [..] it was a daily thing*." (Student: Sarah)

> "*When I actually got there and I saw the machines I was like, oh, this is this [..] but then the physios were like okay can you now unhook this person and I was like [..] No! You know, the module did not really prepare you for the handling of the wires*." (Student: Leah)

Overall, students perceived the e-learning module's general content on the ICU environment to be helpful in preparation for their clinical rotation. It decreased anxiety:

> "*Yes, I felt less scared, I guess. At the beginning I was like I have no idea [..] all those tubes and things and you have no idea how the patients are like, but I feel less scared doing it now [after course completion]*." (Student: Diane)

The e-learning module enabled them to recognize and interpret reporting methods and patient objective data:

> *"I was able to see the PT's SOAP notes [..] it was a different layout than I was used to, but the abbreviations and stuff it was exactly the same. I felt prepared for that."* (Student: Sarah)

> *"Actually, for me, I found many assessment tools from the ICU course in my internship site, so with the RASS and stuff they would use it, so that was actually good to hear about it before."* (Student: Jasmine)

> *"I thought the vital signs [..] it was really, really good because [..] especially I saw that in acute care as well, they get on that a lot [..] they were always the things that they were asking me about like: 'Okay, what do those numbers mean? Why is that important?' and that was really good to have in the module.* (Student: Ella)

The course also enabled the students to anticipate the ICU patients' often complicated recovery process:

> *"We had quite a few long-term patients as well so that was actually really useful to learn about all those syndromes. To put it in to perspective what they might get afterwards [..]".* (Student: Olivia)

Dealing with local variety

Dealing with the local variety was a theme identified from the data and related to situations where the general character of the e-learning module did not match with the clinical practice in the variety of international ICU settings. This was illustrated by situations where students were expected to perform clinical tasks such as respiratory care:

> *"I noticed that, and I think it is different from country to country. [..] like suction is sometimes the work of the physio and sometimes the work of the nurse."* (Student: Sarah)

> *"I saw that physios in England were really involved in the weaning process off of the ventilator, a lot more."* (Student: Ella)

> *"[..] I don't know if respiratory is addressed elsewhere, if not might be worthwhile considering [..] based on our settings in South Africa, sort of 80% of the treatments in the ICU have a respiratory component [..]"* (Wendy, South African clinical expert)

Variety in the use of assessment tools in clinical practice, compared to those covered in the e-learning module, was also noted:

> *"in a hospital I was in, they did like a [Manchester] mobility score. [..] they all knew, all physios knew what it meant [..] that's how they scored [..] and then wrote SOAP notes as well, so you could see how the patient was progressing by these numbers."* (Student: Ella)

"and I know that [in the Netherlands they] like the DEMMI, but [..] I'm not sure if it would be worth looking at, or if that's standard practice in sort of other ICUs [..] so if you're working elsewhere [..] the CPAx is quite a nice tool [..] holistic also."
(Wendy, South African clinical expert)

> *"...they don't know about assessing patients, how to assess MRC or uhm hand grip and uhm functional tests and all that stuff."* (Alexandra, Greek clinical expert)

Participants sometimes experienced discrepancy between the evidence-based content of the e-learning module compared to daily clinical practice:

> *"...so we have a competency checklist for respiratory and we also have an 'on call' checklist so I use those to kind of guide me. But they're quite respiratory-oriented. [..] research is getting less and less supportive of our [..] respiratory interventions and more supportive of our rehab interventions."* (Amy, Irish clinical expert)

> *"Germany is not really famous for using evidence-based assessment tools [laughs] so maybe... I don't know what they did."* (Student: Leah)

> *"..and it's a problem that we have in [our country] that [..] sort of the general ICU cultures are quite different, so if you are teaching students now sort of more evidence-based practice in terms of rehabilitation [..], there's quite a lot of*

resistance [..] from more senior physios and from nursing staff which hinders them [the students] for being able to practice what they [..] have been taught."
(Wendy, South African clinical expert)

DISCUSSION

This study confirms that an e-learning module is a feasible and valuable teaching method to prepare international undergraduates for intensive care unit physiotherapy (ICU-PT), as learning objectives with regards to recognition, interpretation, understanding, and simple application were achieved. Participants to this study perceived the e-learning module to be helpful in anticipating the ICU environment, patient conditions, and basic PT assessment and intervention tasks. Participants felt less well prepared for dealing with emergency situations, handling of patients' lines and attachments, adapting to the variety in clinical expectations across international ICU settings and utilizing higher-level clinical reasoning skills, such as designing tailor-made interventions based on a patient's clinical presentation. Results from this study align with existing evidence that supervised practice in clinical settings is required to increase students' confidence and improve clinical reasoning skills.[19,22,33,34] Integration of this e-learning module with clinical practice provides a foundation for highly demanding clinical responsibilities in ICU. Timing in which the educational tool is offered in relation to the clinical experience is essential.[18,25] If, additional to this e-learning module, more complex and clinical reasoning provoking material would be completed during the clinical rotation, learning on the two highest levels of Miller's pyramid of clinical competence - the 'shows how' and the 'does' - could likely be facilitated.[35]

This study also showed the variety of clinical practice requirements in ICU settings worldwide which provides a challenge for undergraduate curricula in the context of (international) mobility of health professionals.[36] Recent studies highlight these differences; ICU-PTs working in Australia or some European countries are expected to adjust ventilator settings, perform (endo) tracheal suctioning and interpret imaging findings, whereas South African ICU-PTs must also show cultural sensitivity and be a team player.[13,15,16] To accommodate for this international variety in clinical practice e-learning modules prove to be efficient teaching tools, as the content is easily adaptable and additional, elective chapters could be added.[25,28] For faculties, where research, education and clinical practice are tightly linked, e-learning modules can serve as excellent tools to incorporate

the results of ongoing communication between these departments, hence providing students with authentic content in preparation for clinical practice.

Limitations to this study

The small study sample could be a limitation to generalizability of the results to the student population of undergraduate PT programs worldwide. Experts included in this study also comprised a small sample and results are therefore not meant to be representative to clinical practice in ICUs and hospitals across the globe. Our study sample consisted of mainly females (93%), which is a slight overrepresentation compared to undergraduate PT students worldwide, although a majority of applicants to PT programs as well as registered physiotherapists, are of female gender.[37-39]

The chosen topics for the expert interviews were purposefully focused towards required student competencies, and this could have led to bias in the results. However, data collection and analysis did not show reasons for inclusion of new topics or themes and therefore confirmed suitability of the initial topic list.

We did not evaluate clinical performance of the students quantitatively and therefore we cannot quantify improvements in cognitive, behavioral, or technical (skills) performance measures.

Although procedures were monitored carefully, selection bias and observer bias cannot be excluded due to the fact that final year students of our undergraduate program were involved in recruitment of participants as well as data collection through focus groups, which consisted of fellow students.

CONCLUSION

An evidence-based e-learning module on physiotherapy in the ICU is a feasible and valuable contribution to the undergraduate bachelor program and succeeds in preparing students for their clinical rotation in ICU. The flexibility of this teaching method allows for regular updates to the content and catering for variety of PT tasks in ICUs worldwide. However, the course did not fully succeed in removing student anxiety when handling complex patient cases; this objective is difficult to achieve with e-learning only. Future endeavors should investigate the feasibility of a closer integration of this e-learning module and clinical practice as well as incorporating additional module chapters to facilitate complex clinical reasoning and clinical performance.

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Competing interests
The authors report no competing interests.

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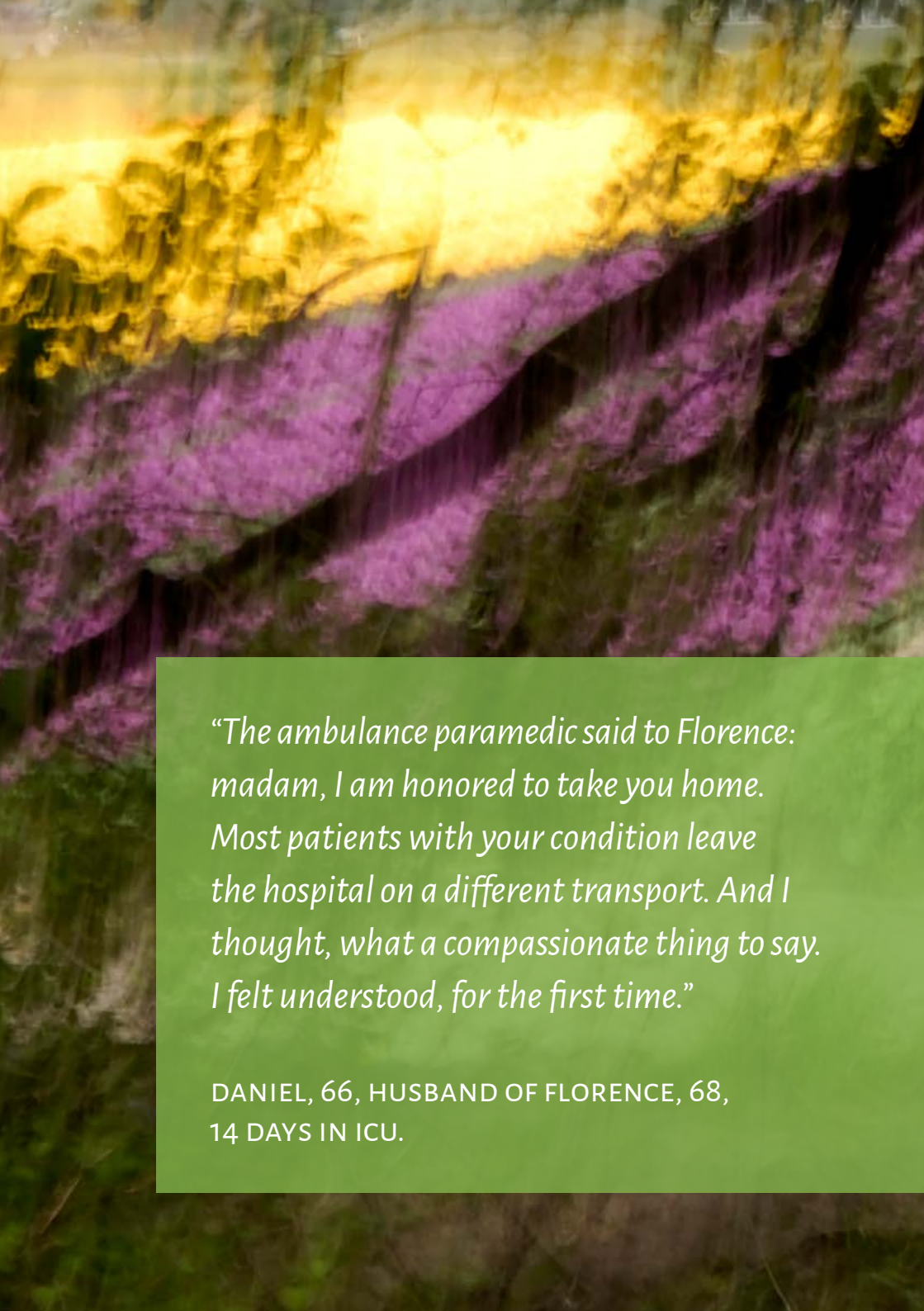
PART 2

Understanding survivorship



"The ambulance paramedic said to Florence: madam, I am honored to take you home. Most patients with your condition leave the hospital on a different transport. And I thought, what a compassionate thing to say. I felt understood, for the first time."

DANIEL, 66, HUSBAND OF FLORENCE, 68,
14 DAYS IN ICU.

CHAPTER 3 Survivors of critical illness and their relatives: a qualitative study on hospital discharge experience

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ABSTRACT

Rationale: To target rehabilitation needs of survivors of critical illness and their relatives in a timely and adequate manner, a thorough needs assessment is recommended when hospital discharge planning is initiated. In light of existing evidence on physical and psychological consequences of critical illness for both patient and family, it is currently unclear if current hospital discharge procedures suffice to meet the needs of this group.

Objectives: To explore hospital discharge experience and to identify perceived barriers and enablers for a positive transition experience from hospital to home or rehabilitation facility as perceived by survivors of critical illness and their families.

Methods: We performed a grounded theory study with semi-structured interviews among a group of survivors of critical illness and their relatives ($n = 35$) discharged from 16 hospitals across the Netherlands. Interviews were audio recorded and transcribed verbatim. Using constant comparative methods, initial and focused coding was applied to the data, which were further labeled into major categories and subcategories, ultimately leading to the identification of key concepts. Triangulation was applied through several reflexivity meetings at different stages of the study.

Results: Twenty-two former intensive care unit patients and 13 relatives were interviewed. The mean age was 53 (standard deviation ± 11.2) and 60% were female. Median intensive care unit and hospital length of stay were 14 days (interquartile range 9.75-24.5) and 35 days (interquartile range 21.75-57.25) respectively.

Thematic analyses led to identification of seven key concepts, representing barriers and enablers to a positive transition experience. "Existing in a fragmented reality", "being overlooked" and "feeling disqualified", were identified barriers and "feeling empowered", "encountering empathic and expert professionals", "managing recovery expectations" and "family engagement" were identified as enablers for a positive perceived transition experience.

Conclusions: Findings of this study suggest that current hospital discharge practice for survivors of critical illness is driven by speed and efficiency, rather than by individual needs assessments, despite advocacies for patient- and familycentered care. Discharge strategies should be customized to facilitate adequate and comprehensive assessment of aftercare needs, conducted at the right time and within the right context, encouraging empowerment and a positive perceived transition from hospital to home.

INTRODUCTION

Being confronted with critical illness and admission to an intensive care unit (ICU) are life-altering experiences for patients and their families. Research on long-term outcomes after critical illness sheds light on the complexity of problems experienced by patient and family, known as Post-Intensive Care Syndrome (PICS).[1-7] In the first 12 months after hospital discharge limitations in physical function, activities, and participation are common in the group of survivors. To enable early and suitable interventions targeting those limitations, a thorough needs assessment at time of hospital discharge is warranted.[8-10]

Discharge planning as described by Weiss and colleagues[11] consists of the following components: assessment of needs after discharge, estimation of hospital readmission risk, arrangement of necessary support, and educational interventions in the form of discharge teaching. To adequately determine discharge destination and set patient- and family-centered rehabilitation goals, active engagement of patients and relatives in discharge planning is recommended.[10-14] However, recent studies report that information needs of survivors of critical illness and their relatives at time of hospital discharge are often not met and continuity of care during the transitional phases of recovery is experienced as lacking.[14-18] It is probable that recommended components of discharge planning are inadequately executed for patients and families dealing with the aftermath of critical illness, though information on experience of hospital discharge is currently lacking.[9]

Therefore, the aim of our study was twofold: to explore experiences of critical illness survivors and their relatives around the hospital discharge process, and to identify perceived barriers and enablers for a positive perceived transition from hospital to home or rehabilitation facility.

METHODS

Design

We conducted a qualitative study founded in the constructive grounded theory approach, using constant comparative methods.[19]

Ethics

The medical research ethics committee of the Amsterdam University Medical Centers, location Academic Medical Center, provided a waiver for this study

(reference W16_245#16.286). Written informed consent was obtained for each participant.

Recruitment and sampling

We recruited participants through websites for former ICU patients, the Foundation Family Centered Intensive Care and ICU aftercare clinics in the Netherlands. Initially, purposeful sampling was applied aiming to include a demographically and geographically heterogeneous sample.[20,21] When saturation of themes became apparent, additional interviews were scheduled with a further group of patients ($n = 7$) and relatives ($n = 3$). These focused interviews were meant to check if emerging findings were grounded in the data and to confirm both code and meaning saturation.[22]

Eligible patients were greater than or equal to 18 years old and discharged 6 or more months ago, had an ICU length of stay (LOS) of 5 or more days, received mechanical ventilation for 48 or more hours, and resided in the Netherlands. Participants with suspected cognitive impairments at time of the interview were excluded from the study.

Data collection

Review of current literature determined an initial topic list, which was piloted through interviews with 2 former ICU patients (data not included), after which the interview guide was finalized. Constant comparison of emerging categories led to fine-tuning of the interview guide at three moments during data collection (*see* online supplement E1).

Data collection took place between January and May 2017, by means of face-to-face, semi-structured interviews, conducted at the participants' location of choice (home, work, or research facility). Duration of the interviews varied between 45 and 120 minutes, and involved individual patients or family members, or patient-family member dyads. In case of dyad interviews, patients were interviewed first with the family member present, who was encouraged to add to the story of the patient with his/her own perceptions. Following, family members were asked questions specifically related to the caregiver experience, and patients could add relevant experiences to the story.

Interviews were audio recorded, and field notes were kept and incorporated in the analysis process. The first author (M.E.M) conducted the interviews. Participants were unknown to the first author and no prior relationship between participants and first author's research institution existed.

Analysis

Interviews were transcribed verbatim, sent to participants for review and corrected when requested. Two coders performed initial coding (M.E.M and S.R) for the first five transcripts after which inter-coder agreement was evaluated and initial coding continued. Through focused coding tentative categories emerged and relationships between these were studied, making use of memo writing. Finally, these tentative categories were refined into major categories and subcategories. Additional theoretical sampling provided new data for further analyses. This led to conceptual mapping and identification of key concepts (*see* online supplement E2). Initially transcripts of patients and family members were coded and analyzed separately but as overlapping categories emerged, further combined analysis was warranted. An audit trail was kept by M.E.M and reviewed by S.R. MAXQDA version 12 was used for data analysis.

Validity

Triangulation was applied through three meetings at different stages of the research process with researchers not involved in data collection. We performed member check by two means. Firstly, participants reviewed and, when applicable, corrected transcripts of their interviews. Secondly, results were presented and verified at a peer support meeting attended by study participants in November 2017. Attendees recognized the identified themes as representative of their experiences. Codes and categories remained in Dutch for as long as possible to enhance the validity of the analysis.[23] Three native English speakers guided the translation process.

RESULTS

We interviewed a total of 35 participants, 22 former ICU patients and 13 relatives, discharged from 16 different hospitals in the Netherlands. Patients had a median ICU and hospital length of stay of 14 days (interquartile range [IQR], 9.8-57.3) and 35 days (IQR, 21.7-57.3) respectively, and a median mechanical ventilation duration of 11.5 days (IQR, 7.8-18.0) Time since discharge showed a large variation (months, median: 34.5; IQR, 19.8-59.0). On further analysis of experiences and perceptions in relation to time since discharge, no patterns emerged (Table 1). Online supplement E3 contains detailed subject descriptions and pseudonyms. Results hereafter are reported using pseudonyms.

Table 1: Participant characteristics

Variable	*n* (%)
Patients (*n* = 22)	Male: 10 (45.5)
Family members (*n* = 13)	Male: 4 (30.8)
Family relationship to patient · Spouse · Adult child · Parent · Sister	 10 1 1 1
Age, mean (SD, Range)	53 (11.2, 19-68)
ICU LOS in days, median (IQR)	14 (9.75-24.5)
Hospital LOS in days, median (IQR)	35 (21.75-57.25)
Mechanical ventilation duration in days, median (IQR)	7.8 (18.0)
Time since discharge in months, median (IQR)	34.5 (19.75-59.0)
Level of education (n, %) · Secondary school / lower vocational · Middle Vocational · Higher Vocational · University	 8 (22.2) 3 (8.4) 16 (44.4) 9 (25)
Admission diagnosis (n, %) · Medical · Surgical	 16 (73) 6 (27)
Discharge destination (n, %) · Home · Rehabilitation facility	
Discharging hospitals · Academic hospital · General hospital	 5 (n=10)* 11 (n=15)

SD: Standard Deviation, ICU: Intensive Care Unit, LOS: length of stay

** Three patients were admitted to both general and academic hospital during the critical illness*

Key concepts

We identified seven key concepts through thematic analysis, representing perceived barriers to and enablers for a positive transition experience from hospital to home or rehabilitation facility (Tables 2 and 3).

Existing in a fragmented reality

The experience of reality being fragmented started with the period of critical illness, a period of heightened consciousness for the relative and a state of mental absence for the patient. Having no or only a blurred recollection of the ICU-stay, patients were starting to make sense of things only when transferred to the ward, which often coincided with the initiation of hospital discharge planning as the patient's medical situation stabilized. When discharge planning and aftercare was discussed, patients overestimated their own physical abilities as well as caregivers' possibilities:

> *"They asked if I needed help when going home. I said: of course not! [..] Here I walk to the door and back, [..] sure I can do that home as well. And bathing [..] I said my husband can help with that. And wound care as well. Completely unrealistic, of course."* (Isabella, 45, 9 days in ICU)

As realization of the critical illness experience set in, patients actively pushed for hospital discharge. For example, the realization of *actual* duration of hospital stay, showed to be a strong motivating factor:

> *"...at one moment I realized: it is not 3 days that I am in hospital, but much longer. And that made me want to go home even more!"* (Alfred, 57, 19 days in ICU)

Patients also displayed intelligence in figuring out what was needed to be discharged, be it stairs climbing or finishing a meal, and were driven to make this reality.

> *"Ah, yes, it was just one big play! I gave it everything. I wanted to go home so I wanted to show everyone how strong and fit I was."* (Molly, 50, 12 days in ICU)

When discharge planning proceeded it became apparent that incongruent perceptions of and emotions related to home discharge existed between patients and their relatives, adding to the experience of reality being fragmented. Where family members expected the home situation to return to normal, patients' anxiety about what lay ahead grew when home discharge became a certainty:

> *"Two weeks of driving up and down to the hospital. I was just happy that things were quiet again, for the kids. That was very important to me. To be home again."* (Isaac, 51, partner of Sophia)

> *"I experienced the complete opposite. But that makes sense, they kept me asleep for a week and with me the worrying only started when I got home."* (Sophia, 47, 9 days in ICU)

Being overlooked

This concept relates to the experience where patients and relatives felt unsupported, guidance was needed, but not received. The contrast with the comprehensive care received while being in intensive care was enormous:

> *"They spend tons of money on you to keep you alive, but as soon as you close the hospital door behind you, then it is like: sort yourself out."* (James, 54, 42 days in ICU)

Contributory to the perception of being overlooked was the experience of lacking communication between ICU, hospital ward, and home caregivers, resulting in the loss of vital (handover) information. Discharge letters contained mistakes, leading to inadequate care provision after discharge. Incomplete or insufficient information delivered to family members on patients' (in)abilities caused a feeling of being ill-prepared for the care tasks expected of them after hospital discharge:

> *"The communication before discharge, [..] that he only needed assistance washing his back, that was very limited. [..] Maybe they didn't know how weak his muscles were, but surely they must have known he needed a shower chair while bathing!"* (Georgia, 54, partner of Alfred)

Hospital discharge planning seemed to gain momentum quickly after initiation and was handled briskly at times. The actual discharge moment felt too abrupt and caused insecurity to set in as soon as patient and relative arrived home:

> *"I was discharged home real soon and thought: okay, maybe I'll find my strength again at home. But for Maria [..] well it was all a little too sudden. And for me too, actually [..]"* (Henry, 59, 10 days in ICU)

"*That's when we started to feel unsure!*" (Maria, 53, partner of Henry)

Feeling disqualified
This concept refers to participants feeling helpless, overwhelmed, or excluded. Patients experienced that dependency on medical staff ingrained a sense of powerlessness in them, rooted in the ICU experience and continuing after the transfer to the ward:

"*You know, you regress to the level of a baby. Like, you can't seem to worry about anything or ask any questions. You just put up with everything.*" (Jessica, 60, 10 days in ICU)

Relatives experienced a marked change in the manner in which they were involved in medical and organizational decision-making, when comparing ward-stay with ICU-stay. During the ward-stay, relatives felt they were 'just visitors' and, excluded from conversations around hospital discharge planning, they were often surprised by the scheduled discharge:

"And Dad had just left [..] when they came to tell me: we have placed the drain, and all looks good [..]. So when you have eaten tomorrow, you can go home in the afternoon. [..] I was super happy. After they left, Dad came back upstairs and I told him: 'If I eat well tomorrow, I can leave the hospital!' And he said: What have you done?? He did not believe me.." (Hannah, 19, 20 days in ICU)

Patients experienced the first moment discharge was mentioned as overwhelming. In their experience the possibility of hospital discharge was casually mentioned during the ward round, a moment when they did not feel empowered or encouraged to ask questions. In some cases an empathic approach was lacking during the conversations about discharge, causing distress:

"And actually real quick, the second or the third day that I was in the ward, a lady appeared at my bedside: 'I am the rehabilitation physician and you have to leave the hospital'. And I thought, they are going to send me home! I thought, that is impossible, so I was completely distraught, crying." (Jacob, 67, 21 days in ICU)

Table 2: Key concepts identified as barriers for a smooth transition experience, attributes and supporting excerpts

Key concept	Attributes	Additional supporting excerpts
Existing in a fragmented reality	· Overestimation of one's abilities · Putting on a façade; pretend to be stronger · Mismatch perceptions patient/relative of going home	*"... Beforehand [before discharge], I had talked to the ICU nurses and the intensivist [..] There I said, it is not necessary, 'cause I have no problems at all." (George, 59, 9 days in ICU)* *"You see, above all I just did not want to be this weak. So I started acting as if there were no problems, because I wanted to go home. [..] I was totally bluffing with everything." (Lucy, 32, 90 days in ICU)* *Georgia: "My idea was: he is just happy to be home, but for me it felt as if the rug was pulled from underneath me". Alfred: "Yes, for Georgia, those were difficult times." (Georgia, 54, and Alfred, 57, 19 days in ICU)*
Being overlooked	· Feeling unsupported · Communication mistakes (or handover mistakes) · Feeling insecure	*"[..] just [would have liked a] conversation where they told me they understood what was going on with me. But I really think they had no idea. They cared for people really well, but they do not see the background. It is difficult, because you have to experience for yourself how your body is reacting, and what has actually happened. And you have to find answers to this on your own." (Emily, 68, 10 days in ICU)* *"And I said: please give us an extra day before discharging us, so that we can arrange a normal bed. [reply was] No, because every day it will be difficult to go home. I was furious, I was furious." (Daniel, 66, husband of Florence 68, 14 days in ICU)*

Key concept	Attributes	Additional supporting excerpts
Feeling disqualified	· Sense of powerlessness · Family member is sidelined · Feeling overwhelmed	*"..And whatever they say, [..] you just let other people lead you or tell you what to do, because you don't fully understand what is going on and what will happen next." (Sophia, 47, 9 days in ICU)* *".. that I was not informed on these decisions, that was too extreme. I understand Henry is a grown-up but at first I was updated almost every hour, and suddenly not at all anymore [..]" (Maria, 53, wife of Henry, 59, 10 days in ICU)* *"I knew, in the morning they do the rounds. So a bunch of nurses, doctors and you know what are at your bedside and at that moment you have to make quick decisions. Even causes anxiety. And after they left, you think ah! Forgot to ask something. That was actually the moment it was discussed: 'well, she is doing so well, she can go home'. I said: 'oh no, going home, I am not up for that'. Like that, you know, it all happens really fast." (Matilda, 56, 15 days in ICU)*

Feeling empowered

Participants experienced a feeling of empowerment when they felt they were being listened to, or actively involved in the discharge decision-making process. This contributed to regaining a sense of control and helped smoothen the transition homeward. Often patients put themselves on an "exercise regime", realizing this was a way to take charge in their own physical recovery:

> *"But I normally put a strict regime on myself, so that is what I also did this time. Just because I realized I have to strengthen my body."* (Ruby, 49, 5 days in ICU)

Encountering empathy and expertise

Participants perceived the transition homewards as a positive experience, when they felt supported by professionals, who could anticipate their physical and psychological needs and were able to aid in regaining a sense of reality. It was experienced as helpful if medical staff assisted with "filling in the blanks" of patients' memories. Positive examples shared were appointments at follow-up

clinics, return visits to the ICU or having access to their electronic patient files. When compassion was shown for the difficult situation patients and family members had found themselves in, this was appreciated immensely:

> *"The ambulance nurse said to Florence: madam, I am honored that I can drive you. Most patients with your condition leave the hospital on a different transport. [..] And I thought, what a compassionate thing to say. I was touched by it, felt understood for the first time."* (Daniel, 66)

Support was also felt by visits or telephone calls from the general practitioner directly after hospital discharge. Often concerns could be addressed immediately:

> *"She [the GP] saw [Alfred] was discharged and came to see him next morning. [..] And she says: I [..] thought I come and check on him. And I said: well, you are a godsend, because I'm really worried about him".* (Georgia, 54)

Managing recovery expectations

Participants believed it added to a positive transition experience when medical staff helped them adjust to the new reality by setting realistic rehabilitation goals and preparing them for tough times ahead. Just knowing recovery would take time, seemed to initiate the healing process:

> *"..maybe two or three times the nurses had said: for recovery, you should really take a year minimum. I am happy that they told me that, because that is what made me decide to allow myself a year to get better."* (Violet, 54, 16 days in ICU)

Engaging the family

When discharge planning was done in collaboration with patient and relative, this helped relatives to anticipate what was expected of them at home, and to make appropriate arrangements.

> *"Well, I loved it that he [Jack] was coming home [..] The doctor thought it wouldn't be possible to go home, but we explained that we have all facilities at home, because of my mother staying with us. And then it was okay."* (Elizabeth, 59)

Table 3: Key concepts identified as enablers for a smooth transition experience, attributes and supporting excerpts

Key concept	Attributes	Additional supporting excerpts
Feeling empowered	· Being listened to · Shared decision-making · Regaining a sense of control	*"But I normally put a strict regime on myself, so that is what I also did this time. Just because I realized I have to strengthen my body." (Ruby, 49, 5 days in ICU)* *"He said: there are several options, but I believe it is best if you go to the rehabilitation facility. Considering the motivation you are showing I believe you might want that as well. But I have to inform you, not everyone wants to be that far from home. [..] If you'd wish to stay closer you could stay in a nursing home. [..] I thought it was positive it only took 10 seconds, because to me it was clear: rehabilitation facility. Arrange it and arrange it as soon as possible." (Lucas, 64, 42 days in ICU)* *"In the hospital, just before I was discharged, the rehab physician came to see me. And he evaluated me to see if I could go to a rehab facility or had to go to a nursing home. Well, that nursing home, I think well, damn I was only 59 back then, so I dreaded that. That's why I pushed for the rehab facility and luckily that worked out". (Thomas, 61, 56 days in ICU)*
Encountering empathy and expertise	· Feeling supported · Regaining a sense of reality · Showing compassion · Anticipating patient and family needs	*"..communication to the GP was really swift, because the hospital sent everything rapidly. [..] My GP, who I spoke to when I got home, first thing he said was: oh, you still sound the same after everything that happened. Most people coming from ICU, with the ventilator and all, have a different voice or what." (Ruby, 49, 5 days in ICU)* *"We had to figure everything out ourselves. And because we had such a good relationship with the cardiologist - he really is a wonderful man. Is enormously empathic and compassionate. Pointed us in certain directions, even though I had to ask for it myself." (Daniel, 66, husband of Florence, 68, 14 days in ICU)*

Table 3 (continued): Key concepts identified as enablers for a smooth transition experience, attributes and supporting excerpts

Key concept	Attributes	Additional supporting excerpts
		"Someone from the ICU aftercare team came to see me at the ward. [..] Well she said that she had been an ICU nurse before and now guided many patients, and that it's very normal that when going home I would still have problems. And if I felt the walls closing in on me when at home, that I should phone her. And yes, that made sense to me." (Matilda, 56, 15 days in ICU) *At one moment, someone was at my bedside, that was the nurse who had taken me in, at the emergency department. She came to see how I was because I had been so ill. [..] And I only wanted to know from her: what happened, and what did you see? I was so eager to hear the whole story. [..] Later I thought, talking about aftercare, that I really missed. Also, aftercare after discharge from ICU. (Jacob, 67, 21 days in ICU)*
Managing expectations	· Setting realistic goals · Being able to prepare for what is coming · Adjusting to new reality	*"Even in ICU, when I was told: 'take a year to get better', I had already decided: that is what I will do. Not quite knowing what that really meant [..] I knew I would get back on track [..] As my job is physically heavy, I even decided that if I couldn't go back to my job, I would retrain for a lighter job". (Violet, 54, 16 days in ICU)* *"..because I had one goal: I was absolutely certain I would pick up my old life again. And she has made me realize that that was not realistic, and that you have to look for alternatives." (Jessica, 60: 10 days in ICU)* *"I really like that, and she [the ICU nurse] had promised me, 'I'll come look you up when you are in the ward' [..] and told me: 'I have some advice and forms, some websites you can find information, for when you're at home'". (Alfred, 57, 19 days in ICU)* *"You know I searched the internet up and down, to find out how long does recovery take? And are these symptoms normal or not? In that I really missed the knowledge and expertise, I thought, of the medical team and health professionals". (Lucy, 32, 90 days in ICU)*

Table 3 (continued): Key concepts identified as enablers for a smooth transition experience, attributes and supporting excerpts

Key concept	Attributes	Additional supporting excerpts
Engaging the family	· Prevent caregiver anxiety · Anticipate family needs · Being able to make arrangements	*"It surprises me too, I have looked into my medical file afterwards, because I just wanted to know everything that happened. And it stated there that I was told on the last day, you can go home. And an hour later only, they phoned Georgia to find out if I could come home. So, the order of things was all wrong." (Alfred, 57, 19 days in ICU)* *"First, they said, you'll go to a rehab facility, but two days later you were in the pulmonary ward. And two days you were discharged home. And I was preparing for you to go to a rehab facility. So, I think, this can't be right. In my opinion, a rehab facility would have been better for you." (Katie, 54, wife of James, 54, 42 days in ICU)* *"I really thought, when we were discussing discharge, - and I think I might have said it to her as well - [..] a bit upset and a bit disappointed: if they created a job for someone to guide the patient when he is being discharged from hospital, but why are you not guiding? 'Cause I really did not understand that at all." (Nancy, 28, daughter of Harry, 60, 14 days in ICU)* *"..I asked how long Henry still had to stay in hospital after he'd left the ICU. 'Assume two weeks', so that was what I expected. But after that, they only talked to Henry, and not to me anymore. Then he phoned me that Friday night: I can come home tomorrow. My heart skipped a beat." (Maria, 53)*

DISCUSSION

Our study results suggest that survivors of critical illness and their relatives experience inadequate support in the transition from hospital to home or rehabilitation facility, despite recommendations for assessment of aftercare needs10. We identified barriers and enablers influencing this transitional experience of patients and relatives.

Barriers for a smooth transition homewards were "existing in a fragmented reality", "being overlooked" and "feeling disqualified". Although patient and relatives do not oversee the reality of the transition, they exist in the duality

of eagerness to go home and transition anxiety. It is within this context, that hospital discharge planning commences. Within the Dutch hospital setting, survivors of critical illness sometimes transfer to the ward via a short stay in a step-down unit, but more often they are transferred directly to the ward most relevant to their admission diagnosis. Recent studies identified a large variation in ICU discharge practice across Dutch hospitals.[24] Situations of "mutual misunderstanding" in communication between ICU staff and ward staff were identified, suggestive of patients' abilities being overestimated in the hospital ward, possibly leading to inadequate care provision.[25,26]

According to Galvin and coworkers[27] the concept of "readiness for discharge" consists of four attributes: 1) physical stability, 2) adequate support, 3) psychological ability and 4) adequate information and knowledge. When assessment of discharge readiness is conducted poorly, hospital readmission is a likely consequence.[27] In the experiences of our participants, discharge decisions seemed predominantly based on medical needs and physical (in)abilities instead of comprehensive readiness assessment, which compares to recent studies among similar populations.[9,18,28-30]

Patients in this study displayed a strong motivation to go home, which could be considered an enabling factor for a positive transition experience, however this individual drive may hinder a thorough estimation of patients' physical abilities and could be responsible for our participants' experience of discharge being rushed. Recent recommendations suggest that assessment of activity limitations to determine rehabilitation needs and discharge readiness, should be performance-based rather than self-reported. Self-reported physical function tools (e.g., the Short Form-36 physical functioning scale) require the individual to have an adequate perception of one's own (in)abilities and, as this study shows, this perception is flawed at time of discharge.[31]

Identified barriers as "being overlooked" and "feeling disqualified", led to discharge being experienced as abrupt, indicating that the timing and context within discharge planning takes place is essential, and should be linked to the moment patients' and relatives start "recalibrating" (i.e., starting to match the mental image of their previously healthy selves with their health status after critical illness). [32] Inclusion of relatives in discharge planning is essential to establish aftercare needs and can also provide family members with a feeling of purpose and facilitate coping strategies.[15,33-34] The concept of "being overlooked" could also be explained by insufficient awareness on or recognition of complications related to PICS and PICS-F which, together with the relatively

short ward-stay, seemed to influence the experience of briskness in the assessment of aftercare needs.[1-4,25,26]

Enabling to a more positive transition from hospital to home or rehabilitation facility were "feeling empowered", "encountering empathy and expertise", being able to "manage recovery expectations" and "family engagement". Transition anxiety can be prevented when professionals empower patients and relatives by acknowledging their state of "betweenness" and assisting them in regaining control.[16,32,35] Patient empowerment refers to the patient as comanager of his or her own health, while experiencing freedom to express all needs and concerns in an equal relationship.[36] As psychological effects of having experienced critical illness only emerge in the wards and after hospital discharge,[13,16,18,37] so do information needs. Revisiting ICU, aftercare clinic appointments and having access to medical files or ICU-diaries have shown to be therapeutic for patient and relatives[38-41].

Management of recovery expectations, for example through individualized education, was considered a powerful tool in setting realistic rehabilitation goals and experienced as helpful during the transition homewards, which is confirmed by a recent study.[40] Effective goal setting should be performed in a partnership continuum with patients, relatives, and healthcare professionals,[42] taking three important factors into consideration: 1) timing, 2) context, and 3) professional expertise. Because timing and context might not be optimal at hospital discharge, because of patient turnover pressure, we recommend that a complete needs assessment be conducted in the home situation, shortly after discharge. Contrary to the situation of in-hospital care dependency, patients and relatives can truly feel empowered when visited by a healthcare professional with expertise in ICU recovery, in the (quiet) context of their own home.

Strengths of this study relate to rigorous qualitative methods applied. Constant comparative methods allowed us to continuously check emerging findings while interviews continued. Methodological choices were carefully checked against the consolidated checklist for reporting of qualitative research (COREQ)[43] (see online supplement E4). Another strength to this study is that the population comprised patients from 16 hospitals across the Netherlands, allowing for a heterogeneous sample, which could be considered representative for the Dutch population of survivors of critical illness. Also, it provided us with insight in experiences of discharge procedures across a variety of hospitals over a longer period of time.

Several limitations can be identified. First, recruitment was conducted through websites for ICU-survivors and aftercare clinics, potentially increasing the likelihood for inclusion of participants with negative experiences and persistent problems at time of the interview. Second, time since hospital discharge showed a large variation among participants to this study, which should be taken into consideration when interpreting the results. Initially it seemed to enrich our dataset, as we were able to investigate if increasing awareness on PICS among professionals influenced participants' discharge experience. Although the study design limits us in drawing inferences on the influence of time, it is expected that hospital discharge procedures for survivors of critical illness in the Netherlands have improved over the past decade. Future studies could explore further if and how transition experiences changed over time. Another limitation related to the concept of time since discharge is the influence on patients' and relatives' recall, as the longer the time period since ICU-stay, the greater the chance of positive recall as unpleasant emotions may become less powerful.[44]

Lastly, the experience of in-hospital delirium was reality for the larger part of this study's population. It is expected that lingering cognitive problems persisted at time of hospital discharge, however within this study this was not identified as a barrier for a positive transition experience. Future studies could explore the possible influence of delirium experience on hospital to home transition.

In conclusion, our study shows that during the transition from hospital to home or rehabilitation facility after critical illness, patients' and relatives' physical and psychological needs are overlooked, resulting in suboptimal aftercare. Consideration for the timing of and context within discharge planning is undertaken and comprehensive needs assessment conducted with patient and relatives is essential to a positive transition experience, and only within an equal partnership can patient and relatives truly feel empowered to begin life after ICU.

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ONLINE DATA SUPPLEMENTS E1 – E4

DOI: https://doi.org/10.1513/AnnalsATS.201902-156OC

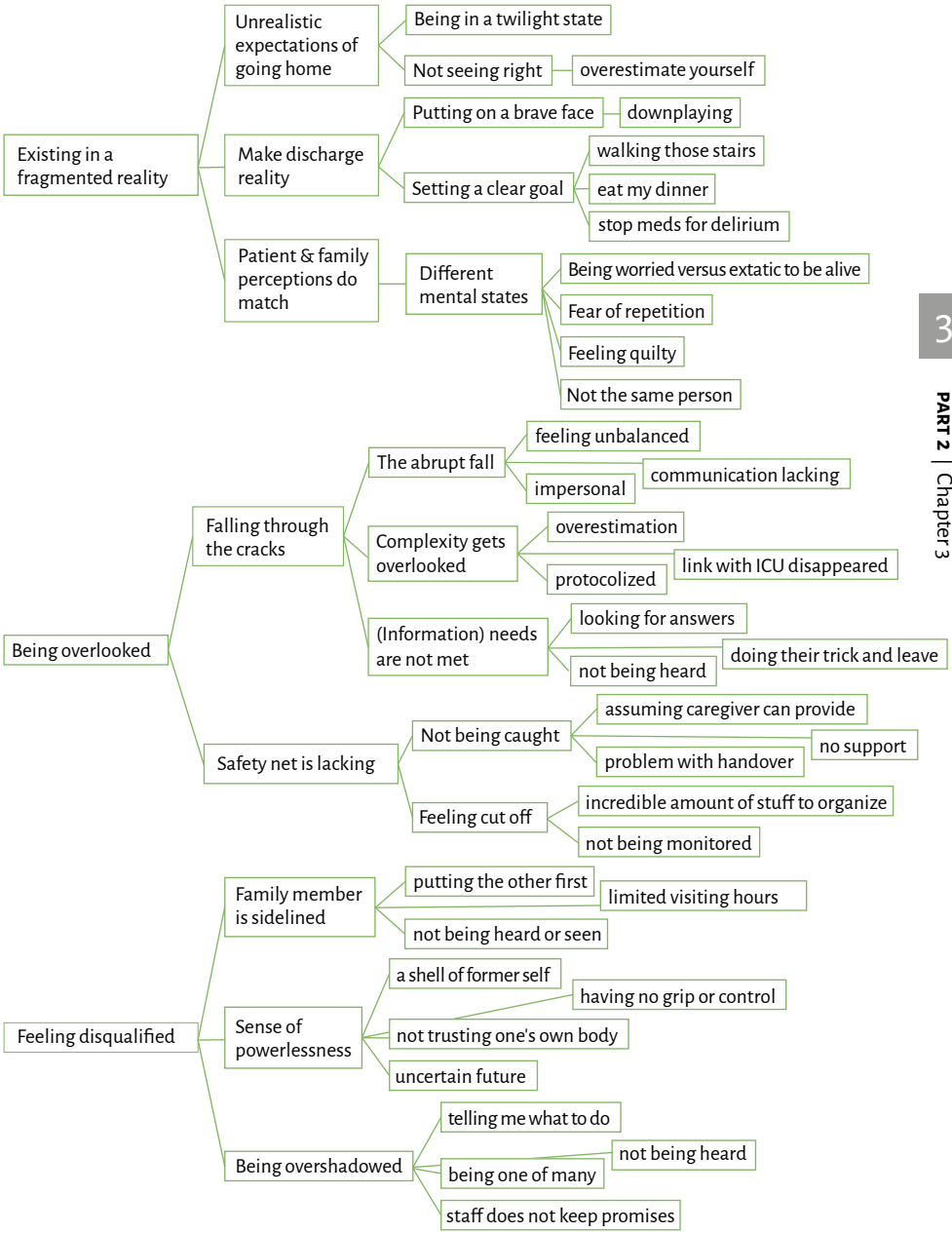
E1 Interview guide and topic list

Interview guide patient	
Topic	**Example question**
Experience regarding ICU admission and medical care received	· Please tell me what happened to you, why you were admitted to ICU and what type of medical care you received in ICU?
Experience with physiotherapy in the ICU	· How did you experience the physiotherapeutic care during ICU and hospital stay?
Moving from medium care to the ward	· How did you experience the transition from ICU/medium care to the ward?
Discharge from hospital	· How was discharge discussed with you and what was organized for you?
Experience with recovery	· How did you experience your recovery after discharge from the hospital until now?
Physiotherapy after hospital discharge	· Did you receive physiotherapy after hospital discharge and how did you experience this?
Other healthcare use and experience	· Have you sought help from other disciplines to help with recovery? Who did you turn to and how did you experience this? · How do you experience the collaboration and communication between healthcare professionals after you were discharged from hospital?
Future goals	· What goals do you still have for the future with regards to your recovery?
Experience regarding ICU admission family member	· Please tell me what happened to you and your [partner/sibling/child/parent] around the time of ICU admission.

Interview guide patient	
Topic	**Example question**
Experience with care, information provision during ICU and hospital stay	· Which type of guidance, care or information have you received during ICU admission and when moving to the ward?
Experience with physiotherapy (of family member) during hospital stay	· How did you experience the physiotherapeutic care during hospital admission?
Moving to the ward and home	· How did you experience the transition from ICU to medium care and to the ward? · How was discharge discussed with you and what was organized for you and your [partner/sibling/child/parent]?
Being at home	· How did the recovery of your [partner/sibling/child/parent] go after you came home?
Influence of ICU admission on family members functioning	· How are you now, compared to before your [partner/sibling/child/parent]'s ICU admission? · (How) is your situation changed?
Healthcare use and experience	· How did you experience the communication and collaboration between health care providers after discharge from hospital?

All topics were approached in a similar manner, with probing questions on three levels: 1) situation, 2) cognition/thoughts about the situation and 3) feelings about the situation.

E2 Initial coding tree



E3 Participant descriptives and pseudonyms

Pseudonym	Age	Gender	Occupation	Participant role	Admission diagnosis	ICU LOS (days)
Harry	60	M	Manager	Patient	Aortic aneurysm, multiorgan failure	14
Nancy	28	F	Recruitment manager	Daughter (Harry)		
Jack	55	M	Nurse	Patient	Bacterial pneumonia, bacterial endocarditis, sepsis	13
Elizabeth	59	F	Jeweler	Wife (Jack)		
Emily	68	F	Retired	Patient	Gastrointestinal perforation, sepsis	10
Isabella	45	F	Nurse	Patient	Necrotizing fasciitis, sepsis	9
George	59	M	Director HR	Patient	Bacterial infection, gangrene, sepsis	9
Alfred	57	M	Financial administrator	Patient	Influenza A pneumonia, ARDS	19
Georgia	54	F	Administrator	Wife (Alfred)		
Sophia	47	F	Team manager	Patient	Gastrointestinal perforation, sepsis	9
Isaac	51	M	Service engineer	Husband (Sophia)		
Jessica	60	F	Retired	Patient	Rheumatic disease, respiratory insufficiency	10
Thomas	61	M	Manager	Patient	CABG, multiorgan failure	56
Harriet	55	F	Administrator	Wife (husband not included)		

Pseudonym	Age	Gender	Occupation	Participant role	Admission diagnosis	ICU LOS (days)
Ruby	49	F	Project manager	Patient	Gastric bypass surgery, sepsis	5
Abigail	45	F	Administrator	Sister (Ruby)		
Matilda	56	F	Nursing assistant	Patient	Liver surgery (hemangioma), sepsis	15
Alexander	60	M	Factory worker	Husband (Matilda)		
Jacob	67	M	Manager (retired)	Patient	Necrotizing fasciitis, sepsis	21
James	54	M	Manager	Patient	Pulmonary embolism, cardiac arrest, sepsis	42
Katie	54	F	Orthoptist	Wife (James)		
Florence	68	F	Chemical analyst (retired)	Patient	Aorta dissection	14
Daniel	66	M	Communications consultant (retired)	Husband (Florence)		
Henry	59	M	ICT professional	Patient	Cardiac arrest	10
Maria	53	F	Policy advisor	Wife (Henry)		
Lucy	32	F	Psychiatric nurse	Patient	Endometriosis surgery, sepsis	90
Edward	36	M	Data analyst	Husband (Lucy)		
Lucas	64	M	Policy advisor	Patient	Influenza A, pneumonia, ARDS	42
Claire	63	F	Video producer	Wife (Lucas)		
Erin	52	F	Tax lawyer	Patient	Gastric bypass surgery, sepsis	35

Pseudonym	Age	Gender	Occupation	Participant role	Admission diagnosis	ICU LOS (days)
Molly	50	F	High school teacher	Patient	Legionnaire's disease, ARDS	12
William	57	M	Internet researcher	Patient	Cardiac arrest	4
Violet	54	F	Drama teacher	Patient	Necrotizing fasciitis, sepsis	16
Hannah	19	F	Student	Patient	Appendicitis, peritonitis	20
Eleanor	40	F	Housewife	Mother (Hannah)		

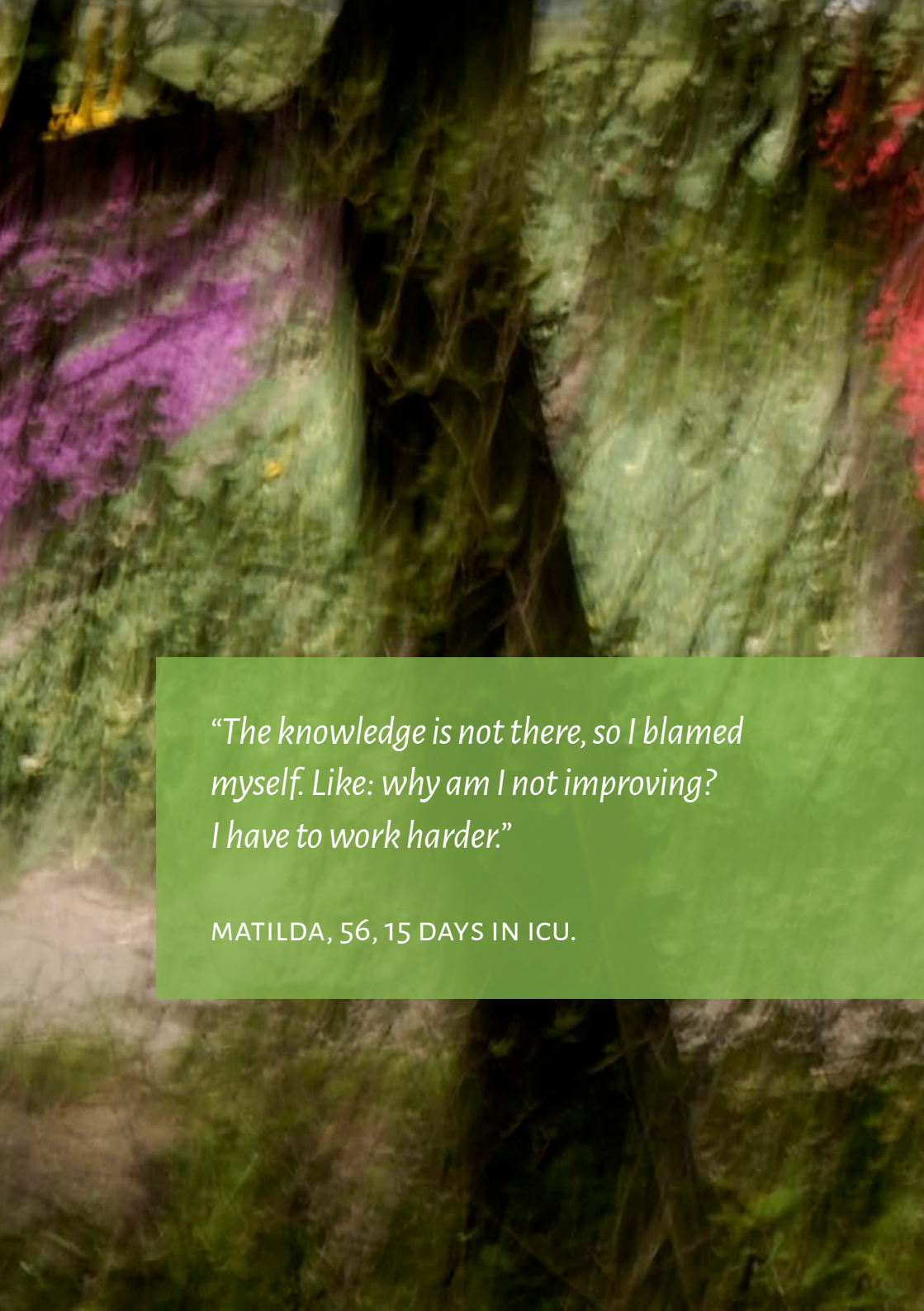
E4 COREQ checklist

No. Item	Guide questions/ description	Reported on Page #
Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Interviewer/ facilitator	Which author/s conducted the interview or focus group?	first author, MM (methods)
2. Credentials	What were the researcher's credentials? E.g. PhD, MD	MSc, PhD-candidate (methods)
3. Occupation	What was their occupation at the time of the study?	Physiotherapist, PhD researcher (methods)
4. Gender	Was the researcher male or female?	Female (methods)
5. Experience and training	What experience or training did the researcher have?	PhD researcher, PT for 15 years, no previous experience in semi-structured interviewing. Followed formal PhD-training on all phases of qualitative research including data-collection.
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	No prior relationship with any of the participants (methods)
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g., personal goals, reasons for doing the research	Researcher was unknown to the participants at the start of the study. No info on personal goals or ambitions was shared with participants but researcher's background could possibly have been checked through social media networks such as LinkedIn (methods)
8. Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g., Bias, assumptions, reasons and interests in the research topic	PT had no prior relationship and no current professional or personal relationship with the participants. Reasons of interest related to PhD research topic (methods)

No. Item	Guide questions/ description	Reported on Page #
Domain 2: study design		
Theoretical framework		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g., grounded theory, discourse analysis, ethnography, phenomenology, content analysis	A constructive grounded theory approach using constant comparative methods
Participant selection		
10. Sampling	How were participants selected? e.g., purposive, convenience, consecutive, snowball	Recruitment was done via websites catering towards patients and family after critical illness, aftercare clinics across the Netherlands, and health care professionals providing workshops for patients after critical illness. Interested participants contacted the researcher directly, and info was spread by word of mouth (snowball)
11. Method of approach	How were participants approached? e.g., face-to-face, telephone, mail, email	Contact via e-mail and phone. Interviews were face to face
12. Sample size	How many participants were in the study?	22 patients and 13 family members
13. Non-participation	How many people refused to participate or dropped out? Reasons?	Nobody refused to participate or dropped out. 3 interested participants were excluded due to 1) < 6 months ago, 2) neurological admission diagnosis and 3) not living in the Netherlands.
Setting		
14. Setting of data collection	Where was the data collected? e.g., home, clinic, workplace	Patient or family member's home: n=32, Workplace: n=1, research facility: n=2

No. Item	Guide questions/ description	Reported on Page #
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	In one interview with a caregiver, a research assistant was present. All other interviews were conducted by MM.
16. Description of sample	What are the important characteristics of the sample? e.g., demographic data, date	See table 2 and 3
Data collection		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Interview guide (table1) included in the article. Pilot mentioned in methods.
18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	No
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	Audio recording
20. Field notes	Were field notes made during and/or after the interview or focus group?	Field notes during the interview
21. Duration	What was the duration of the interviews or focus group?	Between 45 minutes - 1,5 hour
22. Data saturation	Was data saturation discussed?	Data saturation happened after 25 participants were interviewed and transcribed, interviews with 10 participants (some of them dyads) were completed after for verification of the data (methods)
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	Transcripts were returned to participants for check and corrected when required. (methods)

No. Item	Guide questions/ description	Reported on Page #
Domain 3: analysis and findings		
Data analysis		
24. Number of data coders	How many data coders coded the data?	Initial coding with two coders (MM and SR), after check, completed by one coder (MM)
25. Description of the coding tree	Did authors provide a description of the coding tree?	see online supplement 1
26. Derivation of themes	Were themes identified in advance or derived from the data?	Themes derived from the data
27. Software	What software, if applicable, was used to manage the data?	MAXQDA12
28. Participant checking	Did participants provide feedback on the findings?	- Transcripts were sent to participants for check on accuracy, some participants responded with corrections - Plenary session with a subsample of participants in which results were presented, and discussed, feedback was received.
Reporting		
29. Quotations presented	Were participant quotations presented to illustrate the themes/ findings? Was each quotation identified? e.g., participant number	Identified with pseudonym, refer to table 3. Quotations included in the article
30. Data and findings consistent	Was there consistency between the data presented and the findings?	Results section
31. Clarity of major themes	Were major themes clearly presented in the findings?	Results section
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Table 4 and 5 provide attributes (i.e. minor themes) as part of the key concepts.



"The knowledge is not there, so I blamed myself. Like: why am I not improving? I have to work harder."

MATILDA, 56, 15 DAYS IN ICU.

CHAPTER 4 Respiratory muscle weakness persists and is associated with exercise capacity and handgrip strength in survivors of critical illness: a prospective cohort study

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Submitted

ABSTRACT

Background: Mechanical ventilation affects the respiratory muscles. Little is known about the long-term recovery and potential associations with physical functioning in survivors of critical illness. Interventions targeting respiratory muscles rarely extend beyond the intensive care unit (ICU). The aim of this study was to investigate longitudinal changes in respiratory muscle strength and factors associated with functional recovery, in patients who received mechanical ventilation in ICU.

Methods: We conducted a prospective cohort study with 6-month follow-up among survivors of critical illness who received ≥ 48 hours of mechanical ventilation. Primary outcomes, measured at 3 timepoints, were maximal inspiratory and expiratory pressures (MIP/MEP). Secondary outcomes were functional exercise capacity (FEC) and handgrip strength (HGS). Longitudinal changes in physical outcomes and potential associations between MIP/MEP, predictor variables and secondary outcomes were investigated through mixed model analysis.

Results: Fifty-nine participants were included (age mean/SD 59 ± 12.6, 64.4% male) with median (IQR) ICU and hospital length of stay (LOS) of 11 (13) and 35 (31) days respectively. Except for MIP, population outcomes reached predicted values at 6 months. Mean (95% CI) MIP was 68.1% (62.0-74.2), 91.2% (63.6-98.9) and 98.5% (90.7-1.06) of predicted at baseline, 3- and 6-month follow-up respectively. Older age was associated with lower percentages of predicted MIP and FEC (Mean [95% CI]: -0.65 [-1.2 to -0.13] and -1.03 [-1.5 to -0.54] respectively). Significant, longitudinal associations were observed between MIP/MEP and FEC and HGS in both crude and adjusted models.

Conclusions: In a cohort of mechanically ventilated patients, complete 6-month recovery was observed for all outcomes except for MIP. As respiratory muscle weakness was associated with decreased exercise capacity and handgrip strength, we recommend to further explore the need for and applicability of respiratory muscle training within post-ICU exercise programs.

BACKGROUND

Critical illness and medical treatments in the intensive care unit (ICU) impact on physiological and psychological functioning. Due to medical and technological advancements, interventions in the ICU are often lifesaving. Recovery of critical illness is, nevertheless, challenging and often incomplete.[1-3] ICU-acquired weakness (ICU-AW) is one of the major physical consequences resulting from the combination of critical illness, sedation, mechanical ventilation, and immobilization.[4-7] ICU-AW is attributed to a decrease in muscle mass and contractile muscle function, due to immobility and catabolic processes leading to mitochondrial loss and dysfunction.[8,9] This catabolic state may have started prior to critical illness and ICU admission and may extend beyond ICU discharge.[10] Most patients who are mechanically ventilated develop ICU-acquired *respiratory* weakness, which can contribute to failed weaning attempts, prolonged ICU-stay, and reduced chances of survival.[11,12] Respiratory muscle weakness (RMW) is distinguished into dysfunction of inspiratory and expiratory muscles, which can be evaluated with measurements of maximal static inspiratory pressure (MIP, or PImax) and maximal static expiratory pressure (MEP, or PEmax). [13,14]

The diaphragm and external intercostal muscles are primarily responsible for generating the inspiratory force while the abdominal wall muscles and internal intercostal muscles generate most of the expiratory force.[11,15] Prevalence of ICU-diaphragm dysfunction (ICU-DD) can be as high as 80%, initiates after the start of mechanical ventilation and is associated with poor outcome.[11,12,16] The long-term prognosis of patients with concurrent presentation of ICU-AW and ICU-DD is worse compared to patients with independent ICU-AW or ICU-DD.[17-18]

While risk factors for RMW and its relationship with poor outcome are increasingly recognized, limited investigation has been conducted on prevention, treatment, and recovery over time.[11,12,15,19] Most studies on RMW in critically ill patients are conducted during spontaneous breathing trials or directly after extubation, but data on prevalence of RMW beyond the ICU is lacking. A recent study reported that RMW at time of ICU discharge is associated with a decrease in handgrip strength (HGS), physical functioning, and quality of life (QoL) up to 5 years after the critical illness[19] confirming the need for RMW assessment and interventions during, and potentially after ICU and hospital stay.[11] So far, longitudinal studies on the course of recovery of MIP and MEP in survivors of critical illness have not been reported[15,19] and although

interventions targeting RMW have become increasingly common within the ICU,[20-22] they seldom continue after ICU and hospital discharge.[23]

If longitudinal data existed on MIP and MEP and potential associations with functional outcomes in survivors of critical illness, we could determine if tailored interventions targeting MIP/MEP should be incorporated in post-ICU rehabilitation programs. Therefore, this study investigated longitudinal changes in respiratory muscle strength and its associations with functional outcomes at 6-month follow-up, in patients who received mechanical ventilation in the ICU.

METHODS

A prospective cohort study was conducted with a 6-month follow up on patients who received mechanical ventilation and were discharged from hospital. The study was performed between April 2019 and February 2021. Baseline parameters were obtained within one week after hospital discharge, with follow-up data collected at 3 and 6 months.

Setting

We recruited participants from 2 university and 5 general hospitals in the area surrounding Amsterdam, the Netherlands. The study ran concurrently with a pilot feasibility study of the department of rehabilitation medicine at the Amsterdam University Medical Centers (AMC).[24]

Participants

Participants who received mechanical ventilation (MV) for ≥ 48 hours and were discharged with a referral to physical therapy (PT) at home or to a rehabilitation facility, were eligible for inclusion. The need for transfer to a rehabilitation facility or home with PT was determined based on the presence of ICU-AW (Medical Research Council Sum Score < 48), decreased physical function (Functional Ambulation Categories ≤ 4), dependency in Activities of Daily Living and/or general deconditioning. Exclusion criteria were presence of serious (preexisting) cognitive and/or psychiatric impairments or insufficient Dutch or English language skills. Potential participants were contacted within 48 hours after hospital discharge by the primary investigator (MM). After further information on the aim of the study was provided, eligibility was confirmed and oral consent obtained, baseline measurements were scheduled within one week after hospital discharge.

Data collection

The location of data collection depended on the participants' location during scheduled measurements and occurred either at the participants' homes or at a rehabilitation facility. Baseline (T0) visits took place within one week and follow-up visits at 3 months (T1) and at 6 months (T2) after hospital discharge.

At baseline, the following characteristics were obtained: age, sex, educational level, admission diagnosis, ICU- and hospital length of stay (LOS), duration of mechanical ventilation (MV), discharge location and nutritional status. Admission data were cross-checked with the ICU-PT of the discharging hospital in cases where participants or their relatives were unsure.

Primary outcome variables were MIP and MEP, and secondary outcome variables were FEC and HGS.

The following potential predictor variables were identified a priori: ICU LOS, MV days, hospital LOS and age.

Measurements

Respiratory muscle strength was measured using voluntary tests of MIP and MEP with the microRPM spirometer (Micro Medical, Yorba Linda, CA, USA), which has shown to have excellent reliability (ICC > 0.90). [25] These tests can be used as screening tool to detect respiratory muscle weakness, show good within-subject responsiveness and reference values are available.[13,14,26] Three to five maneuvers were completed, until the difference between the two highest maneuvers was ≤ 10%. The highest MIP and MEP values (expressed as cmH2O) were recorded and converted into individual percentages of predicted values (% predicted) corrected for age and sex.[26]

FEC was tested with the two-minute step test (TMST). The TMST is developed as part of the Senior Fitness Test,[27] validated against other (functional) exercise capacity tests, reliable (ICC 0.90) in older adults with and without morbidities, and practical in use at the home environment. The test can be safely conducted if patients use walking aids.[27,28] Individuals are instructed to march in place, raising the knee to a set criterion height, completing as many steps as possible in two minutes. Outcomes are expressed as the 2-minute total number of steps of the right leg reaching criterion height.[27]

HGS was measured with the Jamar hydraulic hand dynamometer (Lafayette Instrument Company, Lafayette, IN, USA), expressed in kilograms. HGS is a commonly measured outcome in observational studies on survivors of critical illness and indicative of the presence of ICU-AW.[29] Three trials were

performed bilaterally, the highest value of the dominant hand was converted to individual percentages of predicted values, corrected for age and sex.[30]

MIP, MEP, FEC and HGS measurements were performed at all three timepoints.

Nutritional status was assessed at T0, with the Short Nutritional Assessment Questionnaire (SNAQ65+). The SNAQ65+ screens nutritional status based on pre-set criteria (involuntary weight loss, upper arm circumference, appetite, and physical function) and distinguishes three categories: undernutrition ('red'), risk of undernutrition ('orange') and no undernutrition ('green') and has shown to have good validity and consistency with mortality in adults.[31]

Study size

No formal sample size calculations were performed *a priori* for this observational study. As this observational study was conducted alongside a pilot feasibility study, sample size was determined by - but not limited to - recruitment potential of that study.[27]

Statistical methods

Sample characteristics were analyzed descriptively and expressed as means (standard deviations, SD) or medians (interquartile ranges, IQR) dependent on distribution of data. Linear mixed model (LMM) analyses were performed to analyze longitudinal changes in MIP, MEP, HGS and FEC, expressed as estimates with 95% confidence intervals (95% CI) at each timepoint and mean difference (Δ) between T0-T1 and T1-T2. Longitudinal associations between outcome variables and predictor variables were investigated through LMM, expressed as regression coefficients and 95% CI's. Associations are reported as crude and adjusted (for age, sex, and time dependence). Significance levels were set as $p \leq 0.05$.

Sensitivity analyses were conducted as follows: participants with missing data on primary and/or secondary outcomes at any of the timepoints were analyzed for baseline characteristics, predictor variables and outcome data. Next, independent t-tests or Mann-Whitney U tests (as appropriate) were applied comparing outcome data and covariates of complete and incomplete cases.[32] Lastly, longitudinal changes in primary and secondary outcomes were plotted for complete cases and compared to plots for the total study population. Analyses were conducted in IBM® Statistical Package for the Social Sciences (SPSS®), version 27, 2020 for Mac.

Ethical considerations

Ethical approval was obtained from the Medical Ethics committee at the Amsterdam University Medical Centers (AMC) (2019_012, ABR NL 68475.018.19). Written, informed consent was obtained from all participants.

Guidelines from the STROBE statement were applied for reporting of this study.[33]

RESULTS

Seventy-four potential participants were screened for eligibility. A total of 59 participants (male: 64.4%, mean age [SD]: 59.4 [12.6]) was included in this study. 69.5% ($n = 41$) of the participants were acutely admitted to the ICU and 66.1% ($n = 39$) had a cardiorespiratory admission diagnosis. The study population had a median (IQR) ICU and hospital LOS of 11 (13) and 35 (31) days respectively, and median (IQR) MV days of 10 (14). Forty-three participants (72.8%) were discharged home, 16 participants (27.2%) were discharged to in-patient rehabilitation. Baseline screening classified 83.1% of the population as having undernutrition (category 'red', SNAQ65+) (Table 1).

Table 1: Population characteristics ($n = 59$)

Variable	Outcome
Age, mean (SD)	59.4 (12.6)
Gender (n, %)	
· Male	38 (64.4)
· Female	21 (35.6)
Admission category (n, %)	
· Respiratory	26 (44.1)
· Cardiac	13 (22.0)
· Sepsis	9 (15.3)
· Oncologic surgery	10 (16.9)
· Trauma	1 (1.7)
Discharge location (n, %)	
· Home	43 (72.8)
· Rehabilitation center	16 (27.2)

Variable	Outcome
Educational level (n, %)	
· Primary education	3 (5.1)
· Lower secondary education	16 (27.1)
· Higher secondary / vocational education	17 (28.8)
· Higher education	23 (39.0)
SNAQ65+ score (n, %)	
· Red (undernutrition)	49 (83.1)
· Orange (risk of undernutrition)	6 (10.2)
· Green (no undernutrition	4 (6.8)

SD: Standard Deviation, IQR: Interquartile Range, LOS: Length of Stay, MV: Mechanical Ventilation, Admission category: relates to original ICU admission diagnosis

Study flow, drop-out and follow-up

Of the population enrolled at baseline, 5 participants (8.5%) withdrew consent during the study; 11.9% (*n* = 7) dropped out due to sudden physical deterioration and/or hospital admission and 1 participant could not be contacted (Figure 1).

Outcome data were obtained from 79.6% (*n* = 47) and from 74.6% (*n* =44) of the participants at 3- and 6-month follow-up respectively.

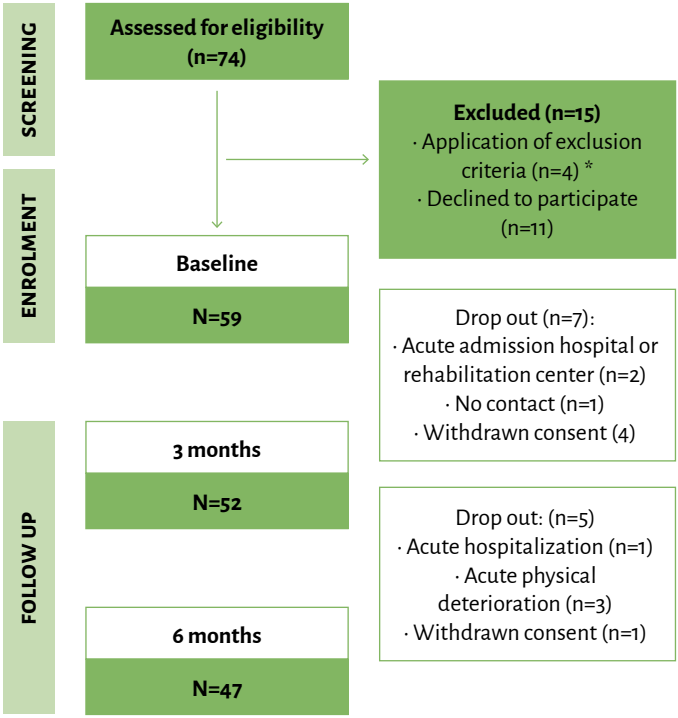
Sensitivity analysis results

Sensitivity analysis showed that out of the potential 177 visits, 3 data collection visits were completed according to protocol in 50.8 % (*n* = 30) of the study population, 2 out of 3 visits were completed in 32.2 % (*n* = 19) and in 17.0% (*n* = 10) only one data collection moment could be established. When analyzing for missing data on primary or secondary outcomes, 12 missing data points (primary outcome: *n* = 1, secondary outcome [FEC]: *n* = 11) could be contributed to safety criteria for testing not being met. Nineteen measurements could not be completed due to restrictions imposed by the national lockdown resulting from the COVID-19 pandemic. When analyzing baseline data for cases with complete follow-up (*n* = 30) versus cases with incomplete follow-up, participants in the complete group were significantly younger (age mean [SD] 55.9 [13.8] versus 64.2 [12.7], p 0.03) but no significant difference was observed for other participant characteristics or outcomes (Supplemental file).

Longitudinal changes in MIP and MEP

For MIP, the mean (95% CI) percentage of predicted values at T0, T1 and T2 was 68.4% (61.2-75.7), 91.4% (84.2-98.6), and 98.7% (91.4-106.0) respectively.

Figure 1: Consort Flow Diagram



**Not mechanically ventilated (n=1), cognitive impairment (n=1), language barrier (n=2)*

Significant changes were observed between each timepoint, but predicted values were not reached at T2. The mean (95% CI) percentage of predicted MEP was 76.0% (68.5-83.5), 100.9% (93.4-108.4), and 105.5% (97.9-113.0) at T0, T1 and T2 respectively. MEP improved significantly between T0-T1, reaching predicted values, but no further improvement was observed between T1-T2 (Table 2, Figure 2).

Table 2: Longitudinal changes: MIP, MEP, FEC and HGS

Variable	T0	T1	Δ T1-T0 (95% C.I)	T2	Δ T2-T1 95% CI
MIP % predicted **Mean cmH2O** **ß (95% CI)** *p* value	68.4 (61.2-75.7)	91.4 (84.2-98.6)	30.3 (25.2-35.3)* < 0.001	98.7 (91.4-1.06)	7.3 (2.5-12.0)* 0.003
MEP % predicted **Mean cmH2O** **ß (95% CI)** *p* value	76.0 (68.5-83.5)	100.9 (93.4-108.4)	29.5 (23.6-35.3)* 0.001	105.5 (97.9-113.0)	4.6 (-0.9 – 10.1) 0.103
FEC **ß (95% CI)** *p* value	54.8 (47.1-62.5)	80.0 (72.5-87.5)	32.2 (25.5-38.9)* 0.001*	87.0 (79.2-94.7)	7.0 (0.7-13.2)* 0.029
HGS % predicted **Mean kg** **ß (95% CI)** *p* value	73.3 (66.4-80.2)	93.9 (87.0-100.8)	31.4 (26.7-36.0)* 0.001	104.7 (97.7-111.6)	10.8 (6.3-15.2)* 0.001*

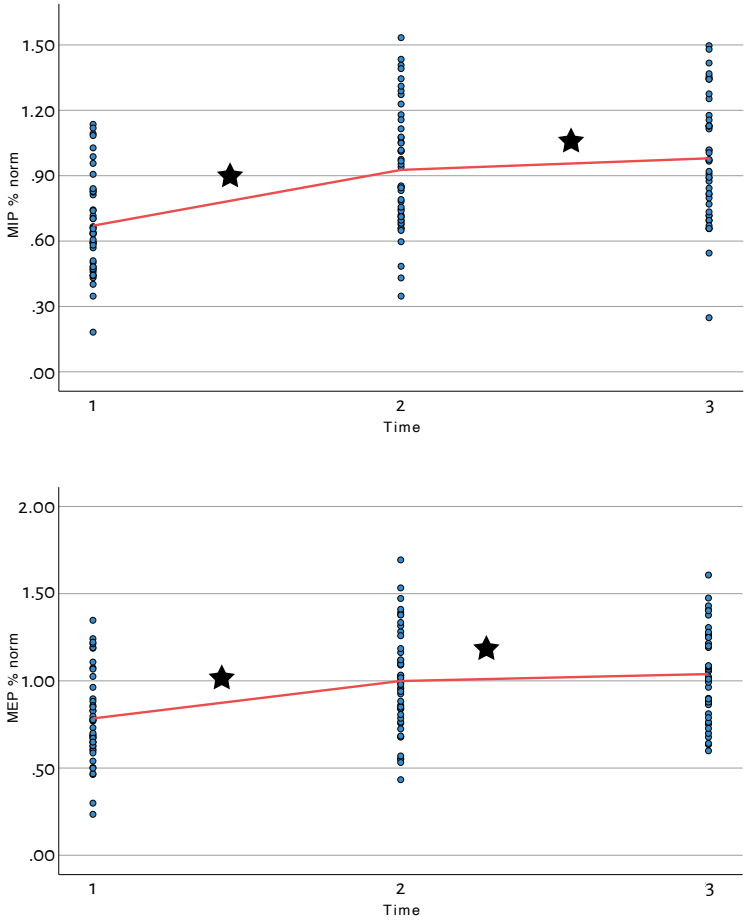
*ß beta regression coefficient Δ change in regression coefficient between timepoints, * significant at α 0.05 CI: confidence interval, MIP: maximum static inspiratory pressure, MEP: maximum static expiratory pressure, FEC: Functional Exercise Capacity, HGS: Handgrip Strength MIP/MEP percentage of predicted expressed in cmH2O, FEC expressed in total steps per 2 minutes (Two-minute step test), HGS percentage of predicted expressed in kilogram*

Longitudinal changes in FEC and HGS

FEC changed as follows: the mean (SD) steps were 54.8 (47.1-62.5), 80.0 (72.5-87.5), and 87.0 (79.2-94.7) at T0, T1 and T2 respectively. A significant improvement was observed between all timepoints.

For HGS the mean (95%) percentages of predicted values at T0, T1 and T2 were 73.3% (66.4-80.2), 93.9% (87.0-100.8), and 104.7% (97.7-111.6) respectively, improving significantly between each of the timepoints and reaching predicted values at T2 (Table 2, Figure 2).

Figure 2: Graphic presentation of longitudinal course in functional outcomes



PImax: maximum inspiratory mouth pressure (MIP), Pemax: maximum expiratory mouth pressure (MEP), HGS: Handgrip Strength, TMST: Two-minute Step Test. Error bars: 95% CI
Significant change between timepoints = ★

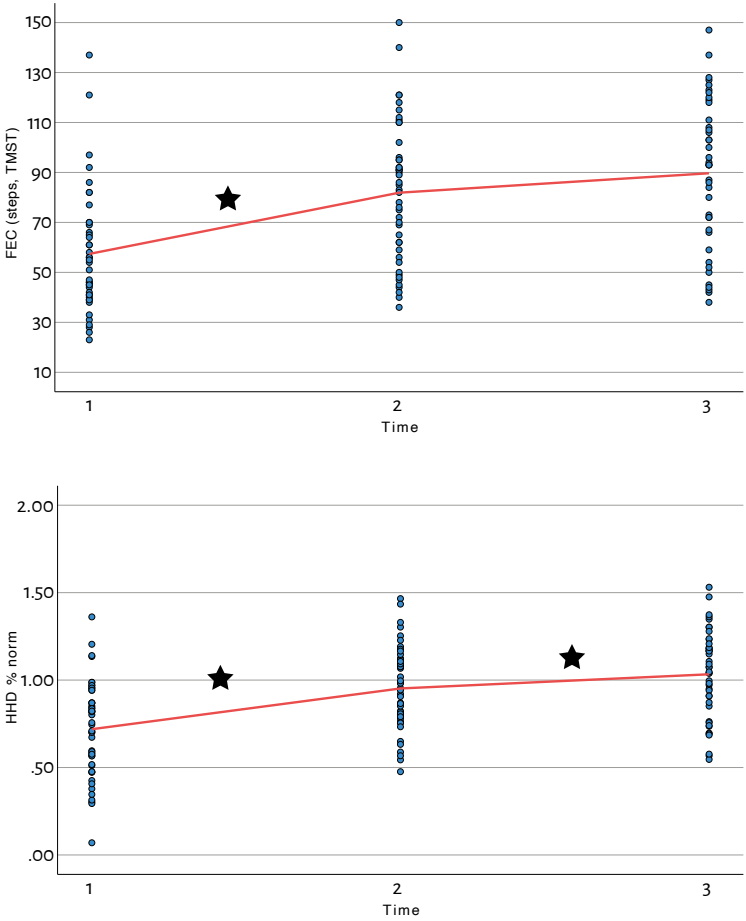


Figure 2 (continued): Graphic presentation of longitudinal course in functional outcomes PImax: maximum inspiratory mouth pressure (MIP), Pemax: maximum expiratory mouth pressure (MEP), HGS: Handgrip Strength, TMST: Two-minute Step Test. Error bars: 95% CI Significant change between timepoints = ★

Predictors for primary, secondary outcomes

Age was identified as a predictor for MIP (% predicted), as a significantly longitudinal, negative association was observed (-0.65 [-1.2 to -0.13], p 0.016),

as well as for FEC (-1.03 [-1.5 to -0.54, p < 0.001). Hospital LOS was predictive for HGS (% predicted) (-0.50 [-0.73 to -0.23], p < 0.001), as well as for FEC (-0.30 [-0.59 to -0.01] p 0.043). ICU LOS and MV days were predictors for HGS (% predicted) (-0.64 [-1.1 to -0.23] p 0.003, and -0.83 [-1.3 to -0.34] p 0.001 respectively) (Table 3).

Table 3: Univariate associations of predictor variables with physical outcomes

Predictor	MIP (% predicted)	MEP (% predicted)	HGS (% predicted)	FEC (steps, TMST)
Hospital LOS ß (95% CI)	-0.3 (-0.6 - 0.0)†	-0.1 (-0.4 - 0.1)	-0.5 (-0.7 to -0.2)*	-0.3 (-0.6 to -0.01)*‡
ICU LOS ß (95% CI)	-0.1 (-0.6 - 0.3)	0.1 (-0.4 - 0.5)	-0.64 (-1.1 to -0.2)*‡	-0.4 (-0.9 - 0.08)
MV days ß (95% CI) *p* value	-0.1 (-0.7 - 0.5)	0.21 (-0.3 - 0.8)	-0.83 (-1.3 to -0.3)*	-0.33 (-0.9- 0.2)
Age ß (95% CI) *p* value	-0.6 (-1.2 to -0.1)*	-0.3 (-0.8 – 0.2)	0.11 (-0.6- 0.4)	-1.0 (-1.5 to -0.5)*

*ß beta regression coefficient, CI = Confidence Interval * Significant at α 0.05*
‡ Did not remain significant in multivariate analysis † Reached significance in multivariate analysis

MIP = maximum inspiratory mouth pressure, MEP = maximum expiratory mouth pressure, HGS = Handgrip Strength, FEC = Functional Exercise Capacity, TMST = Two-minute Step Test, LOS = Length of Stay, ICU = Intensive Care Unit, MV = Mechanical Ventilation.

Associations between RMW, FEC and HGS

In both the crude and the adjusted models, the observed MIP (PImax) and MEP (PEmax) were significantly associated with FEC. In the age, sex and time adjusted models, the association between PEmax and FEC remained significant, whereas for PImax this association did not remain in the time adjusted model. For PImax and PEmax, significant associations were found with HGS in the models adjusted for sex and time dependency, but not for age. Table 4 provides regression coefficients for the crude and adjusted models.

Table 4: Associations between respiratory muscle weakness and functional outcomes

	Univariate	Multivariate (age adjusted)	Multivariate (sex adjusted)	Multivariate (time adjusted)
PImax‡ * FEC ß (95% CI)	0.69 (0.54 - 0.84)*	-0.44 (-0.95 - 0.07)	18.3 (5.1 - 31.4)*	6.14 (-4.1-16.3)
PEmax‡ * FEC ß (95% CI)	0.52 (0.40 - 0.64)*	-0.54 (-1.07 to -0.1)*	23.4 (9.6 - 37.2)*	18.1 (7.6-28.5)*
PImax‡ * HGS ß (95% CI)	0.27 (0.22 - 0.33)*	-0.08 (-0.30-0.14)	-8.61 (-14.1 to -3.2)*	3.72 (0.87 - 6.57)*
PEmax‡ * HGS ß (95% CI)	0.21 (0.17 - 0.25)*	-0.12 (-0.35 - 0.11)	-7.05 (-12.96 to -1.14)*	4.39 (1.40 – 7.38)*

Independent: PImax, PEmax, ß = beta regression coefficient, CI = Confidence Interval

*PImax = **observed** maximum inspiratory mouth pressure, PImax = **observed** maximum expiratory mouth pressure, ‡ absolute, observed values FEC = Functional exercise capacity, HGS = Handgrip Strength, * Significant at α 0.05*

DISCUSSION

In our population of mechanically ventilated patients, we found both MIP and MEP to be below predicted values directly after hospital discharge. While significant recovery occurred between timepoints, normative values were not reached for MIP at 3- or 6-month follow-up, indicative of persistent isolated diaphragm weakness.[11] While the influence of persistent diaphragm weakness on physical recovery after critical illness is not yet fully understood,[19] potential contributions to decreased exercise capacity and generalized fatigue can be anticipated. This study shows a similar recovery trajectory of MIP, FEC and HGS; the greatest improvements occurred in the first 3 months after hospital discharge, followed by significant – but smaller – improvements between 3 and 6 months. Visualized in figure 2, the recovery in our study sample seems to correspond with recovery trajectories as proposed by Iwashyna.[34]

For MEP, FEC and HGS, complete recovery was observed at 6 months, which can possibly be explained by age and educational level of our study population.

Additionally, our study found age, hospital LOS, and ICU LOS to be independent predictors for functional recovery. These findings are supported by several recent publications.[35-38] For MIP, however, this study shows incomplete recovery at 6 months. MIP/MEP were found to be significantly associated with FEC and HGS. The association between MIP/MEP and FEC can be explained by the fact that a functional respiratory muscle pump is required for optimal performance during aerobic exercise.[15] HGS is commonly used as a marker for generalized muscle weakness in survivors of critical illness29, but this study is the first to show longitudinal associations between RMW and HGS. This potentially justifies continued assessment of MIP and MEP in patients with generalized weakness and deconditioning after ICU and hospital discharge,[19,23] to determine the need for specific interventions.

While recommendations exist for inspiratory muscle training (IMT) in the ICU,[20,21,39] few studies report on IMT continuing after ICU discharge. Isolated IMT protocols, besides improving the MIP, have shown to positively influence the cardiovascular system and exercise capacity[40] and improved exercise capacity has been reported in patients with heart failure,[41] chronic obstructive pulmonary disease (COPD)[42] and those recovering from critical illness.[21]

In survivors of critical illness, inspiratory muscle weakness is often defined as a MIP of ≤ 70% of predicted values,[43,44] but this is not well founded in literature. The European Respiratory Society statement on respiratory muscle testing recommends MIP and MEP values to be interpreted in the context of the overall clinical presentation,[13] which might be more suitable for the post-ICU population.[21] In our study, we found markedly decreased MIP/MEP as well as FEC and HGS at the different timepoints after hospital discharge, suggesting that our population included patients with ICU-AW and possible concurrent ICU-DD. In this, our population shows similarities to populations in other observational studies.[12,17,18] Although we did not distinguish between patients with and without ICU-AW and great variability was seen between patients, our findings confirm that assessment of MIP and MEP might be clinically relevant and important for patients presenting with generalized weakness and decreased exercise capacity. Recent publications highlight the relevance of MEP measurements in critically ill patients while receiving mechanical ventilation, as decreased MEP is associated with extubation failure, decreased airway clearance and diaphragm contractile efficiency.[15,45] Shi et al. reported that expiratory muscles are recruited in circumstances where the respiratory load is high and/or inspiratory muscles are weakened,[15] which could explain our

findings that recovery of MEP was achieved earlier compared to other outcomes and justifies continued MIP and MEP assessments. In choice of interventions, combined inspiratory and expiratory muscle training (EMT) has been shown to be superior to IMT alone, in improving athletic performance,[46] whereas evidence exists that IMT training alone can increase both MIP and MEP in the critically ill population.[21] With regards to rehabilitation programs after ICU and hospital discharge, however, evidence is lacking on optimal application of IMT or EMT within exercise programs. Extensive rehabilitation research in cardiorespiratory patients can possibly serve as a guideline; combined exercise programs targeting respiratory and overall muscle strength as well exercise capacity, are likely to be more effective than isolated interventions.[47,48]

Limitations to this study

First, our recruitment procedure and eligibility criteria might infringe on generalizability of our study data. As participants had to have an indication for home discharge with PT or discharge to a rehabilitation center, the more functional patient was not included in this study. Similarly, the severely deconditioned patient was also likely missed. Plus, our study sample was relatively small.

Second, as is common with prospective cohort studies on vulnerable populations, we performed our analyses on incomplete datasets. Data were missing for several reasons, with the restrictive circumstances during the initial national lockdown in 2020 being the largest contributor. While sensitivity analyses showed no significant differences in outcomes between participants with complete datasets versus the participants with missing data, our results should be interpreted with caution.

Third, no data were available on MIP/MEP prior to or during ICU admission, limiting the interpretation of our findings considering pre-existing functional problems, comorbidities, or severity of the critical illness. Next, we did not explore if MIP was independently associated with MEP, as one recent publication suggests.[15] Considering the pathophysiology of the respiratory muscle pump, it would have been interesting to explore such relations and possible expiratory compensatory mechanisms in the presence of inspiratory muscle weakness. However, our relatively small dataset limited us to conduct such analyses.

Fourth, data on FEC are expressed in observed values (step count), not corrected for age and gender, as for the population < 60 years, no reference values exist.[28,49] Step count performance over time is likely confounded by age and/or sex. Unfortunately, data could not be obtained for severely fragile

participants. While the test showed responsiveness in detecting change in FEC, especially in the first 3 months after hospital discharge, a tendency towards a ceiling effect was observed in the second 3 months. Considering this, we recommend exploring different (functional) exercise capacity tests for patients recovering from critical illness.

CONCLUSIONS

To our knowledge, this is the first study presenting longitudinal data on MIP and MEP in a population which received mechanical ventilation up to 6 months after hospital discharge. We identified persistent RMW to be present for 3-6 months after hospital discharge, potentially influencing physical functioning. As persistent RMW was associated with decreased exercise capacity and handgrip strength, we recommend continued assessment of MIP/MEP as part of critical care follow-up programs. More studies are needed to investigate pathophysiological mechanisms explaining associations between RMW, ICU-AW and decreased exercise capacity and the potential benefits of respiratory muscle training within post-ICU rehabilitation programs.

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SUPPLEMENTAL FILE: RESULTS OF THE SENSITIVITY ANALYSIS

Baseline characteristics and outcomes: complete follow-up versus incomplete follow-up

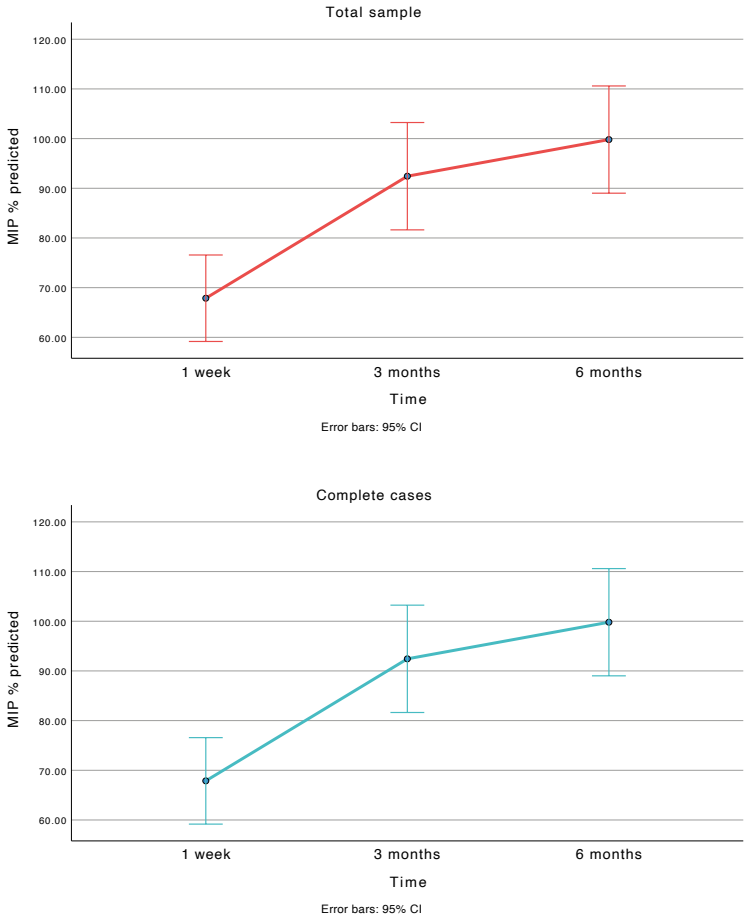
Variable	Complete visits (*n* = 30)	Incomplete visits (*n* = 29)	Comparison
Age, mean (SD)	55.9 (13.8)	64.2 (12.7)	p 0.03*
Gender (n, %) · Male · Female	 22 (73.3) 8 (26.7)	 16 (55.2) 13 (44.8)	
ICU LOS, median (IQR)	14.5 (17)	10 (27)	p 0.75‡
Hospital LOS, median (IQR)	40.5 (34)	31 (35)	p 0.20‡
MV days, median (IQR)	11.5 (14)	8 (17)	p 0.85‡
Admission category (n, %) · Acute · Elective	 21 (70.0) 9 (30.0)	 20 (69.0) 9 (31.0)	
Discharge location (n, %) · Home · Rehab	 23 (76.7) 7 (23.3)	 20 (69.0) 9 (31.0)	
SNAQ65+ (n, %) · Green · Orange · Red	 3 (10.0) 4 (13.3) 23 (76.7)	 1 (3.4) 2 (6.9) 26 (89.7)	
Baseline outcome data			
PImax, mean % predicted (SD)	67.9 (23.3)	65.5 (21.0)	p 0.74*
PEmax, median % predicted (IQR)	69.6 (26.4)	81.2 (42.8)	p 0.58‡
HGS, mean % predicted (SD)	71.8 (26.0)	72.3 (30.0)	p 0.85*
TMST, median steps (IQR)	57 (31)	53 (30)	p 0.46‡

SD: Standard Deviation, LOS: Length Of Stay, IQR: Interquartile Range, MV: Mechanical Ventilation, SNAQ65+: Short Nutritional Assessment Questionnaire 65+, Pimax: Maximum Inspiratory mouth Pressure, Pemax: Maximum Expiratory mouth Pressure, HGS: Grip Strength, TMST: Two-Minute Step Test

** independent samples t-test ‡ Mann Whitney U test*

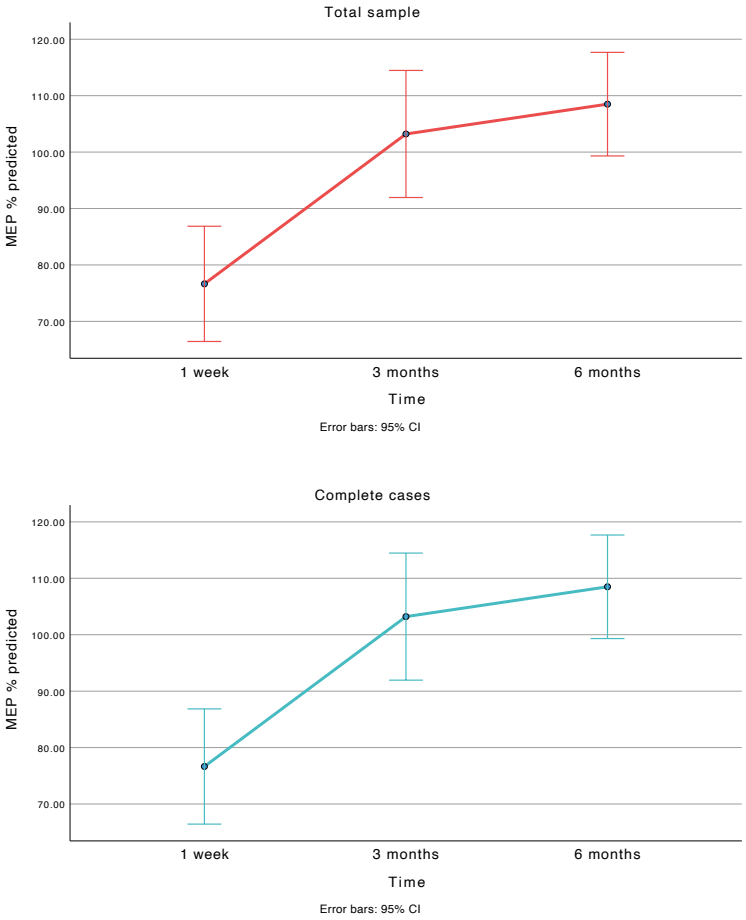
Graphic presentation for primary outcomes total sample versus complete cases

MIP % predicted, course over time: total N (n=59) versus complete cases (n=30)



MIP: Maximum Inspiratory mouth Pressure, MEP: Maximum Expiratory mouth Pressure, CI: Confidence Interval

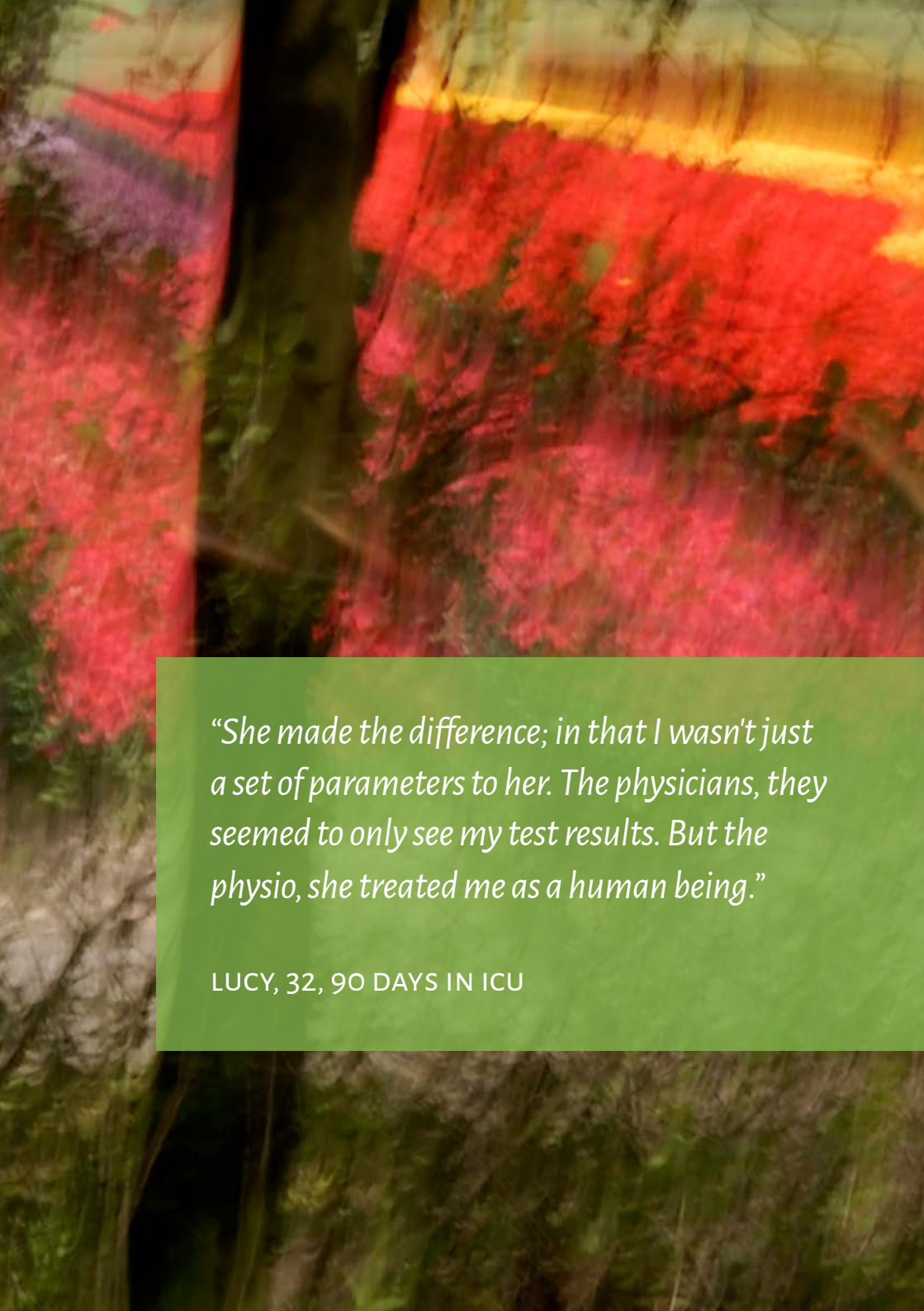
MEP % predicted, course over time: total N (n=59) versus complete cases (n=30)



MIP: Maximum Inspiratory mouth Pressure, MEP: Maximum Expiratory mouth Pressure, CI: Confidence Interval

PART 3

Recommendations for state-of-the-art rehabilitation interventions after hospital discharge



"She made the difference; in that I wasn't just a set of parameters to her. The physicians, they seemed to only see my test results. But the physio, she treated me as a human being."

LUCY, 32, 90 DAYS IN ICU

CHAPTER 5 Surviving critical illness, what is next? An expert consensus statement on physical rehabilitation after hospital discharge

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ABSTRACT

Background: The study objective was to obtain consensus on physical therapy (PT) in the rehabilitation of critical illness survivors after hospital discharge. Research questions were: what are PT goals, what are recommended measurement tools, and what constitutes an optimal PT intervention for survivors of critical illness?

Methods: A Delphi consensus study was conducted. Panelists were included based on relevant fields of expertise, years of clinical experience and publication record. A literature review determined five themes, forming the basis for Delphi round one, which was aimed at generating ideas. Statements were drafted and ranked on a 5-point Likert scale in two additional rounds with the objective to reach consensus. Results were expressed in median and semi-interquartile range (SIQR), with the consensus threshold set at ≤ 0.5.

Results: Ten internationally established researchers and clinicians participated in this Delphi panel, with a response rate of 80%, 100%, and 100% across three rounds. Consensus was reached on 88.5 % of the statements, resulting in a framework for PT after hospital discharge. Essential handover information should include information on 15 parameters. A core set of outcomes should test exercise capacity, skeletal muscle strength, function in activities of daily living, mobility, quality of life, and pain. PT interventions should include functional exercises, circuit and endurance training, strengthening exercises for limb and respiratory muscles, education on recovery, and a nutritional component. Screening tools to identify impairments in other health domains and referral to specialists are proposed.

Conclusions: A consensus-based framework for optimal PT after hospital discharge is proposed. Future research should focus on feasibility testing of this framework, developing risk stratification tools, and validating core outcome measures for ICU survivors.

BACKGROUND

Interdisciplinary interventions directed towards early mobilization of critically ill patients within ICUs are implemented in many hospitals across the world.[1,2] Serious functional decline associated with immobility, sedation, pharmacological treatment, and mechanical ventilation has been shown in recent publications.[3-8] Long-term impairments in physical and mental health, associated with prolonged ICU stay and impeding recovery have now been characterized as post-intensive care syndrome (PICS).[9]

The Society of Critical Care Medicine (SCCM) recommends improvement of continuity of care for ICU survivors, involving risk assessment and comprehensive documentation during all phases of recovery.[10] In the absence of established care pathways or evidence-based guidelines, physical therapists involved in treatment of patients after hospital discharge conceivably draw on clinical expertise with patients within the cardiopulmonary scope of practice, for which such evidence does exist.[11] However, because the recovery process of survivors of critical illness is explicitly different to the aforesaid group—due to the consequences of critical illness, medical interventions, and persistent systemic inflammation[12]—rehabilitation needs likely extend beyond the physical domain.

The need for standardized sets of outcome measures or a core outcome set (COS) for survivors of critical illness has been highlighted in recent publications.[13-16] A COS aids researchers and clinicians in selecting measurement tools for a certain population. Measuring the core outcomes is essential, while additional measurements can be undertaken dependent on individual patient needs.[17] Currently, no consensus exists on a COS for survivors of critical illness. Several 'COS for trials' projects are registered with the Core Outcome Measures in Effectiveness Trials (COMET) initiative18 but published results are lacking. A 'COS for clinical practice' likely differs from a 'COS for trials' because instruments used in physical therapy (PT) practice must be practical and feasible, as well as psychometrically solid to contribute to an evidence-based clinical decision-making process.[19,20]

In the absence of scientific evidence, Delphi processes can be used to unite researchers, clinicians, patients, and stakeholders in collaborative initiatives aiming to produce a consensus statement.[21] Results of such studies may contribute to the post-ICU rehabilitation knowledge base, facilitate feasibility studies and randomized controlled trials (RCTs), and assist in implementing evidence-based interventions across the continuum of care. The aim of this study was to develop, through the use of Delphi methodology, a consensus

statement including recommendations for PT practice for survivors of critical illness after hospital discharge. Leading research questions were: what are PT goals, what are recommended measurement tools, and what constitutes an optimal PT intervention for survivors of critical illness?

METHODS

The design of this Delphi project consisted of three stages (Figure 1). An independent steering committee - consisting of experts in the field of rehabilitation medicine, ICU PT, and ICU aftercare at the Amsterdam University Medical Centers in Amsterdam, the Netherlands - supervised all stages.

A scoping literature review was conducted during March and April 2015 searching PubMed, Medline, PEDro, CINAHL, Science Direct and ProQuest Social Sciences. Articles were considered for review if they were clinical trials, published in the last 10 years, and PT was the studied intervention. The Appendix illustrates the search strategy. Data were extracted, themes identified, and statements drafted by MEM and RK and approved by the steering committee.

Stage 2 consisted of a three-round Delphi process. A final consensus meeting was not feasible considering the international character of our panel; hence consensus was sought through discussion of the manuscript's content.

Figure 1: Delphi Consensus Process

COMET Core Outcome Measures in Effectiveness Trials

Panel recruitment

A purposive selected expert panel was used. A shortlist of eligible panelists, derived from the literature review, was approved by the steering committee. Eligibility was determined based on field of expertise and relevant publications indexed in PubMed/Medline. Anonymity of the panelists was assured throughout all Delphi rounds. With acceptance of the invitation, informed consent was obtained for publication of the results.

Delphi methodology

The need for a minimum of three online Delphi rounds was estimated prior to the start, as per literature recommendations in situations where the quantity of scientific research is limited.[21,22] In the first round, panelists generated ideas within five themes identified through the literature review (Table 1). Open and closed questions were drafted by MEM and RK. Open questions related to opinions and experiences with PT care after ICU and hospital discharge. Closed questions related to the panelist's view on the relevance on patient information, measurement tools, and interventions. The answers to the closed questions were dichotomized as either relevant or nonrelevant for PT after hospital discharge. Items unanimously marked as 'nonrelevant' were excluded from following rounds. Open question answers were analyzed for transcending themes. Results of round one were formatted into 83 statements, within three categories: hospital phase, hospital discharge information and post-hospital phase.

Table 1. Themes defined for Delphi round one

Theme 1	Defining the patient with PICS. Most common impairments in body functions, structures, activity limitations and restrictions in participation (ICF).
Theme 2	Discharge information, which should be made available to the physical therapist after hospital discharge.
Theme 3	Reliable and validated outcome measures to use in daily physical therapy practice through the different phases of recovery.
Theme 4	Optimal physical therapy interventions.
Theme 5	The critical care pathway.

PICS post-intensive care syndrome

Round two required panelists to rank each statement on an ordinal scale of 1 to 5 (1 = essential, 2 = very important, 3 = important, 4 = unimportant and 5 = undesirable).[23] For the third round, each panel member received controlled feedback consisting of group and personal scores (median and semi-interquartile range [SIQR]) for round two. Panelists were asked to re-rank the statements if their individual score lay outside the SIQR. Explanation was required when panelists chose not to adjust their score to the group's consensus. The Delphi process was terminated once consensus was reached on ≥ 80% of the statements, because additional Delphi rounds were not expected to provide potentially different results.[21]

Statistical analysis and consensus

Median and SIQR were calculated for each statement, an appropriate statistical choice for data scored on an ordinal scale.[24] The SIQR was expressed as half the numerical distance between the first and third quarter of the interquartile range (IQR). Consensus was defined a priori as SIQR of ≤ 0.5.
The project was registered within the COMET initiative database.[25]

RESULTS

All shortlisted panelists agreed to participate (n = 10). The response rate was 80%, 100%, and 100% respectively for the three Delphi rounds. Table 2 presents the countries, disciplines, and field of expertise represented by the panel.

Panelists' comments after round two, related to discharge information and screening tools, initiated the drafting of four additional statements. Consensus was reached on 88.5% of the statements after round three; no consensus was reached on the ranking of 10 statements (SIQR > 0.5) (Additional file 1: Table S1).

Hospital phase

The panel consensually ranked the use of valid ADL instruments to establish patients' functional level at hospital discharge as very important (score: 2; SIQR: 0.5). Consensus was reached on the importance of screening family members for the presence of PICS-family (PICS-F) (score: 3; SIQR: 0.05), but no consensus was achieved on the importance of screening patients for the presence of PICS at hospital discharge (score: 1.25; SIQR: 0.65). Panelists' explanations related to the absence of validated risk assessment tools for PICS(-F) and disagreement on the preferred timing of this screening (ICU or hospital discharge). No consensus

Table 2: International Delphi panel characteristics

Number	Country	Field of expertise (title)	Years of clinical experience	No. of publications indexed in PubMed	Agreed to participate	Response Round 1	Response Round 2	Response Round 3
1	Australia	Physiotherapy (Prof. Dr)	> 20	68	✔	—	✔	✔
2	Australia	Physiotherapy (Associate Prof. Dr)	> 20	12	✔	✔	✔	✔
3	Belgium	Physiotherapy / Movement Science (Prof. Dr)	> 20	128	✔	✔	✔	✔
4	Canada	Physiotherapy (Dr)	15-20	44	✔	—	✔	✔
5	The Netherlands	Physiotherapy (Associate Prof. Dr)	> 20	16	✔	✔	✔	✔
6	South Africa	Physiotherapy (Associate prof. Dr.)	> 20	24	✔	✔	✔	✔
7	United Kingdom	Physiotherapy (MSc, Physical Therapist)	10-15	3	✔	✔	✔	✔
8	United Kingdom	Nursing / Psychology (Dr)	> 20	10	✔	✔	✔	✔
9	United Kingdom	Physiotherapy (Dr)	15-20	9	✔	✔	✔	✔
10	USA	Medicine (Prof. Dr/MD)	15-20	> 200	✔	✔	✔	✔

— No response ✔ Response obtained

was reached on education of patient and family on PICS at the time of hospital discharge (score: 2; SIQR: 0.65).

Hospital discharge information

Consensus was reached on the inclusion of 15 items in the hospital discharge information. Items ranked as essential (score: 1) were: premorbid level of functioning (SIQR: 0); physical, mental, and cognitive course of recovery during hospital stay (SIQR: 0); rehabilitation provided and rehabilitation goals (SIQR: 0); and current psychological, cognitive, and physical state (SIQR: 0.5). Items ranked as very important (score: 2) were: severity of illness (SIQR: 0), pre-ICU psychiatric symptoms (SIQR: 0); physiological response to exercise (SIQR: 0); comorbidities (SIQR: 0.15); diagnosed ICU – Acquired Weakness (ICU-AW) (SIQR: 0.3); delirium whilst in hospital (SIQR: 0.5); ICU and hospital length of stay (LOS) (SIQR: 0.5); and complications during hospital stay (SIQR: 0.5). Items ranked important (score: 3) were: specific patient and/or family characteristics such as personal and environmental factors (SIQR: 0.5); and days of immobility (SIQR: 0.5). Inclusion of the Acute Physiology and Chronic Health Evaluation (APACHE) score, information on genetic factors, and biomarkers was ranked unimportant (score: 4; SIQR: 0.3). No consensus was reached on the importance of including details on duration of mechanical ventilation, sedation, and surgery in the discharge information (score: 2; SIQR: 0.65). Panelists considered details on mechanical ventilation and sedation to be related to ICU LOS, an easier measure to report at discharge (Additional file 1: Table S1).

Physical therapy goals after hospital discharge

The panel reached consensus on the following five goals for PT after hospital discharge. Improvement of function in activities of daily living (ADL) and functional exercise capacity was ranked an essential PT goal (score: 1; SIQR: 0 and SIQR: 0.15 respectively). Improvement of skeletal muscle strength and aerobic capacity were ranked very important PT goals (score: 2; SIQR: 0.05 and SIQR: 0.5 respectively) and targeting respiratory muscle strength was ranked an important PT goal (score: 2.75; SIQR: 0.3).

Core set of outcome measures

Exercise capacity and starting exercise intensity: ranking of tools

Consensus was reached on the importance of using both the 6-minute walk test (6MWT) and the 4-meter time walk/gait speed for functional exercise capacity, with a higher ranking for the 6MWT (score 2; SIQR: 0.05 versus score: 3; SIQR: 0.05). Cycle ergometry testing was ranked important for establishing submaximal exercise capacity (score: 3; SIQR: 0.5). The 2-minute walk test

(2MWT) was unanimously ranked an unimportant tool for measuring exercise capacity after hospital discharge (score: 4; SIQR: 0).

Two methods for determining starting exercise intensity – with regards to the exercise program – were consensually ranked important (score: 3; SIQR: 0). The first method, commonly practiced in pulmonary rehabilitation,[26,27] recommends to set the starting exercise intensity for walking on a treadmill at 80 % of the average 6MWT speed or 75 % of peak Incremental Shuttle Walk Test (ISWT) speed. The second method proposes setting starting exercise intensity at 50-70 % of heart rate reserve, combined with a score 3-4 on the modified Borg scale for perceived exertion. The use of Cardio-Pulmonary Exercise Testing (CPET) to establish starting exercise intensity was consensually ranked unimportant (score: 4; SIQR: 0.25).

No consensus was reached on the use of the ISWT or CPET for testing exercise capacity (score: 2.5 and 3.5 respectively, SIQR: 0.65). Panelists provided comments regarding the feasibility and practical applicability (CPET) and lack of data on validity (ISWT) of these measures.

Physical functioning: ranking of tools

The following physical function and mobility scales were ranked important (score: 3) in consensus: the De Morton Mobility Index (DEMMI) (SIQR: 0); the Timed Up and Go test (SIQR: 0.15); the Functional Independence Measure (SIQR: 0.15); the Short Physical Performance Battery (SIQR: 0.15); and the Short Form 36 – physical function domain (SIQR: 0.5). Consensus was also reached on tools to assess (instrumental) ADL function; the Barthel Index, the KATZ-ADL and Lawton's iADL were ranked important (score: 3; SIQR: 0.15).

Muscle, nerve integrity and body composition: ranking of tools

Consensus was reached on the importance of using handgrip (HG) strength and handheld dynamometry (HHD) to establish overall muscle strength, with a higher rating for HG strength (score: 2.25; SIQR: 0.3 versus score: 3; SIQR: 0.05). Both maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) were consensually ranked important tools for measuring respiratory muscle function (score: 3; SIQR: 0 and 0.25 respectively). Consensus was also reached on the importance of using the Medical Research Council (MRC) dyspnea scale (score: 2.5; SIQR: 0.3) for perceived respiratory disability and spirometry (score: 3; SIQR: 0) for pulmonary function.

Ultrasound of large skeletal muscles and anthropometry were ranked important (score: 3) in consensus (SIQR: 0.15), while body composition tests

using bio-impedance spectroscopy or multi-frequency bioimpedance analysis achieved consensual ranking as unimportant (score: 4; SIQR: 0.15). Nerve conduction studies and electromyography were unanimously and consensually ranked unimportant for usage after hospital discharge (score: 4: SIQR: 0).

No consensus was reached on the importance of using the MRC Sum Score (MRC-SS) for muscle strength, nor for peak expiratory flow measurement after hospital discharge (score: 2.5 and 3.0; SIQR: 0.65).

Quality of life and pain: ranking of tools

The Short Form 36 and the EuroQol© Health Questionnaire (EQ-5D) were consensually ranked as very important (score: 2; SIQR: 0 and 0.5 respectively), and both were ranked higher than the Sickness Impact Profile (score: 3; SIQR: 0.15). The Visual Analogue Scale (VAS) for pain was unanimously ranked as very important (score 2; SIQR: 0) (Additional file 1: Table S1).

Physical therapy interventions

Consensus was achieved in ranking functional exercises (score: 1.25; SIQR: 0.5), circuit training and endurance training (both score: 2; SIQR: 0.15), and range of motion exercises and balance training (both score: 2; SIQR: 0.5) as very important PT interventions for improving physical function in survivors of critical illness after hospital discharge. Interval training (SIQR: 0) and high intensity interval training (SIQR: 0.3) were both consensually ranked important (score: 3).

Targeting muscle strength through strengthening exercises and nutritional support achieved consensual ranking as very important interventions (score: 1.5; SIQR: 0.25 and 0.45 respectively). Inspiratory and expiratory muscle training consensually ranked 3.5 (SIQR 0.3 and 0.5 respectively), suggestive of being useful additional interventions, dependent on assessment outcomes. Neuromuscular electrical stimulation (NMES) achieved consensual ranking of unimportant (score: 4; SIQR: 0) as a PT intervention after hospital discharge.

Education of patients and caregiver(s) on PICS as well as involvement of caregivers in the rehabilitation process was unanimously ranked an essential PT intervention after hospital discharge (score: 1; SIQR: 0). No consensus was reached on the importance of relaxation exercises (score: 2; SIQR: 0.65).

Other health domains; ranking of screening tools

From a predefined list of screening tools for other PICS-related impairments, panelists consensually ranked the Multidimensional Fatigue Inventory (MFI) or

modified Borg scale for the presence of fatigue as very important (score: 2; SIQR: 0.05). The Hospital Anxiety and Depression Scale was ranked as very important (score: 2; SIQR: 0.25) and the Impacts of Events Scale – Revised as important (score: 3; SIQR: 0) for screening for problems in the psychological domain. The Mini Mental State Examination for cognitive function, the Subjective Global Assessment Tool, Malnutrition Universal Screening Tool, or Short Nutritional Assessment Questionnaire for nutritional status, and the Richard Campbell Sleep Questionnaire for sleep quality were all ranked important (score: 3; SIQR: 0) in consensus. No consensus was reached on the importance of the Trauma Screening Questionnaire for post-traumatic stress syndrome (PTSS) (score: 3; SIQR: 0.65).

DISCUSSION

This Delphi project resulted in consensus rankings of statements related to PT goals, a COS, and PT interventions for survivors of critical illness after hospital discharge. An international panel of ICU rehabilitation experts rated the importance of each statement on a 5-point scale, with scores from 1 = 'essential' to 5 = 'undesirable'. We propose the use of a consensus-based framework to optimize the transition and recovery of critical illness survivors after hospital discharge. This framework contains recommendations for essential discharge information, PT goals, a COS, and optimal PT interventions (Figure 2).

Although critical illness survivors might seek PT without referral in countries with direct access,[7,8] a formal and structured care pathway may more appropriately address patients' comprehensive rehabilitation needs.[10] Initiatives such as multidisciplinary follow-up clinics succeed in assessing recovery problems in patients after hospital discharge,[28,29] but do not offer rehabilitation interventions. Additionally, follow up often commences only after 3 months, consequently not utilizing the time window of recovery directly after discharge.[30] Our framework aims to facilitate a continuum of rehabilitation across all phases of post-ICU recovery.

Risk assessment for the development of PICS and PICS-F at hospital discharge was a topic of discussion within the panel. Although ranked essential, consensus was not achieved on the importance of screening patients for PICS at hospital discharge. This could be explained by the phrasing of the statement, as it implied the presence of a valid screening tool (Additional file 1: Table S1).

Figure 2: Physical therapy after critical illness: a consensus-based framework

HOSPITAL PHASE	HOSPITAL DISCHARGE INFORMATION
Screening · Establish ADL function (KATZ-ADL/ BO) · Collect handover information relevant to long-term recovery and PICS · Educatie patient and family on PICS(-F) and expected recovery	**Essential:** · Premorbid level of functioning · Course of recovery during hospital stay (mental / cognitive / physical) · Current mental / cognitive / physical state **Very important:** · Co-morbidities · Pre-ICU psychiatric symptoms · Diagnosed ICU-AW (MRC-SS ≤ 48) · ICU and hospital LOS · Severity of illness · Complications during hospital stay · Physiological response to exercise **Additional:** · Specific patient- and / or family characteristics · Environmental factors · Days of immobility · Type of surgery (if applicable)
Education patient and family	

BI: Barthel Index, PICS(F): Post-Intensive Care Syndrome (family), ICU: Intensive Care Unit, ICU-AW: ICU Acquired Weakness, MRC-SS: MRC Sum Score, LOS: Length of stay, ADL: Activities of Daily Living, 6MWT: 6 Minute Walk Test, SPPB: Short Physical Performance Battery, HHD: Handheld Dynamometry, MIP: Maximum Inspiratory Pressure, MEP: Maximum Expiratory Pressure, iADL: Instrumental Activities of Daily Living, HRR: Heart Rate Reserve, HIIT: High Intensity Interval Training, MFI: Modified Fatigue Inventory, RCSQ: Richard Campbell Sleep Questionnaire, MUST: Malnutrition Universal Screening Tool, SNAQ: Short Nutritional Assessment Questionnaire, HADS: Hospital Anxiety and Depression Scale, IES-R: Impact of Event Scale-Revised, MMSE: Mini-Mental State Examination.

AFTER HOSPITAL DISCHARGE

Physical therapy goals

↑ Fucntional exercise capacity
↑ Aerobic capacity
↑ Skeletal & respiratory muscle strength
↑ ADL function
↑ Quality of life
↑ Understanding of PICS and recovery
↓ Pain

Core outcome set

· 6MWT, 4m timed walk/gait
· Sub-maximal cycle ergometry
· Handgrip strength, HHD
· MIP/MEP
· Spirometry / MRC Dyspnea Scale
· Ultrasound / Antrhopometry
· KATZ-ADL, BI or Lawton's iADL
· SF36, TUG, FIM, DEMMI or SPPB
· EuroQoL
· VAS (pain)

Physical therapy interventions

Set Exercise intensity to:
80% average 6MWT speed or 75% peak speed ISWT or 50-70% HRR with BORG ¾
· Interval training or endurance cardio training
· Circuit training
· HIIT
· Functional exercises (incl. ROM)
· Balance training
· Strengthening exercises
· IMT/EMT
· Education (patient & family) on recovery process
· + nutritional support

SCREENING

Referral to general physician

Additional screening tools
Fatigue: MFI
Sleep: RCSQ
Nutrition: MUST/SNAQ
Mental/cognition: HADS, IES-R
Cognition: MMSE

Priority should be given to the development and validation of a risk assessment tool to facilitate optimal rehabilitation pathways for individual patients. Promising results in recent publications clarify patient-specific, ICU-specific, and environmental-specific factors affecting long-term outcomes.[31-34] Risk stratification based on pre-existing chronic disease, ICU LOS, or age might predict recovery outcomes and health care usage and may assist in determining tailor-made rehabilitation interventions within this proposed framework.[33,34]

This study resulted in a consensus statement on essential handover information at time of hospital discharge. Fifteen parameters related to critical illness and recovery, as well as known risk factors for PICS[10] were ranked very high in importance. Currently these data are rarely provided in discharge summaries,[35] and further testing should determine the feasibility of collecting these data at hospital discharge.

This Delphi process resulted in consensus on PT goals and interventions for critical illness survivors after hospital discharge. Exercise programs should target the cardiovascular system, as well as skeletal muscle strength, range of motion (ROM), balance and function in ADL, dependent on the outcome of the assessment. Two methods for setting exercise intensity are proposed, with no preference for one over the other. Although respiratory muscle training was consensually ranked an important PT intervention, panelists commented on the lack of evidence on effectiveness in this population after hospital discharge. The panel consensually ranked additional nutritional support as very important. A combined exercise and nutrition intervention was not addressed in this Delphi project, but a recently published RCT showed positive effects of such an intervention on walking distance at 3 months.[36] Reaching consensus on a core set of outcomes proved difficult. Quality of life scales, the VAS scale for pain, HG strength and the 6MWT were the only tools scoring 'very important' in consensus. The 6MWT is a widely used test, is feasible, and is validated for the population of ICU survivors.[14,37,38] Disadvantages could be the expected ceiling effects with patients who have greater initial cardiovascular fitness or in later phases of recovery. Criterion validity has not so far been established.[39] Predicting maximum exercise capacity by means of the ISWT may be an appropriate alternative, as criterion validity against the CPET was established[40-42] and psychometric properties of the ISWT in similar populations yield promising results. This Delphi panel, however, did not reach consensus on the usage of the ISWT after hospital discharge.

Several mobility scales were ranked 'important', but many have yet to be validated for this population in the post-hospital situation. Such a tool could be

the DEMMI, for which psychometric properties were recently established for survivors of critical illness, albeit within the hospital setting.[43]

Screening for PICS-related cognitive and mental impairments is deemed essential for establishing an optimal rehabilitation pathway, because these factors potentially influence the outcome of rehabilitation interventions. Dependent on country and setting, physical therapists can assist in screening and refer to specialist health professionals when such screenings are not conducted at ICU-follow up clinics.[7,8,29,30]

This consensus statement complements published evidence statements on safe and effective PT interventions in the ICU,[1,2,23] and contributes to the provision of optimal PT throughout the continuum of care, from critical illness to full participation and return to work.

Limitations to this study

Although eligible panelists were carefully recruited, selection bias could not be prevented. The panel included a heterogeneous group of researchers and clinicians from different countries, settings, and cultural backgrounds. Although this heterogeneity might strengthen the consensus statement and its' practical applicability worldwide, it is emphasized that the results of this Delphi study should be seen as an adjustable framework rather than as a directive guideline.

The small sample size as well as the absence of survivors of critical illness or caregivers in this expert panel, is a limitation to this study as important input from other perspectives is lacking.

The 5-point Likert scale is a commonly used ranking scale in Delphi procedures.[23] Although the ordinal scale was carefully explained to the panel, it was considered likely that panelists would select 'important' (score: 3) in cases where they felt indifferent to a certain item. This scoring possibly affected the outcome of rounds two and three. Future Delphi projects should clarify this 5-point Likert scale or consider a 9-point ranking scale. It should also be noted that scoring related to 'relevance' rather than practicality and feasibility in clinical practice, which necessitates feasibility testing of the proposed framework.

Recommendations for future research

Future Delphi panels should include a larger group of representatives from a variety of health disciplines as well as survivors of critical illness to incorporate all health domains relevant to rehabilitation of critically ill patients.

Efforts on development and validation of a screening tool for PICS should continue to be a research priority in order to determine patients' rehabilitation needs and design tailor-made interventions. Psychometric properties of the proposed core outcome measures for out-of-hospital PT practice should be established for the population of critical illness survivors.

Within the proposed framework for PT interventions after hospital discharge, feasibility studies and RCTs must be set up to investigate intervention effectiveness and appropriateness of exercise training modalities.

CONCLUSIONS

This consensus-based framework for PT after hospital discharge aims to improve long-term outcomes for survivors of critical illness. Physical therapists should seek close collaboration with the multidisciplinary team at ICU-follow-up clinics (when available) when assessing rehabilitation needs. Multimodal and targeted exercise interventions should be set up and feasibility tested. Future research should focus on validation of core measurement tools for cognitive, mental, and physical function in the population of critical illness survivors at different points of their recovery trajectory.

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APPENDIX

Search strategy scoping review

Database	Search terms	Hits	For review
Pubmed	#1 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] OR "Aftercare"[Mesh]	7017	
Pubmed	#2 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] AND "Aftercare"[Mesh]	9	2
Pubmed	#3 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Aftercare"[Mesh] (Limits: last 10 yrs, clinical trials only, Filters: adults)	115	3
Pubmed	#4 post intensive care syndrome[Title/Abstract]) OR PICS[Title/Abstract] (Limits: adults 19+ published last 10 years)	53	1
Pubmed	#5 intensive care[Title/Abstract]) OR ICU[Title/Abstract] AND survivor*[Title/Abstract] (Limits: adult / last 10 years / clinical trial)	227	13
Pubmed	#6 intensive care[Title/Abstract] OR ICU[Title/Abstract] AND surviv*[Title/Abstract] AND recovery[Title/Abstract] (Limits: adults 19+, last 10 years, clinical trials)	51	6
Pubmed	#7 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] AND after care	10	0
Pubmed	#8 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] (Limits last 10 years, adults 19+)	103	16
PEDro	#1 Critical care	129	3
CINAHL	#1 AB Critical Care AND AB rehabilitation	137	16
CINAHL	#2 AB Critical Care AND physical therapy OR physiotherapy AND recovery (Limits: last 10 years, all adult)	116	0
CINAHL	#3 post intensive care syndrome [Title/Abstract]	12	6
MEDLINE	#1 Critical Care AND post intensive care syndrome	8	8
MEDLINE	#2 Post intensive care syndrome	14	7

Database	Search terms	Hits	For review
Science Direct	#1 Critical Care (title/abstract/key words) Rehabilitation (title/abstract/key words #2 pub-date > 2003 and TITLE (post intensive care syndrome) or TITLE-ABSTR-KEY (post intensive care syndrome) #3 pub-date > 2003 and TITLE (post intensive care syndrome) or TITLE-ABSTR-KEY (post intensive care syndrome) AND LIMIT-TO(topics, "icu")	203 293 12	9
ProQuest Social Sciences	#1 SU.EXACT ("Intensive care") AND SU.EXACT("Rehabilitation") OR SU.EXACT ("After care") 2004-2015 #2 Limits: peer reviewed #3 Limits: rehabilitation	232 187 20	1
PubMed (9-4-2015)	#1 ("Critical Care"[Mesh]) OR "Critical Illness"[Mesh]) AND "Physical Therapy Modalities"[Mesh]) OR "Exercise"[Mesh]) OR "Exercise Therapy"[Mesh]) OR "Physical Therapy Specialty"[Mesh]) #2 ("Critical Care"[Mesh]) OR "Critical Illness"[Mesh]) AND "Physical Therapy Modalities"[Mesh]) OR "Exercise"[Mesh]) OR "Exercise Therapy"[Mesh]) OR "Physical Therapy Specialty"[Mesh])) AND Humans[Mesh] AND adult[MeSH])))) AND recovery[Title/Abstract]) OR post intensive care[Title/Abstract] #3 (("Intensive Care"[Mesh]) AND "Critical Care"[Mesh]) OR "Critical Illness"[Mesh]) AND "Rehabilitation"[Mesh]) OR "Aftercare"[Mesh]) AND "Physical Therapy Modalities"[Mesh] limits last 10 years, adults #4 ("Intensive Care"[Mesh]) AND "Critical Care"[Mesh]) OR "Critical Illness"[Mesh]) AND "Physical Therapy Modalities"[Mesh])) limits: last 10 years, adults	74431 5413 33 85	3 (duplicates) 7 (6 duplicates)

Database	Search terms	Hits	For review
PubMed (diagnostics)	#1 "Diagnosis"[Mesh]) AND "Intensive Care"[Mesh]) OR "Critical Illness"[Mesh])) AND rehabilitation[Title/Abstract] OR physical therapy modalities[MeSH Terms] AND recovery[Title/Abstract]	4466	
	#2 "Exercise Tolerance"[Mesh]) OR "Exercise Therapy"[Mesh] OR "Exercise"[Mesh] AND "Survivors"[Mesh] AND "Critical Illness"[Mesh]	4	1
	#3 "Exercise Tolerance"[Mesh]) OR "Exercise Therapy"[Mesh] OR "Exercise"[Mesh]) AND "Survivors"[Mesh]) OR "Critical Illness"[Mesh]	5271	
	#4 "Muscle Strength"[Mesh] AND "Survivors"[Mesh]) AND "Critical Illness"[Mesh]	1	1
	#5 "Exercise Test"[Mesh]) AND "Critical Illness"[Mesh]	15	1
	#6 "Outcome Assessment (Health Care)"[Mesh] AND "Critical Illness"[Mesh] AND survivor*[Title/Abstract]	104	36

Searches were done on 13 March 2015, 19 March 2015, 26 March 2015, and 9 April 2015; alerts were entered into the appropriate database with similar search terms.

Additional file Table S1: Statements and ranking Delphi round two and three

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Clinical Phase			
The patient is discharged from hospital when his (independent) functional level is established (through KATZ-ADL, Barthel Index, or similar measure) and his home environment is carefully analyzed	2.0 (0.65)	2.0 (0.5)	✔
At the time of discharge from hospital the patient's family should be screened for the presence (or risk of development) of PICS-F	3.0 (0.5)	3.0 (0.05)	✔
At the time of discharge from hospital the patient should be screened for the presence (or risk of development) of PICS	1.5 (0.65)	1.25 (0.65)	✘
At the time of discharge from the hospital the patient and family should be educated on PICS and expected recovery (i.e., rehab manual)	2.0 (0.65)	2.0 (0.65)	✘
Essential discharge information			
Course of recovery of critical illness during hospital stay (mental, cognitive, physical)	1.0 (0.5)	1.0 (0)	✔*
Rehabilitation provided, goals achieved and further rehabilitation goals	1.0 (0.15)	1.0 (0)	✔*
Premorbid level of functioning	1.0 (0.65)	1.0 (0)	✔
Current psychological state (i.e., presence of depression)	**	1.0 (0.5)	✔
Current cognitive functioning	**	1.0 (0.5)	✔
Current physical functioning	**	1.0 (0.5)	✔
Diagnosed ICU-Acquired Weakness (MRC score)	1.5 (1.0)	1.5 (0.3)	✔
Pre-ICU psychiatric symptoms	2.0 (0.65)	2.0 (0)	✔
Physiological response to exercise	2.0 (1.0)	2.0 (0)	✔
Severity of illness (i.e., sepsis / multi organ failure / other)	2.0 (0.5)	2.0 (0)	✔

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Comorbidities	2.0 (1.0)	2.0 (0.15)	✔
ICU length of stay	2.0 (0.5)	2.0 (0.5)	✔
Hospital length of stay	2.0 (0.65)	2.0 (0.5)	✔
Presence of delirium while in hospital	2.0 (0.65)	2.0 (0.5)	✔
Complications during hospital stay	2.0 (1.0)	2.0 (0.5)	✔
Specific patient- and/or family characteristics (personal factors / environmental factors)	3.0 (0.5)	3.0 (0.5)	✔
Days of immobility (defined as being bed-bound)	3.0 (0.65)	3.0 (0.5)	✔
Apache II or Apache IV score	3.5 (0.5)	3.5 (0.3)	✔
Genetic factors / biomarkers	3.5 (0.5)	3.5 (0.3)	✔
Days of sedation and mechanical ventilation	2.0 (1.0)	2.0 (0.65)	✘
Surgery	2.0 (1.0)	2.0 (0.65)	✘
Post-discharge phase: physical therapy goals			
Improvement of physical function and function in ADL	1.0 (0.0)	1.0 (0)	✔
Improvement of functional exercise capacity	1.0 (0.65)	1.0 (0.15)	✔
Improvement of skeletal muscle strength	2.0 (1.0)	2.0 (0.05)	✔
Improvement of aerobic capacity	2.0 (0.65)	2.0 (0.5)	✔
Improvement of respiratory muscle strength	2.5 (1.0)	2.75 (0.3)	✔
Post-discharge phase: measurement tools			
Pain (such as joint pain) – in the post clinical phase – should be measured through the use of the Visual Analogue Scale (VAS)	2.0 (1.3)	2.0 (0)	✔
Quality of life – in the post clinical phase – should be measured through the use of the Short Form 36	2.0 (1.15)	2.0 (0)	✔
Functional exercise capacity should be measured through the use of the 6-minute walk test (6MWT)	2.0 (0.15)	2.0 (0.05)	✔
Quality of life – in the post clinical phase – should be measured through the use of the EuroQol Health Questionnaire	2.0 (1.5)	2.0 (0.5)	✔

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Skeletal muscle strength should be measured through the use of handgrip strength	2.5 (0.65)	2.25 (0.3)	✔
Respiratory muscle function – in the post clinical phase – should be measured through the use of MRC dyspnea scale	2.5 (0.5)	2.5 (0.3)	✔
Physical function should be measured through the use of the De Morton Mobility Index (DEMMI)	3.0 (0.25)	3.0 (0)	✔
Respiratory muscle function – in the post clinical phase – should be measured through the use of maximum inspiratory pressure (MIP)	3.0 (0.65)	3.0 (0)	✔
Respiratory muscle function – in the post clinical phase – should be measured through the use of spirometry	3.0 (0.5)	3.0 (0)	✔
Functional exercise capacity should be measured through the use of the 4 m timed walk/gait speed (single test from SPPB)	3.0 (0.25)	3.0 (0.05)	✔
Skeletal muscle strength should be measured through the use of handheld dynamometry	3.0 (0.65)	3.0 (0.05)	✔
Physical function should be measured through the use of the Timed Up and Go (TUG)	3.0 (0.5)	3.0 (0.15)	✔
Physical function should be measured through the use of the Functional Independent Measure (FIM)	3.0 (0.25)	3.0 (0.15)	✔
Physical function should be measured through the use of the Short Physical Performance Battery (SPPB)	3.0 (1.0)	3.0 (0.15)	✔
Function in ADL should be measured through the use of the Barthel Index	3.0 (1.0)	3.0 (0.15)	✔
Function in ADL should be measured through the use of the KATZ-ADL	3.0 (0.25)	3.0 (0.15)	✔
Function in ADL should be measured through the use of the Lawton's iADL	3.0 (0.25)	3.0 (0.15)	✔
Body composition (such as muscle mass and fat free mass) – in the post clinical phase – should be measured through the use of ultrasound	3.0 (1.0)	3.0 (0.15)	✔

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Body composition (such as muscle mass and fat free mass) – in the post clinical phase – should be measured through the use of anthropometry	3.0 (0.65)	3.0 (0.15)	✔
Quality of life – in the post clinical phase – should be measured through the use of the Sickness Impact Profile 68	3.0 (0.65)	3.0 (0.15)	✔
Respiratory muscle function – in the post clinical phase – should be measured through the use of maximum expiratory pressure (MEP)	3.5 (0.5)	3.0 (0.25)	✔
Aerobic capacity should be measured through the use of submaximal cycle ergometry test	3.0 (0.65)	3.0 (0.5)	✔
Physical function should be measured through the use of short form 36 – physical domain (SF 36-PD)	3.0 (1.0)	3.0 (0.5)	✔
Physical function should be measured through the use of the Functional Assessment Measure (FAM)	3.5 (0.65)	3.25 (0.3)	✔
Functional exercise capacity should be measured through the use of the 2-minute walk test (2MWT)	4.0 (0.75)	4.0 (0)	✔
Neuromuscular function – in the post clinical phase – should be measured through the use of electromyography	4.0 (0.65)	4.0 (0)	✔
Neuromuscular function – in the post clinical phase – should be measured through the use of nerve conduction velocity test	4.0 (0.65)	4.0 (0)	✔
Body composition (such as muscle mass and fat free mass) – in the post clinical phase – should be measured through the use of bioimpedance spectroscopy (BIS) or multifrequency bioimpedance analysis (BIA)	4.0 (0.65)	4.0 (0.15)	✔
Functional exercise capacity should be measured through the use of the incremental shuttle walk test (ISWT)	2.5 (0.65)	2.5 (0.65)	✘
Skeletal muscle strength should be measured through the use of MRC sum score	2.5 (0.65)	2.5 (0.65)	✘

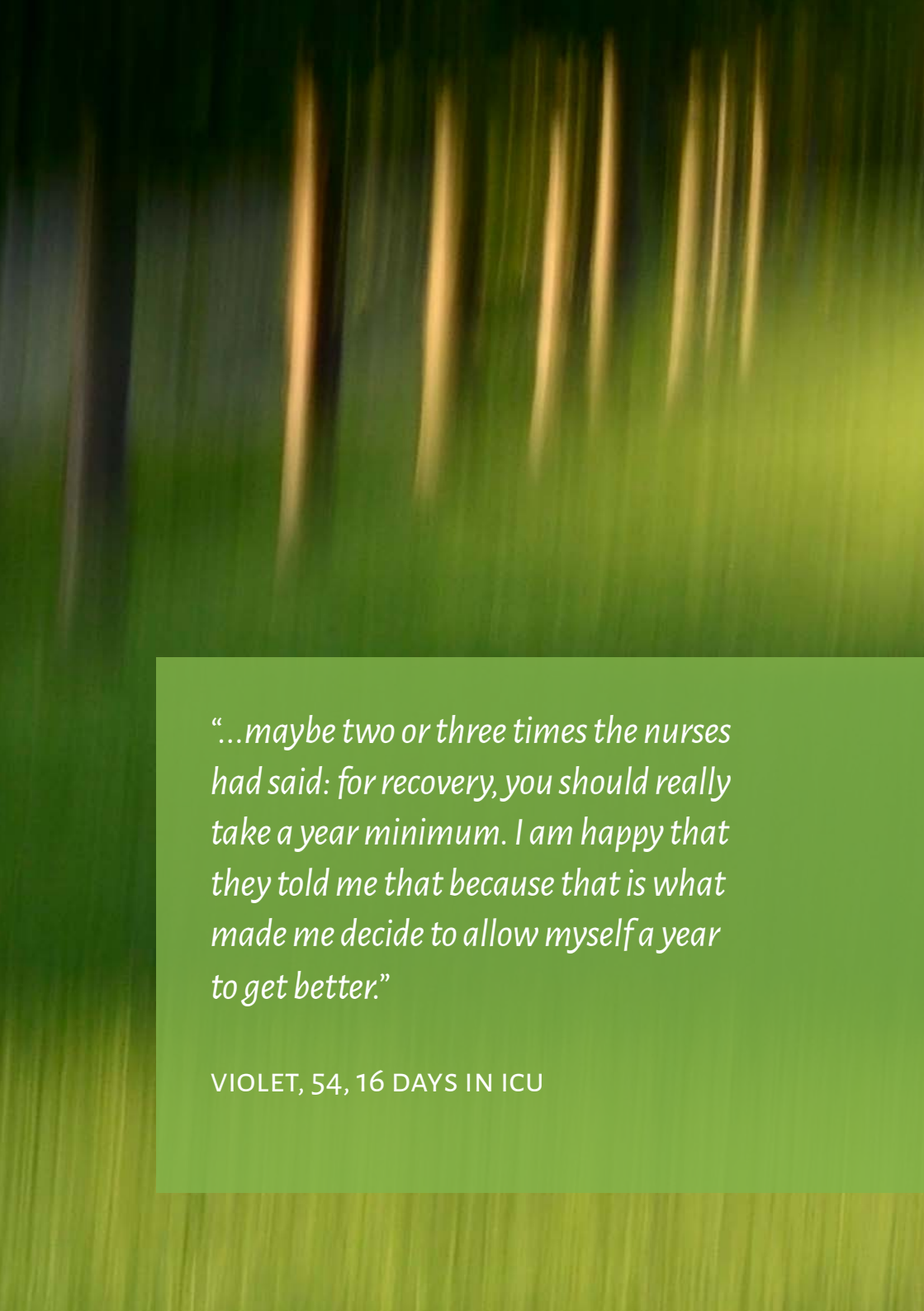
Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Respiratory muscle function – in the post clinical phase – should be measured through the use of peak expiratory flow	3.0 (0.65)	3.0 (0.65)	✘
Aerobic capacity should be measured through the use of cardio-pulmonary exercise testing (CPET)	3.5 (0.65)	3.75 (0.65)	✘
Post-discharge phase: starting exercise intensity			
Starting exercise intensity or aerobic capacity should be set at 80% of the average 6MWT speed or 75% of peak speed achieved on the ISWT (as with formal rehab tracks set for pulmonary rehab)	3.0 (0.5)	3.0 (0.0)	✔
Starting exercise intensity should be set at 50-70% of HR reserve (Karvonen) in combination with the modified Borg 3 or 4 for perceived exertion	3.0 (0.65)	3.0 (0.0)	✔
Starting exercise intensity should be set at 50-80% of VO2max as measured with CPET	4.0 (1.15)	4.0 (0.25)	✔
Post-discharge phase: physical therapy interventions (physical function)			
Functional exercises	1.5 (0.5)	1.25 (0.5)	✔
Circuit training	2.0 (0.5)	2.0 (0.15)	✔
Endurance cardio training	2.0 (0.65)	2.0 (0.15)	✔
Balance training	2.0 (1.0)	2.0 (0.5)	✔
ROM exercises	2.5 (0.65)	2.75 (0.5)	✔
High intensity interval training (HIIT)	3.0 (0.75)	3.0 (0.0)	✔
Interval cardio training	2.0 (1.0)	3.0 (0.3)	✔
Relaxation exercises	2.0 (0.75)	2.0 (0.65)	✘
Physical therapy interventions (skeletal muscle strength)			
Strengthening exercises	1.5 (0.65)	1.75 (0.25)	✔
Nutritional support	1.5 (1.0)	1.75 (0.45)	✔
Inspiratory muscle training	3.5 (1.0)	3.0 (0.3)	✔
Expiratory muscle training	3.5 (1.0)	3.25 (0.5)	✔
Neuromuscular electrical stimulation (NMES)	4.0 (0.5)	4.0 (0)	✔

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Physical therapy interventions (education)			
Physical therapists should educate caregivers and patients on the recovery process and PICS in general	1.0 (0.15)	1.0 (0)	✔
Physical therapists should involve caregivers in the rehabilitation process of the patient with PICS	1.0 (0.5)	1.0 (0)	✔
Screening tools and referral			
Multidimensional Fatigue Inventory or BORG scale for the presence of fatigue	2.0 (0.65)	2.0 (0.05)	✔
Mini Mental State Examination for cognitive function	3.0 (0.65)	3.0 (0)	✔
Impacts of Events Scale – Revised for psychological well-being and PTSD	3.0 (0.5)	3.0 (0)	✔
Subjective Global Assessment Tool, Malnutrition Universal Screening Tool (MUST) or Short Nutritional Assessment Questionnaire (SNAQ) for nutritional status	3.0 (0.65)	3.0 (0)	✔
Richard Campbell Sleep Questionnaire for sleep quality	3.0 (1.0)	3.0 (0.5)	✔
Trauma Sreening Questionnaire for PTSS	**	3.0 (0.65)	✘

Score: 1 = essential, 2 = very important, 3 = important, 4 = unimportant, 5 = undesirable

✔ = consensus threshold reached (SIQR ≤ 0.5) ✘ = no consensus reached

** = unanimous score by panel ** = generated idea in round 2, ranked only in round 3*



"...maybe two or three times the nurses had said: for recovery, you should really take a year minimum. I am happy that they told me that because that is what made me decide to allow myself a year to get better."

VIOLET, 54, 16 DAYS IN ICU

CHAPTER 6 Physiotherapy treatment approaches for survivors of critical illness: a proposal from a Delphi study

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ABSTRACT

Purpose: The aim of this study was to develop practical recommendations for physiotherapy for survivors of critical illness after hospital discharge.

Methods: A modified Delphi consensus study was performed. A scoping literature review formed the basis for three Delphi rounds. The first round was used to gather input from the panel to finalize the survey for the next two rounds in which the panel was asked to rank each of the statements on an ordinal scale with the objective to reach consensus. Consensus was defined as a SIQR of ≤ 0.5. Ten Dutch panelists participated in this study; three primary care physiotherapists, four intensive care physiotherapists, one occupational therapist, one ICU-nurse and one former ICU-patient. All involved professionals have treated survivors of critical illness. Our study was performed in parallel with an international Delphi study with hospital-based healthcare professionals and researchers.

Results: After three Delphi rounds, consensus was reached on 95.5% of the statements. This resulted in practical recommendations for physiotherapy for critical illness survivors in the primary care setting. The panel agreed that the handover should include information on 14 items. Physiotherapy treatment goals should be directed towards improvement of aerobic capacity, physical functioning, activities in daily living, muscle strength, respiratory and pulmonary function, fatigue, pain, and health related quality of life. Physiotherapy measurements and interventions to improve these outcomes are suggested.

Conclusion: This study adds to the knowledge on post-ICU physiotherapy with practical recommendations supporting clinical decision-making in the treatment of survivors of critical illness after hospital discharge.

INTRODUCTION

Over the last decade, the number of critically ill patients surviving admission to an intensive care unit (ICU) has significantly increased through improvements in medical care.[1,2] The flipside is that many patients suffer from long-term limitations in physical and mental well-being as part of the Post-Intensive Care Syndrome (PICS) after hospital discharge.[3] These limitations often result in restrictions in participation and return to daily activities such as work, leisure- and sports.[4-9] Physiotherapy during ICU treatment has been recommended to improve physical recovery and an increasing number of practice guidelines to support physiotherapy as early as possible on the ICU have been published.[10-13]

Most patients will be discharged from the ICU to the general ward. In the Netherlands, discharge destination after hospitalization depends on the severity of functional limitations, level of independence, and age. Discharge options include temporary stay in a nursing home or rehabilitation centre, or discharge home.[14] Approximately 80% of the patients are discharged home and, confronted with severe muscle weakness and deconditioning, will seek treatment of a primary care physiotherapist.[15]

In contrast with recommendations for physiotherapy on the ICU, guidelines for physiotherapy for critically ill patients after hospital discharge are lacking. Moreover, the British NICE guidelines contain advice regarding functional assessment three months following hospital discharge but do not provide recommendations for physiotherapy practice in primary care.[10] Considering the lack of knowledge and clinical expertise among primary care physiotherapists on the relatively new syndrome PICS[16] and the lack of both national and international clinical guidelines to support physical rehabilitation in primary care after critical illness,[17] it is assumed that survivors of critical illness do not receive optimal physiotherapy treatment.[14]

In parallel with our study, a Delphi project on physical rehabilitation for ICU patients after hospitals discharge was performed by Major et al.[16] with an international panel of hospital-based clinicians and researchers with expertise in the field of critical illness. The authors proposed a consensus-based framework for physical rehabilitation for survivors of critical illness, after hospital discharge. This included recommendations for handover information, physical therapy interventions and a Core Outcome Set (COS) for clinical practice.[16]

The international framework by Major et al.[16] needs to be translated into recommendations for daily clinical primary care practices according to the Dutch national health care system. Therefore, the aim of this study was to

develop practical recommendations for physiotherapy for survivors of critical illness after discharge from Dutch hospitals.

In the present study the following research questions were addressed: (1) Which handover information is required; (2) what are feasible measurement instruments; and (3) which physiotherapy interventions are recommended to attain optimal continuity of care for critical illness survivors after hospital discharge?

METHODS

Design

We performed a modified Delphi consensus study with a panel of Dutch physiotherapy experts with experience in the treatment of ICU survivors after hospital discharge with the addition of experts from adjacent fields of expertise and a former ICU patient. This study was performed independently but in parallel with an international Delphi study for the development of a consensus statement on physiotherapy practice for ICU survivors after hospital discharge.[16] This modified Delphi study consisted of a preparatory stage and a Delphi stage. In the preparatory stage, in March and April 2015, we performed a scoping literature review searching PubMed, Medline, PEDro, CINAHL, Science Direct, and ProQuest Social Sciences for relevant scientific evidence regarding physiotherapy and rehabilitation after critical illness (Appendix 1). Articles were considered for review if they were clinical trials, published in the last 10 years. Four themes were identified: hospital discharge, handover information to primary care, measurement instruments per treatment goal and interventions in the post-hospital phase (Table 1).

Table 1: Themes defined for Delphi round 1

Theme 1	Discharge information, which should be made available to the physiotherapist in the primary care setting.
Theme 2	Reliable and validated measurement instruments to use in daily physiotherapy practice for the different suggested treatment goals.
Theme 3	Optimal physiotherapy interventions.

In the second stage, we performed Delphi rounds. A priori we decided to apply a minimum of three rounds which is recommended when the quantity of scientific research in the field studied, is limited.[18] To ensure the highest level of

consensus, we used the first round to gather input from the panel to finalize the survey for further consensus rounds. Once consensus was reached on ≥ 80% of the statements, additional Delphi rounds were deemed unnecessary.

The draft statements and the themes identified from the scoping literature review formed the basis for round one in which the panel was asked to provide feedback and provide additional topics from their (clinical) expert point of view. The results of round one were analyzed and formatted into 68 statements, within three categories: hospital discharge and handover information to primary care physiotherapy, measurement instruments per treatment goal, and physiotherapeutic interventions in the post-hospital phase.

Round two required the panel members to rank each of the statements on an ordinal scale of 1 – 5 (1 = essential, 2 = very important, 3 = important, 4 = unimportant and 5 = undesirable).[19] For the third round each panel member received controlled feedback consisting of the group results and their personal scores of round two. Panelists were asked to re-rank the statements in case their individual score lay outside of the semi-interquartile range (SIQR). The SIQR was defined as half the numerical distance between the first and third quarter of the Inter Quartile Range (IQR). Panel members were asked to elucidate their choice if they did not adjust their score to the group's consensus.

Participants

We aimed to include a panel of Dutch physiotherapy experts with experience in the treatment of ICU survivors, with at least 5 years of clinical experience. Additionally, we aimed to include experts with other relevant backgrounds such as human movement sciences, occupational therapy, and nursing. Furthermore, a former ICU patient as representative from the Dutch Foundation of Patient and Family Centered Intensive Care participated in the panel (Table 2). Panelists remained anonymous to each other throughout all Delphi rounds. With acceptance of the invitation informed consent was obtained for data analysis and publication of the results. Because no patients were involved in this study, approval of the medical ethical committee was not required.

Data analysis

Median and SIQR were calculated for each of the statements, an appropriate statistical choice when data is scored on an ordinal ranking scale.[20] Consensus was defined a priori as a SIQR of ≤ 0.5. The level of agreement (LA) was also calculated and was expressed as the percentage of panel members scoring the median value of the statement; these values were presented for all statements in round 2 and 3.

Table 2: Delphi panel characteristics

No.	Field of expertise / Title	Experience (years)	Specialisations
1	Physiotherapy (MSc)	15-20	Intensive care
2	Physiotherapy (MSc)	10-15	Intensive care
3	Physiotherapy	15-20	Primary care, oncology
4	Physiotherapy (MSc)	5-10	Intensive care, surgery
5	ICU survivor (MD)	5-10	Former ICU patient
6	Physiotherapy	5-10	Chronic diseases
7	Physiotherapy (MSc)	15-20	Primary care, Sports and cardiac rehabilitation, movement sciences
8	Physiotherapy (MSc)	> 20	Primary care, cardiac rehabilitation, COPD
9	Nursing	15-20	Intensive care
10	Occupational therapy (MSc)	15-20	Movement sciences, spinal cord injuries

MSc: Master of Science, MD: Medical Doctor, COPD: Chronic Obstructive Pulmonary Disease.

RESULTS

Statements scored as essential and very important (score 1 and 2, respectively) are described underneath. For a complete review of all scored statements, we refer to Table 3. For an overview of the practical recommendations made by the panel we refer to Figure 1.

Flow of participants

All invited panelists agreed to participate ($n = 10$). The response rate was 90%, 100%, and 100%, respectively, for the three Delphi rounds. The panel member who did not respond in the first round has participated in round two and three. Table 2 describes the disciplines and fields of expertise of the members in this panel.

After round two, consensus was reached on 68.7% of the statements and after round three on 95.5% of the statements (SIQR ≤ 0.5) of which 48.4% unanimously (Table 3). In only three (out of 68) statements no consensus was reached.

Table 3: Statements and ranking Delphi rounds 2 and 3

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Hospital Phase			
At the time of discharge from hospital the patient should be screened for the presence (or risk of development) of PICS	1.0 (0.5)	1.0 (0.5)	Yes
At the time of discharge from hospital the patient's family should be screened for the presence (or risk of development) of PICS-F	2.5 (0.5)	2.0 (0.05)	Yes
At the time of discharge from the hospital the patient should be educated on PICS and expected recovery (i.e. rehab manual)	1.5 (0.5)	1.5 (0.5)	Yes
At the time of discharge from the hospital the family should be educated on PICS-F	2.0 (0.375)	2.0 (0)	Yes
Preferred patient handover information			
Reason for admission and length of stay in the ICU	1.0 (0)	1.0 (0)	Yes
Course of recovery and complications during hospital stay	1.0 (0.375)	1.0 (0)	Yes
Duration of mechanical ventilation	1.5 (0.5)	1.0 (0.5)	Yes
Whether a patient has undergone plasmapheresis, dialyses or other drastic interventions	2.0 (0.375)	2.0 (0)	Yes
Medication	2.0 (0.75)	2.0 (0.375)	Yes
Level of Mobility (transfers/walking)	1.5 (0.5)	2.0 (0.5)	Yes
Muscle strength	2.0 (0.5)	2.0 (0.375)	Yes
Muscle/Fat mass	3.0 (0.5)	3.0 (0)	Yes
Joint mobility	2.0 (0.75)	2.0 (0)	Yes
Pulmonary function	2.0 (0.5)	1.5 (0.5)	Yes
Limitations in activities at discharge	2.0 (0.5)	1.5 (0.5)	Yes
Nutritional status	2.0 (0,75)	2.0 (0.375)	Yes
Patient goals achieved and further rehabilitation goals	2.0 (0.5)	2.0 (0.5)	Yes

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Premorbid level of functioning	1.5 (0.875)	2.0 (0.375)	Yes
Involvement of disciplines in the clinical phase (i.e., physiotherapy/psychology/occupational therapy/ dietitian etc.)	1.0 (0.875)	1.0 (0.375)	Yes
Personal and environmental factors affecting rehabilitation	2.0 (0.75)	2.0 (0.75)	No
After hospital discharge – Treatment goals and instruments			
Muscle strength as measured with the:			
Handgrip strength dynamometry	2 (0)	2 (0)*	Yes
MRC sum score	2 (1)	2 (0.25)	Yes
Pulmonary function as measured with:			
Spirometry	2 (1)	2 (0)*	Yes
MRC Dyspnoea scale	2 (0.875)	2 (0.25)	Yes
Maximum inspiratory and expiratory pressure	3 (0.5)	3 (0.5)	Yes
Perceived exertion - as measured with the:			
BORG RPE Scale	1.5 (0.5)	1 (0.5)	Yes
Pain as measured with the:			
Numeric Rating Scale	2 (0.875)	2 (0)*	Yes
Visual Analogue Scale	2.5(0.875)	3 (0.5)	Yes
Body composition (such as muscle mass and fat free mass) measured with: Multi-frequency bio-impedance analysis	3 (0.75)	3 (0.75)	No
Aerobic capacity as measured with the:			
Six minutes walking test	2 (0.375)	2 (0)*	Yes
Cardiopulmonary exercise testing	2 (0.375)	2 (0)*	Yes
Steep Ramp Test.	3 (0.375)	3 (0.5)	Yes
Incremental shuttle walk test	3 (0)	3 (0.5)	Yes
Functional status as measured with the:			
Short Physical Performance Battery	3 (0.375)	3 (0.125)	Yes

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
The De Morton Mobility Index	3 (0.875)	3 (0.5)	Yes
Limitations in activities in daily living as measured with the:			
Patient-specific Functional Scale	2.5 (0.5)	2 (0.5)	Yes
Katz-ADL	3 (0.375)	3 (0)*	Yes
Barthel Index	3 (0.75)	4 (0.5)	Yes
Health related quality of life as measured with the:			
Short Form 36	2 (0.75)	2 (0)*	Yes
Sickness Impact Profile	3 (0.5)	3 (0)*	Yes
Euroqol Health Questionnaire	3 (0.5)	3 (0)*	Yes
Other health domains			
Cognitive function – measured with the Mini Mental State Exam	2 (0.375)	2 (0)*	Yes
Nutritional status – measured with the Short Nutritional Assessment Questionnaire	2 (0.5)	2 (0)*	Yes
Posttraumatic stress syndrome – measured with the Trauma Screening Questionnaire	2 (0.875)	2 (0)*	Yes
Anxiety and depression – measured with the Hospital Anxiety and Depression Scale	2 (0.5)	2 (0.5)	Yes
Post clinical phase – interventions			
Interventions to improve muscle strength and muscle mass must contain:			
Muscle strength training	1 (0.875)	1 (0)*	Yes
Functional exercises	1 (0.375)	1 (0)*	Yes
Nutritional support	2 (0)	2 (0)*	Yes
Interventions to improve pulmonary function must contain:			
Muscle strength training	2 (0.5)	2 (0.5)	Yes
Inspiratory muscle training	3 (0.375)	3 (0)*	Yes
Expiratory muscle training	3 (0.375)	3 (0)*	Yes
Low intensity interval training	3 (0.5)	3 (0.5)	Yes

Statement	Round 2 Median (SIQR)	Round 3 Median (SIQR)	Consensus
Interventions to improve airway secretion clearance must contain:			
Active cycle of breathing exercises	2.5 (0.5)	2 (0.5)	Yes
Interventions to improve coping with pain must contain:			
Pain education (understanding pain)	2 (0.875)	2 (0)*	Yes
Graded activity or exposure	2 (0.375)	2 (0)*	Yes
Interventions to improve aerobic capacity must contain:			
Interval cardio training	2 (0.375)	2 (0)*	Yes
Circuit training	2 (0)	2 (0)*	Yes
Continuous cardio training	2 (0.5)	2 (0.125)	Yes
Hydrotherapy	3 (0.875)	3 (0.5)	Yes
Interventions to improve physical functioning in ADL must contain:			
Functional exercises	1 (0)	1 (0)*	Yes
Muscle strength training	2 (0.375)	2 (0.375)	Yes
Relaxation exercises	2.5 (1)	2 (1)	No
Starting exercise intensity for cardio training			
Starting exercise intensity should be set at 50-80% of VO2max as measured with cardiopulmonary exercise testing (CPET)	2 (0.5)	2 (0.125)	Yes
Starting exercise intensity should be set at 50-70% of HR reserve (Karvonen)	3 (0.375)	3 (0)*	Yes
Starting exercise intensity should be set at 80% of the average 6MWT speed	3 (0.875)	3 (0.5)	Yes

Score: 1 = essential, 2 = very important, 3 = important, 4 = unimportant, 5 = undesirable

Yes: consensus threshold reached (SIQR ≤ 0.5) No: no consensus reached

** = unanimous score by panel*

At hospital discharge
The panel consensually judged the screening of patients on the risk of developing PICS at hospital discharge as essential (1; SIQR: 0.5; LA: 56%). Screening family members on the presence of PICS-family (PICS-F) was consensually ranked as very important (2; SIQR: 0.5; LA: 40%). The panel expressed concerns regarding availability of valid screening instruments for measuring the presence of PICS-F in the nearby future. Consensus was also reached on the importance of educating the patient (1,5; SIQR: 0.5; LA: 50%) and the family (2; SIQR: 0.5; LA: 67%) on PICS and PICS-F, respectively.

Preferred patient handover information to primary care PT
Regarding preferred patient handover information for primary care physiotherapists, the panel reached consensus on 15 out of 16 of the ranked items. Handover items ranked as essential (score: 1) were: reason for admission and length of stay in the ICU (SIQR:0, LA:100%), course of recovery and complications during hospital stay (SIQR: 0, LA: 80%), duration of mechanical ventilation (SIQR: 0.5, LA: 60%) and healthcare disciplines involved in patient treatment (SIQR: 0.375, LA: 70%). Handover information ranked as very important (score: 2) were: joint mobility (SIQR: 0, LA: 80%), dialyses, or other drastic interventions performed (SIQR: 0, LA: 60%), medication (SIQR: 0.375, LA: 60%), nutritional status (SIQR: 0.375, LA: 50%), muscle strength (SIQR: 0.375, LA: 50%), premorbid level of functioning (SIQR: 0.375, LA: 50%), pulmonary function (SIQR: 0.5, LA: 50%), limitations in activities at discharge (SIQR: 0.5, LA: 50%), level of mobility (transfers/walking) (SIQR: 0.5, LA: 60%), patient goals achieved and further rehabilitation goals set during hospital stay (SIQR: 0.5, LA: 50%).

No consensus was reached on handover information concerning patients' personal and environmental factors potentially affecting rehabilitation (2; SIQR: 0.75; LA: 40%).

Treatment goals and measurement instruments after hospital discharge
Nine treatment goals were identified from the scoping review and the first Delphi round. Per treatment goal, the following instruments were ranked for use in clinical practice after hospital discharge.

Muscle strength
Both handgrip strength dynamometry (SIQR: 0, LA: 70%) and the use of the

MRC Sum Score (SIQR: 0.25, LA: 50%) were ranked as very important (score: 2) for measuring muscle strength.

Pulmonary function
Consensus was achieved in ranking the use of spirometry, forced vital capacity and forced expiratory volume, (2; SIQR: 0; LA: 67%) as very important (score 2). The MRC-dyspnea scale for patient-perceived level of breathlessness, was also considered very important (2; SIQR: 0.25; LA: 71%).

Perceived exertion
The panel consensually ranked perceived exertion during physiotherapy exercise treatment as measured with the BORG Ratings of Perceived Exertion Scale (BORG RPE) as essential (1; SIQR: 0.5; LA: 60%).

Pain
The panel reached unanimous consensus on ranking the Numeric Rating Scale (NRS) for measuring pain as very important (2; SIQR: 0; LA: 88%).

Body composition
No consensus was reached on the use of body composition (such as muscle mass and fat free mass) as measured with multi-frequency bio-impedance analysis (3; SIQR: 0.75; LA: 0%). The panel stated that it might be useful for research purposes but not as much for primary care physiotherapy practice.

Aerobic capacity
The panel unanimously ranked the following instruments as very important (score: 2) in measuring aerobic capacity: the 6-minute walk test (6MWT) (SIQR: 0, LA: %) and cardiopulmonary exercise testing (CPET) (SIQR: 0, LA: 88%).

Limitations in activities of daily living (ADL)
The panel reached consensus in ranking the Patient Specific Functional Scale (PSFS) as very important (score: 2) in measuring limitations in ADL (SIQR: 0.5, LA: 63%). The Barthel Index was consensually considered unimportant for measuring ADL limitations in the primary care setting (SIQR: 0.5, LA: 57%).

Health related quality of life
Unanimous consensus was achieved in ranking the use of the SF-36 for measuring quality of life as very important (2; SIQR: 0; LA: 75%).

Other health domains
Cognitive function as measured with the Mini Mental State Examination (MMSE) (LA:60%), nutritional status as measured with the Short Nutritional Assessment Questionnaire (LA: 60%), and posttraumatic stress disorder as measured with the Trauma Screening Questionnaire (LA: 56%) were consensually ranked as very important (2; SIQR: 0).

Physiotherapeutic interventions after hospital discharge
Muscle strength
The panel reached unanimous consensus on interventions improving muscle strength and muscle mass. Functional exercises (1; SIQR: 0; LA: 80%) and muscle strength training (weight training) (1; SIQR: 0; LA: 80%) were considered essential. Nutritional support was considered very important complementary to physical training methods (2; SIQR: 0; LA: 67%).

Pulmonary function
Consensus was achieved on ranking muscle strength training as very important (2; SIQR: 0.5; LA: 56%) to improve pulmonary function.

Airway secretion clearance
Consensus was achieved on ranking active cycle of breathing exercises as very important (2; SIQR: 0.5; LA: 50%) in case of the presence of airway secretion.

Pain
Pain education (LA: 67%), graded activity and graded exposure (LA: 88%) were unanimously ranked very important interventions for improvement of coping with pain (2; SIQR: 0).

Aerobic capacity
The panel consensually ranked the following physiotherapeutic interventions as very important (score: 2) on improving aerobic capacity: interval cardio training (SIQR: 0, LA: 88%), circuit training (SIQR: 0, LA: 75%) and continuous cardio training (SIQR: 0.125, LA: 75%). Hydrotherapy was unanimously ranked as important (3; SIQR: 0.5, LA: 50%) for improving aerobic capacity, though comments were made on availability of hydrotherapy in primary care settings for severely impaired patients.

Setting starting exercise intensity for aerobic capacity
The panel reached consensus on ranking starting exercise intensity for aerobic training set at 50-80% of maximum oxygen uptake (VO2max) as measured with CPET (2; SIQR: 0.125; LA: 75%) as very important, though comments were made on the availability of the required materials and knowledge in primary care practices. Therefore, the panel proposed two alternative methods for setting starting exercise intensity: using the Karvonen method (50-70% of heart rate reserve) or setting starting exercise intensity for walking on a treadmill at 80% of the average 6MWT speed. Both scored as important by the panel.

Physical functioning in ADL
Unanimous consensus was achieved in ranking functional exercises as essential (1; SIQR: 0; LA: 90%) on improving physical functioning. The panel consensually ranked muscle strength training (weight training) as very important (2; SIQR: 0.375; LA: 70%).

No consensus was reached on the use of relaxation exercises (2; SIQR: 1; LA: 22%), though the former ICU patient in our panel did comment that she valued this intervention as an additional element.

DISCUSSION

As a result of this Delphi study, we provide practical recommendations for physiotherapy treatment for survivors of critical illness in the Dutch primary care setting. These recommendations support clinical decision-making within the continuum of care regarding the content of handover information, screening, the use of functional measurement instruments and targeting interventions, based on the Dutch primary care physiotherapy practice (Figure 1). We recommend to use these recommendations supplementary to other national or international practice guidelines that may apply to the population of ICU survivors, such as the guidelines for cardiac rehabilitation and Chronic Obstructive Pulmonary Disease (COPD). [10,21,22]

The results of our study are to a great extent in concordance with the recommendations in the framework derived from the international Delphi panel by Major et al., [16] indicating that many of these could be transferred to a national healthcare setting. Although the findings of this study highlight important differences for implementation in the Dutch health care system.

In our study the expert panel emphasized the importance of detailed handover information regarding the course of rehabilitation treatment during

hospital stay regarding disciplines involved and patient-centered goals which were not mentioned in the earlier published international recommendations. Furthermore, our Dutch panel recommended different interventions such as graded activity and hydrotherapy whereas the international panel did not. The use of hydrotherapy was suggested by the panel for improvement of aerobic capacity. Yet, the effectiveness of this intervention has not yet been investigated for the population of ICU survivors and it could be argued that hydrotherapy is not suitable for all ICU survivors. The panel stated that hydrotherapy is not widely available in primary care practices but should be considered in consultation with the patient, as in the Netherlands public swimming pools are often available in close proximity.

The use of measurement instruments like the PSFS, SPPB and the Steep Ramp Test were also only suggested by the Dutch panel. The PSFS is often used in Dutch primary care and is also suggested in multiple Dutch practice guidelines.[12,21] The PSFS helps setting patient goals which can go further than just physical problems. The differences between the international and Dutch Delphi study might be explained by the fact that in the current study, the perspectives from primary care physiotherapists as well as from a patient were represented, whereas these stakeholders were not involved in the international Delphi panel.[16]

The suggested treatment goals and instruments in this study are in concordance with existing literature on core outcome measures for research purposes.[16,23-26] The Dutch panel does question the feasibility of the CPET as a tool to evaluate aerobic capacity as in the Netherlands only few primary care physiotherapy practices are equipped for this assessment. Furthermore, the Dutch panel commented that use of a screening tool such as the MMSE for primary care physiotherapy practices requires additional education and instructions before it can be implemented correctly.

Similar to our findings, the results of recent studies showed the need for assessment of physical, cognitive and mental functioning, as well as pain and quality of life in survivors of critical illness after hospital discharge.[23,24,26] Despite the similarities regarding outcomes of interest within the different health domains, our panel did not put forward the same outcomes measures as those, which were recently proposed by Needham et al.[25] We hypothesize that this disagreement might reflect the gap that exists between preferences for the use of measurement instruments for daily clinical practice (as represented by our Dutch panel) and for research.

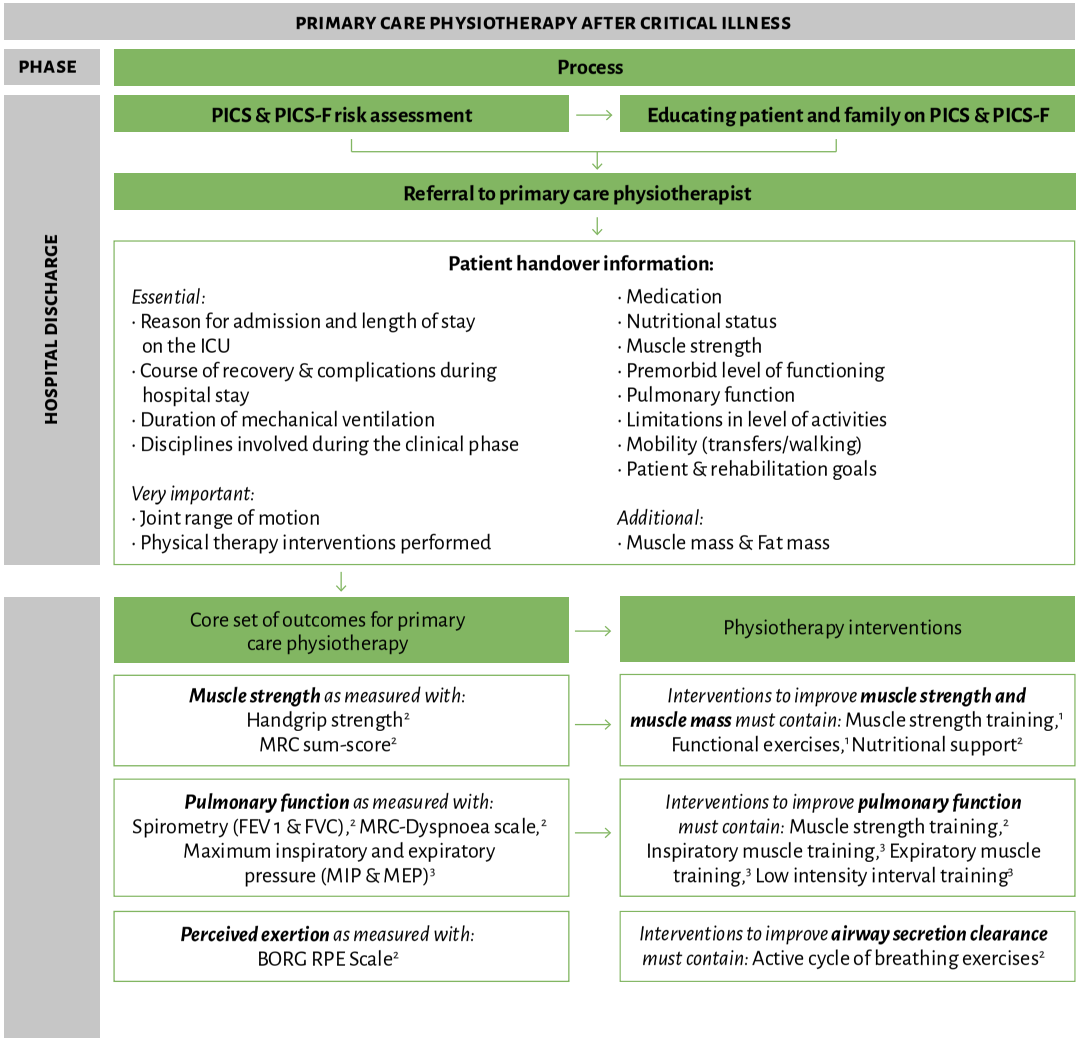
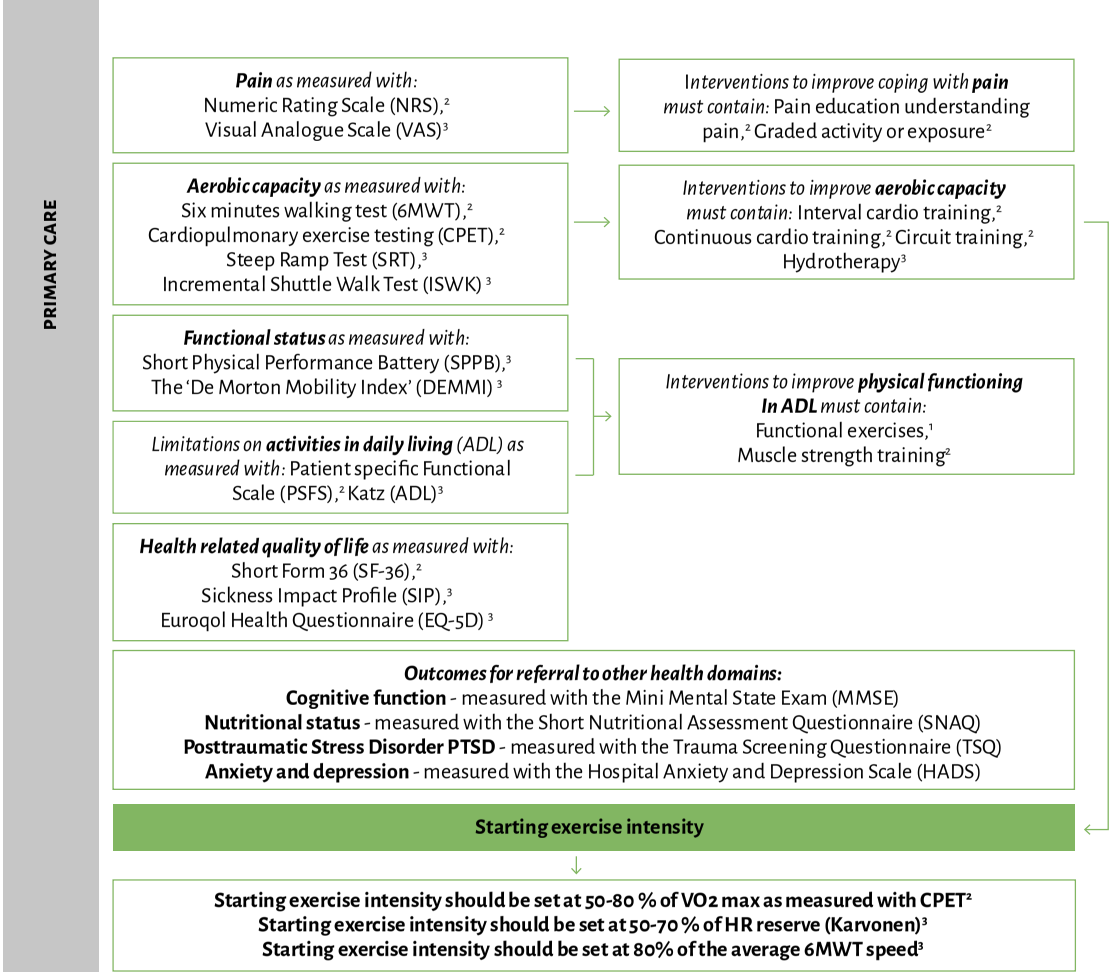


Figure 1: A framework for physical rehabilitation of survivors of critical illness


PRIMARY CARE
Pain as measured with:
Numeric Rating Scale (NRS),[2]
Visual Analogue Scale (VAS)[3]
Interventions to improve coping with pain must contain: Pain education understanding pain,[2] Graded activity or exposure[2]
Aerobic capacity as measured with:
Six minutes walking test (6MWT),[2]
Cardiopulmonary exercise testing (CPET),[2]
Steep Ramp Test (SRT),[3]
Incremental Shuttle Walk Test (ISWK) [3]
Interventions to improve aerobic capacity must contain: Interval cardio training,[2]
Continuous cardio training,[2] Circuit training,[2]
Hydrotherapy[3]
Functional status as measured with:
Short Physical Performance Battery (SPPB),[3]
The 'De Morton Mobility Index' (DEMMI) [3]
Limitations on activities in daily living (ADL) as measured with: Patient specific Functional Scale (PSFS),[2] Katz (ADL)[3]
Interventions to improve physical functioning In ADL must contain:
Functional exercises,[1]
Muscle strength training[2]
Health related quality of life as measured with:
Short Form 36 (SF-36),[2]
Sickness Impact Profile (SIP),[3]
Euroqol Health Questionnaire (EQ-5D) [3]
Outcomes for referral to other health domains:
Cognitive function - measured with the Mini Mental State Exam (MMSE)
Nutritional status - measured with the Short Nutritional Assessment Questionnaire (SNAQ)
Posttraumatic Stress Disorder PTSD - measured with the Trauma Screening Questionnaire (TSQ)
Anxiety and depression - measured with the Hospital Anxiety and Depression Scale (HADS)
Starting exercise intensity
Starting exercise intensity should be set at 50-80 % of VO2 max as measured with CPET[2]
Starting exercise intensity should be set at 50-70 % of HR reserve (Karvonen)[3]
Starting exercise intensity should be set at 80% of the average 6MWT speed[3]

In this Delphi study a number of interventions are proposed by the panel based on clinical expertise and the panel's experience with national guidelines for cardiac rehabilitation and COPD.[21,22] No specific interventions to reduce perceived exertion are suggested by the panel nor in recent literature on ICU survivors.[27,28] Even though a recent Cochrane study suggests that exercise therapy can contribute to alleviate fatigue as part of chronic fatigue syndrome,[29] this was not suggested by the panel. The panel considered relaxation exercises to be unimportant in improving physical function. However, the national guidelines for cardiac rehabilitation and COPD state that relaxation exercises can help improving a patient's confidence, intrinsic motivation, body awareness and breathing regulation.[21,22]

To ensure a smooth transition of physiotherapeutic care from hospital discharge to primary care, the panel points out the importance of screening for symptoms of PICS. The panel proposes that the hospital physiotherapist could execute this screening. The panel emphasizes that education on awareness and the recognition of symptoms of post-intensive care syndrome should be provided to all health care professionals, survivors of critical illness and their family members.[3,30] In addition, follow up clinics could play a vital role in screening for signs of PICS and PICS-Family and refer to primary care physiotherapists when needed.[10,15,16]

Limitations

Some limitations of our study should be considered. Our panel existed of only 10 national experts of which six were physiotherapists, three members were represented by experts in human movement sciences, occupational therapy and nursing, and one member was a former ICU patient. The low number of panel members, the diversity of the panel and the country in which the panelists practise, influence the generalisation of the study results. However, we believe that the group size might have been sufficient with respect to the number of experts and patients available, which is also supported by recent literature.[31] Little or no research has been conducted in the area of clinical decision-making within the continuum of care regarding the content of handover information, screening, the use of functional measurement instruments and targeted interventions for ICU-survivors in a primary care setting. The presented results are therefore based on the expert opinion of our panel and represents level 4 evidence.

A strength of this study is that the perspectives of experienced primary care practitioners as well as an ICU survivor were represented. Specifically,

the clinical expertise of physiotherapists with the treatment of patients with other complex needs in primary care was of additional value as feasibility and implementation of tools and interventions could be taken in to account. Additionally, the contribution of the ICU survivor added to tailoring the recommendations to the needs of the target population.[16,31]

Concerning the overall generalizability to other healthcare systems it is our opinion that the results from this study can be used as a practice guideline, supplementary to other national guidelines that may apply to the population of ICU survivors. However, it should be stated that differences between national healthcare systems can be considerable and should be taken into account.

Future research is needed to develop a feasible and effective physiotherapy intervention according to these recommendations and recently published literature on physical therapy interventions. Recent studies on interventions in a primary care setting state that physical therapy interventions should be tested and implemented seamlessly throughout the continuum of care. These studies also point out the need for a multidisciplinary, more flexible and personalized approach including nutritional and mental care for such a program.[17,27,32]

In a subsequent research project we will implement these recommendations, in co-creation with former ICU patients and different healthcare providers, into an interdisciplinary rehabilitation programme for patients that have been treated in an ICU and are discharged home.

This Delphi study adds to the knowledge on post-ICU physiotherapy with practical recommendations to support clinical decision-making in the treatment of survivors of critical illness after hospital discharge. As the recommendations reflect the perspective and needs from different professionals as well as from patients, the proposed guidelines are expected to be adapted successfully in daily practice.

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APPENDIX

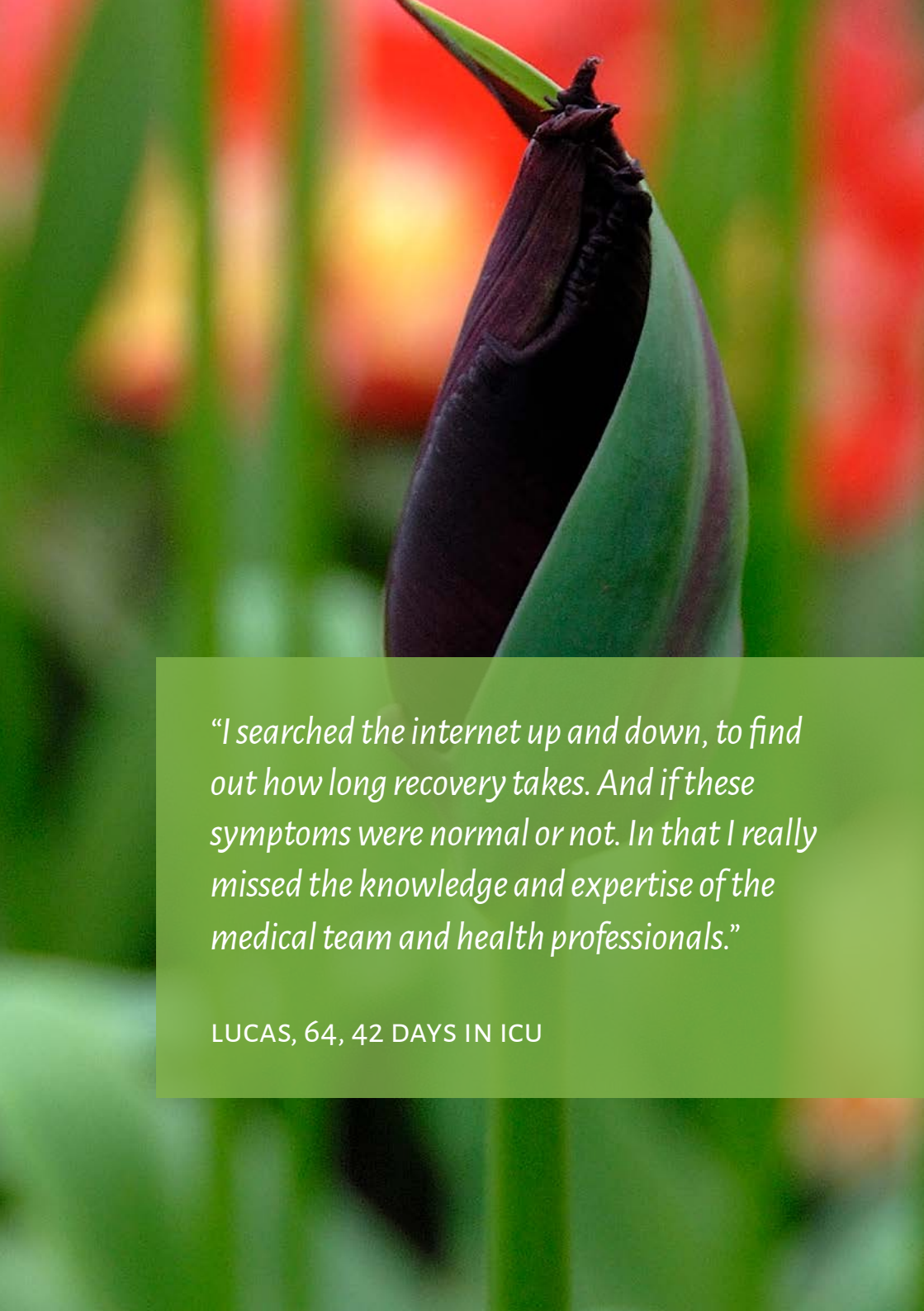
Search strategy scoping review
(reprinted with permission from Major et al. 2016)

Database	Search terms	Hits	For review
Pubmed	#1 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] OR "Aftercare"[Mesh]	7017	
Pubmed	#2 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] AND "Aftercare"[Mesh]	9	2
Pubmed	#3 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Aftercare"[Mesh] (Limits: last 10 yrs, clinical trials only, Filters: adults)	115	3
Pubmed	#4 post intensive care syndrome [Title/Abstract]) OR PICS [Title/Abstract] (Limits: adults 19+ published last 10 years)	53	1
Pubmed	#5 intensive care [Title/Abstract]) OR ICU [Title/Abstract] AND survivor*[Title/Abstract] (Limits: adult / last 10 years / clinical trial)	227	13
Pubmed	#6 intensive care [Title/Abstract] OR ICU[Title/Abstract] AND surviv*[Title/Abstract] AND recovery[Title/Abstract] (Limits: adults 19+, last 10 years, clinical trials)	51	6
Pubmed	#7 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] AND after care	10	0
Pubmed	#8 "Critical Care"[Mesh] OR "Intensive Care"[Mesh] AND "Rehabilitation"[Mesh] (Limits last 10 years, adults 19+)	103	16
PEDro	#1 Critical care	129	3
CINAHL	#1 AB Critical Care AND AB rehabilitation	137	16
CINAHL	#2 AB Critical Care AND physical therapy OR physiotherapy AND recovery (Limits: last 10 years, all adult)	116	0
CINAHL	#3 post intensive care syndrome [Title/Abstract]	12	6
MEDLINE	#1 Critical Care AND post intensive care syndrome	8	8

Database	Search terms	Hits	For review
MEDLINE	#2 Post intensive care syndrome	14	7
Science Direct	#1 Critical Care (title/abstract/key words) Rehabilitation (title/abstract/key words #2 pub-date > 2003 and TITLE (post intensive care syndrome) or TITLE-ABSTR-KEY (post intensive care syndrome) #3 pub-date > 2003 and TITLE (post intensive care syndrome) or TITLE-ABSTR-KEY (post intensive care syndrome) AND LIMIT-TO(topics, "icu")	203 293 12	9
ProQuest Social Sciences	#1 SU.EXACT ("Intensive care") AND SU.EXACT("Rehabilitation") OR SU.EXACT ("After care") 2004-2015 #2 Limits: peer reviewed #3 Limits: rehabilitation	232 187 20	1
PubMed (9-4-2015)	#1 ("Critical Care" [Mesh]) OR "Critical Illness"[Mesh]) AND "Physical Therapy Modalities"[Mesh]) OR "Exercise"[Mesh]) OR "Exercise Therapy"[Mesh]) OR "Physical Therapy Specialty"[Mesh]) #2 ("Critical Care"[Mesh]) OR "Critical Illness"[Mesh]) AND "Physical Therapy Modalities"[Mesh]) OR "Exercise"[Mesh]) OR "Exercise Therapy"[Mesh]) OR "Physical Therapy Specialty"[Mesh]) AND Humans [Mesh] AND adult[MeSH]) AND recovery[Title/Abstract]) OR post intensive care[Title/Abstract] #3 (("Intensive Care"[Mesh]) AND "Critical Care"[Mesh]) OR "Critical Illness"[Mesh]) AND "Rehabilitation"[Mesh]) OR "Aftercare"[Mesh]) AND "Physical Therapy Modalities"[Mesh] limits last 10 years, adults #4 ("Intensive Care"[Mesh]) AND "Critical Care"[Mesh]) OR "Critical Illness"[Mesh]) AND "Physical Therapy Modalities"[Mesh]) limits: last 10 years, adults	74431 5413 33 85	3 (duplicates) 7 (6 duplicates)

Database	Search terms	Hits	For review
PubMed (diagnostics)	#1 "Diagnosis"[Mesh]) AND "Intensive Care"[Mesh]) OR "Critical Illness"[Mesh])) AND rehabilitation [Title/Abstract] OR physical therapy modalities[MeSH Terms] AND recovery[Title/Abstract]	4466	
	#2 "Exercise Tolerance"[Mesh]) OR "Exercise Therapy"[Mesh] OR "Exercise"[Mesh] AND "Survivors"[Mesh] AND "Critical Illness"[Mesh]	4	1
	#3 "Exercise Tolerance"[Mesh]) OR "Exercise Therapy"[Mesh] OR "Exercise"[Mesh]) AND "Survivors"[Mesh]) OR "Critical Illness"[Mesh]	5271	
	#4 "Muscle Strength"[Mesh] AND "Survivors"[Mesh]) AND "Critical Illness"[Mesh]	1	1
	#5 "Exercise Test"[Mesh]) AND "Critical Illness"[Mesh]	15	1
	#6 "Outcome Assessment (Health Care)"[Mesh] AND "Critical Illness"[Mesh] AND survivor*[Title/Abstract]	104	36

Searches were done on 13 March 2015, 19 March 2015, 26 March 2015, and 9 April 2015; alerts were entered into the appropriate database with similar search terms



"I searched the internet up and down, to find out how long recovery takes. And if these symptoms were normal or not. In that I really missed the knowledge and expertise of the medical team and health professionals."

LUCAS, 64, 42 DAYS IN ICU

CHAPTER 7 Feasibility of a home-based interdisciplinary rehabilitation program for patients with Post-Intensive Care Syndrome: the REACH study

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ABSTRACT

Background: Survivors of critical illness experience long-term functional challenges, which are complex, heterogeneous, and multifactorial in nature. Although the importance of rehabilitation interventions after intensive care unit (ICU) discharge is universally recognized, evidence on feasibility and effectiveness of home-based rehabilitation programs is scarce and ambiguous. This study investigates the feasibility of an interdisciplinary rehabilitation program designed for patients with post-intensive care syndrome (PICS) who are discharged home.

Methods: A mixed method, non-randomized, prospective pilot feasibility study was performed with a 6-month follow-up, comparing the intervention (REACH) with usual care. REACH was provided by trained professionals and included a patient-centered, interdisciplinary approach starting directly after hospital discharge. Primary outcomes were patient safety, satisfaction, adherence, referral need and health care usage. Secondary outcomes, measured at 3 timepoints, were functional exercise capacity, self-perceived health status, health-related quality of life (HRQoL), return to work and psychotrauma. Risk of undernutrition was assessed at baseline.

Results: 43 patients with a median mechanical ventilation duration of 8 (IQR:10) days, were included in the study and 79.1% completed 6-month follow-up. 19 patients received the intervention, 24 received usual care. Groups were similar for gender distribution and ICU length of stay. No adverse events occurred. REACH participants showed higher satisfaction with treatment and reported more allied health professional visits, while the usual care group reported more visits to medical specialists. Qualitative analysis identified positive experiences among REACH-professionals related to providing state-of-the-art interventions and sharing knowledge and expertise within an interprofessional network. Similar recovery was seen between groups on all secondary outcomes, but neither group reached reference values for HRQoL at 6 months. Larger return to work rates were seen in the REACH group. Prevalence of undernutrition at hospital discharge was high in both groups (> 80%), warranting the need for careful tuning of physical therapy and nutritional interventions.

Conclusions: This study shows that providing early, home-based rehabilitation interventions for patients with PICS-related symptoms is feasible and perceived positively by patients and professionals. When provided in an interdisciplinary collaborative network state of the art, person-centered interventions can be tailored to individual needs potentially increasing patient satisfaction, adherence, and efficacy.

BACKGROUND

Whilst more patients survive critical illness because of improvements in medical care, a growing number of patients leaves the hospital needing rehabilitation interventions for multifactorial problems associated with long-term disability as part of the Post-Intensive Care Syndrome (PICS).[1-6] The new or worsened impairments reported by survivors of critical illness manifest in considerable heterogeneity with regards to health domains (physical, psychological, cognitive), duration, and severity of activity limitations and participation restrictions in life situations.[7-12]

Although a range of interventions within the intensive care unit (ICU) is employed targeting these long-term functional problems, such as early mobilization and the use of ICU diaries, a rehabilitation continuum or coordinated care pathway after ICU- and hospital discharge is lacking.[13,14] The diversity of problems survivors might experience warrant the need for an interdisciplinary approach towards recovery to provide tailor-made, individualized interventions at the right time, in the right setting and by the right professional.[12,15-20]

The World Health Organization's (WHO) definition of rehabilitation describes the importance of providing interventions directed towards interaction within the individual's *environment*, to facilitate participation in meaningful activities.[21] To date, few studies investigated interventions for patients recovering from critical illness after home discharge, which reported poor attendance of outpatient exercise programs. Travel time and patients' lack of motivation were identified as reasons for non-attendance.[22-24] If primary care rehabilitation specialists such as physical therapists (PTs), occupational therapists (OTs) and dietitians (DTs) can provide early home-based interventions for patients with functional impairments related to PICS, this might increase adherence and satisfaction, decrease the chance of hospital readmissions, and cut healthcare costs.[12,23,25-27] Care provided within an interprofessional network has shown to increase professional expertise and improve the quality of care.[28,29]

While expert recommendations for home-based, PT-led interventions for survivors of critical illness have been published,[26,30,31] feasibility of such interventions within the primary care setting is yet to be investigated. Therefore, the aim of this study was to investigate the feasibility of an interdisciplinary home-based intervention for patients with new or worsened impairments within one of the domains of PICS, initiated immediately after

hospital discharge and targeting (physical) recovery and self-management in comparison to patients receiving usual care.

METHODS

Study design

A mixed method, non-randomized, prospective pilot feasibility study was undertaken with a 6-month follow up and a total study duration of 22 months. The pilot feasibility study consisted of two arms, an intervention group (REACH, REhabilitation After Critical illness and Hospital discharge) and a usual care group. Group allocation was based on convenience sampling; participants received the intervention if they lived in an area covered by REACH-therapists, unless they preferred otherwise (i.e., their own therapist). Participants living outside of the REACH geographical area were allocated to the usual care group. In line with the pilot feasibility character of the study, no a priori sample size calculations were conducted.[32]

Setting

This study was part of ongoing research of the department of rehabilitation medicine at the Amsterdam University Medical Centers, location Academic Medical Center (AMC).

Participants

Participants were recruited from 2 university and 5 general hospitals in the Amsterdam area, the Netherlands. Participants were eligible for inclusion if they had received mechanical ventilation (MV) of ≥ 48 hours in the ICU, had developed new or worsened impairments during or after the ICU-stay unrelated to the initial admission diagnosis,[33] and were discharged home with an indication for physical therapy (PT). Indication for PT was determined according to the hospitals' protocols for referral, i.e., presence of any (or a combination) of the following: ICU-acquired weakness (MRC Sum Score < 48), limited walking ability (Functional Ambulation Categories (FAC) ≤ 4), problems with climbing stairs, decreased independence in activities of daily living (ADL), limited cardiopulmonary capacity during exertion (dyspnea, resting respiratory rate > 30, oxygen saturation < 95%, Borg CR10 scale > 4).

Exclusion criteria were presence of serious (preexisting) cognitive and/or psychiatric impairments hindering compliance to the physical tests and inadequate understanding of the Dutch or English language. Eligible patients

were identified by ICU-PTs and after verbal permission was obtained, were contacted by telephone by the primary investigator (MM) within 2 days after hospital discharge. Once oral consent was obtained, a home visit was planned.

Intervention

The intervention, called the *REACH program*, was designed in an iterative, 8-month developmental process in a community of practice (CoP) of primary care PTs ($n = 18$), OTs ($n = 3$), DTs ($n = 4$), ICU-PTs ($n = 8$), researcher/clinicians ($n = 6$), a health coach and representatives from patient- and professional organizations (including general practitioners), prior to the start of the study. First, CoP members from different fields of expertise provided training on the presentation and potential interventions for the different facets of PICS. Next, the components of the REACH program were developed in co-creation. Lastly, the 'positive health' concept was integrated in the REACH program. This concept emphasizes support to the 'ability to adapt and self-manage'.[34] Professionals within the REACH-network received extensive training with regards to the application of this concept of health in their daily practice, allowing for individualized, tailor-made treatment programs. The intervention, which was initiated by the hospital PTs, constituted an elaborate written and telephonic handover from hospital PT to REACH-PT, a core outcome set (COS) and a tailored exercise program. Regular (online) CoP meetings facilitated peer-to-peer learning and interdisciplinary collaboration.

The PT interventions started within one week after hospital discharge, initially provided in the home situation of the patient and continuing in the nearby PT practice as soon as their physical condition allowed. During the first intake and/or during the treatment period PTs performed a screening to detect functional problems within the field of OT and DT and referred patients when indicated. The Short Nutritional Assessment Questionnaire (SNAQ65+) was used to screen for (the risk of) undernutrition,[35] in which case DTs were consulted, who performed further diagnostics. DT interventions were targeted towards optimization of protein intake, according to the Dutch guidelines for malnutrition: 1.2 - 1.5 g protein per kg bodyweight[36] in participants in which undernutrition and/or sarcopenia were identified. For OT, 4 screening questions were designed as advised by expert OTs within the CoP: these were binary questions on the presence of fatigue, problems with return to work or performance of daily activities and problems with memory and/or concentration. If any of these questions were answered with yes, OTs were consulted (additional file 1: OT screening protocol). OT interventions

addressed problems with fatigue and (insight in) physical capacity, (education on) cognitive functioning in daily activities and self-management. All REACH professionals were trained to regularly check for problems within other PICS domains but outside of the scope of their profession - such as psychological problems or worsening medical conditions - and informed general practitioners (GPs) when required.

PT started with functional exercises aimed at improving ability in ADL and gradually progressive resistance training to increase muscle strength. Interventions targeting exercise capacity progressed from functional, home-based training to in-practice aerobic training. Aerobic capacity was trained by first increasing the duration of the activity before increasing the intensity. If the participant's perceived exertion was > 4/10 on the Borg CR10 scale,[37] therapists were to cease the exercise or the therapy session. The protocol identified 3 rehabilitation phases: (1) the (acute) home phase, (2) the (subacute) training phase at the PT clinic and (3) the evaluation (long-term follow up) phase. Progression between phases was left to the PTs professional judgment. Frequency of sessions averaged 2 half hour sessions per week in phase 1 and 30- to 60-minute sessions twice a week in phase 2. In phase 3 participants often trained independently with irregularly scheduled supervised exercise sessions, as deemed necessary. The total duration of the REACH intervention was not specified a priori as decision-making depended on individual patient needs.

Usual care group

The reference group consisted of participants receiving 'usual care', which was defined as 'unrestricted clinical practice', either sought through self-referral or recommended by the discharging hospital.[38] As no formal care pathway exists in the Netherlands for patients recovering from critical illness, we considered any participant who did not receive the REACH intervention, to be eligible for the usual care group.

Professionals involved in the usual care provision were not part of the REACH-network and did not receive additional training on (interventions targeting) PICS and application of the positive health concept. Some patients in the usual care group may not have received interventions from allied health professionals at all, dependent on their own preferences and the organization of health care.

Outcomes

Primary (feasibility) outcomes were safety and optimal dose of the REACH program, patient and professional satisfaction, adherence to treatment and protocol, need for interdisciplinary referral and health care usage. Secondary outcomes were functional exercise capacity, self-perceived health status, health-related quality of life (HRQoL), return to work (RTW), prevalence of psychological problems (including symptoms of PTSD) and risk of undernutrition at time of hospital discharge.

Data collection took place between April 2019 and February 2021.

Primary (feasibility) outcomes

Data on safety and optimal dose of the intervention were collected throughout the duration of the study by tracking adverse events and protocol deviations. Participant satisfaction with PT treatment was measured at 3- and at 6-month follow up with the Patient Reported Experience Measure (PREM). [39] The PREM Physical Therapy is developed to measure patient experienced quality of the PT and the interventions received, estimating a global perceived effect and a net promotor score (NPS), which is calculated from the 0-10 score given to the question 'Would you recommend your PT to others with similar health problems?'. Scores to this question are grouped into 'Promotors' (score 9 or 10), 'Passively satisfied' (score 7-8) and 'Detractors' (score 0-6). The NPS is the derived result from the percentage promotors minus the percentage detractors.

Data on professional satisfaction and adherence to protocol were collected through a mixed-method approach using an online survey and a focus group session among REACH professionals, conducted at the end of the study. Information on referral need (DT and OT) was assessed as follows: DT need was assessed counting all cases with (risk of) undernutrition at time of hospital discharge and OT need was assessed at 3- and at 6-months after discharge by counting the cases applicable for OT based on the outcome of the screening protocol (supplementary material). Data on health care usage were collected at 3- and 6-months after hospital discharge, using a self-reported questionnaire from a prior ICU follow-up study.[40]

Secondary outcomes

Physical measurements (conducted through home visits) and data collection of self-perceived health status, HRQoL and psychological status (GPS) were conducted at three timepoints: 1-2 weeks (T0), 3 months (T1) and 6 months (T2) after hospital discharge.

Functional exercise capacity was measured with the two-minute step test (TMST). [41] The TMST is developed as part of the Senior Fitness Test and has shown to be a valid and reliable (ICC > 0.90) tool in older adults with and without morbidities, is practical in use in the home situation and can be safely conducted in frail (elderly) patients.[42,43] Before testing, participants' vital signs were assessed by monitoring resting heart rate (RHR) blood pressure (BP) and oxygen saturation (SaO2) to determine safety and feasibility of test execution. Cut-off values for safe execution of the test were RHR ≤ 110, BP ≤ 180/100, and SaO2 > 90%. Other contra-indications for test execution were chronic heart failure, presence of chest pain, dizziness, wounds under the foot or inability to raise the knee to the height halfway between the iliac crest and the patella.

Self-perceived health status was assessed asking the participants to rate their health on a numeric rating scale (NRS) ranging from 0 (very bad) to 10 (excellent). Health-Related Quality of Life (HRQoL) was measured using the 36-item Short Form health survey (SF36). [44] The SF36 consists of 8 subscales, which can be transformed into a physical component score (PCS) and mental component score (MCS). [45] Return to work (RTW) data were collected via a self-reported questionnaire administered at 3- and 6 months.[40]

The SNAQ65+ screening tool was used to determine undernutrition prevalence at hospital discharge (baseline). This tool categorizes nutrition status based on involuntary weight loss, upper arm circumference, appetite, and physical function in three categories: undernutrition (red), risk of undernutrition (orange) and no undernutrition (green). [35] Prevalence of traumatic symptoms was determined at all 3 timepoints using the Global Psychotrauma Screen (GPS), a 22-item questionnaire designed to screen for a broad scope of potential trauma-related outcomes. The first 5 questions consist of the Primary Care PTSD Screen for DSM-5 (PC_PTSD-5),[46] allowing for calculating an overall score for PTSD symptoms, where a score ≥ 3 indicates possible PTSD. A sum score of the remaining 17 questions provides a total score for GPS symptoms.[47]

Statistical analysis

Quantitative outcomes were analyzed descriptively and reported in raw counts, percentages, mean/SD or median/IQR, dependent on type and distribution of data. Due to the feasibility design of this study, no formal hypotheses testing on within and between group change over time were conducted - as the study was underpowered to test for effectiveness.[32]

Baseline parameters between group were analyzed with the Mann-Whitney U test to explore if significant differences were present (α set at 0.05). For the secondary (clinical) outcomes, descriptive statistics at the 3 timepoints were calculated and converted to percentage of predicted values for outcomes where normative values exist. IBM SPSS version 27 was used. Qualitative data obtained through the focus group session were transcribed verbatim and combined with qualitative survey data. Further coding and thematic analysis of qualitative data took place and results are reported narratively.

Ethical approval

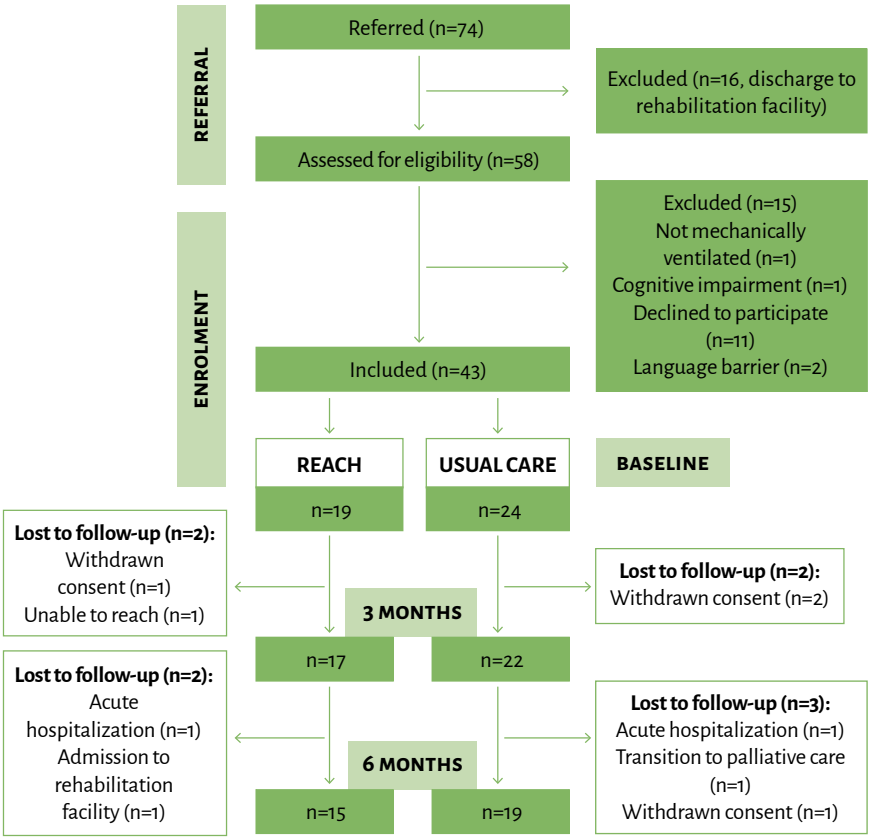
As the REACH intervention is implemented in the form of quality improvement, the Medical Ethics committee of the Amsterdam University Medical Centers (location AMC) provided a waiver for the feasibility study (METC W18_237 #18.282), but additional ethical approval was obtained for the physical measurements (2019_012, ABR NL 68475.018.19). Written informed consent was obtained from all participants in line with the Good Clinical Practice directives.

RESULTS

In total, 74 survivors of critical illness were referred for participation in the study, of which 16 were excluded because they were transferred to a long-term rehabilitation facility before home discharge, leaving 58 eligible participants. Application of the in- and exclusion criteria left a total of 43 participants, 19 participants were included in the intervention group and 24 in the usual care group.

In each group 2 participants dropped out during the study due to an acute new medical event, unrelated to the intervention, requiring admission to hospital, rehabilitation- or palliative care facility. Loss-to-follow up occurred in both groups for the following reasons: withdrawn consent (REACH: $n = 1$, usual care: $n = 3$), unable to contact (REACH: $n = 1$). This resulted in a 6-month follow-up of 79.1% ($n = 34$). Due to the start of the COVID-19 pandemic halfway through this study, measurements were conducted telephonically during the 2-month complete lockdown in March/April 2020. Physical measurements continued as soon as protocols were put in place respecting social distancing and hygiene. This resulted in some missing data but no participant drop-out (Figure 1).

Figure 1: Flow of participants (Consort diagram)



Baseline characteristics

Participant demographic and medical characteristics were similar between groups, except for age and hospital length of stay (LOS); participants in the intervention group were older than in the usual care group (median [IQR] age 63 [9] vs 54 [23], p 0.09) and had a significantly shorter median hospital LOS (23 vs 34 days, p 0.04). The majority of the participants were acutely admitted to ICU (REACH: 89.5%, usual care: 70.8%) and most had admission diagnoses of cardiorespiratory origin (Table 1).

Table 1: Population characteristics

Variable	REACH intervention group (n=19)	Usual care group (n=24)
Age (median, IQR)	63 (9)	54 (23)[a]
Gender (male) (n, %)	14 (73.6)	15 (62.5)
ICU LOS (days) (median/IQR)	10 (16)	11 (12)[a]
MV duration (days) (median/IQR)	8 (10)	8.5 (12)[a]
Hospital LOS (days) (median/IQR)	23 (21)	34.5 (28)[b]
Admission diagnosis (n, %)		
· Respiratory	12 (63.2)	11 (45.8)
· Cardiac	2 (10.5)	7 (29.2)
· Sepsis	3 (15.8)	2 (8.3)
· Oncologic surgery	2 (10.5)	4 (16.7)
Admission category (n, %)		
· Acute	17 (89.5)	17 (70.8)
· Elective	2 (10.5)	7 (29.2)
SNAQ65+ screening score (n, %)	n=19	n=24
· Red (undernutrition)	16 (84.2)	20 (83.3)
· Orange (risk of undernutrition)	2 (10.5)	1 (4.2)
· Green (no undernutrition)	1 (5.3)	3 (12.5)
Employment status (n, %)		
· Employed*	7 (36.8)	10 (41.7)
· Unemployed	12 (63.2)	14 (58.3)
o Pensioner	4 (33.3)	5 (35.8)
o Unemployed due to disability	4 (33.3)	3 (21.4)
o Unemployed not due to disability	3 (25.0)	4 (28.6)
o Family responsibilities	1 (8.4)	1 (7.1)
o Student	-	1 (7.1)
Living situation (n, %)		
· Living alone	6 (31.6)	6 (25.0)
· Living with others†	13 (68.4)	18 (75.0)

LOS: Length of Stay, MV: Mechanical ventilation, SNAQ: Short Nutritional Assessment Questionnaire
[a] *no significant between group differences (p > 0.05),* [b] *significant between group difference (p=0.04)*
* *Includes permanent, casual, and self-employed employees, † living in partnership, with child(ren), in student housing, living with friends or other family members*

Primary outcomes

Feasibility and safety of the intervention

No intervention related adverse events occurred and participants showed compliance to the treatment, as evaluated by the PTs providing the intervention: none of the patients included in the REACH group ceased treatment against the advice of the professional. REACH-PTs recognized that the treatment approach within the interdisciplinary network resulted in motivated patients showing high adherence to treatment, but identified challenges related to balancing care provision considering the patient's physical and mental capacity throughout the different stages of recovery. The frequency of PT treatment often had to be decreased when other disciplines were increasingly involved and/or demands from patients' environment intensified, to limit the strain on the patient.

Patient and professional satisfaction, adherence to treatment and protocol

Satisfaction scores were higher in the REACH group compared to the usual care group (NPS 92.8% vs 60.0% at 6 months). Evaluation of satisfaction among REACH professionals manifested the following positive feedback: applying the broader concept of health ('positive health') facilitated patient-centered care, in turn increasing patient satisfaction:

> "*I notice that [Positive health] is increasingly benefiting my way of communicating with patients [..] in which I have learned to place the patient first [..] and I really enjoy it. I notice patients are very satisfied ... with the treatment*" (REACH PT #3)

Thematic analysis of the results of the focus group session with REACH-PTs ($n = 11$) revealed two themes: 'Being part of the state-of-the-art' and 'Balancing patients' needs with professional practice requirements'.

Being part of the state-of-the-art

The continuous professional development experienced by professionals within the interdisciplinary network, resulting from (online) meetings and training sessions, social media channels, discussion fora and monthly newsletters, increased awareness towards problems beyond the professional scope and led to changing one's daily practice:

> *"That meeting where we received information about nutrition and training opened my eyes! With every REACH patient, actually during my first consultation I check if the nutrition is in order, and always schedule a meeting with the dietitian in our center"* (REACH PT #6)

Additionally, professionals experienced urgency in continuance of their professional development considering the complexity and heterogeneity of PICS, suggesting the network to be expanded with professionals from other disciplines, such as psychology and speech and language therapy (SLT). Similar emphasis was given to the need to expand the REACH network to a larger geographical area and ultimately to have nationwide coverage. Being ready to provide fitting interventions for patients recovering from COVID-19 and being able to share knowledge and expertise to colleagues through national webinars was seen as a powerful opportunity:

> *"How great is it…no how terrible is it that we are in this COVID period, but how great is it that we can use the power of these webinars and online meetings. I really hope that we can take part in future research projects and continue meeting like this"* (REACH PT #6)

Balancing patients' needs with professional practice requirements

Thematic analysis revealed professional challenges regarding the delivery of optimal rehabilitation interventions for patients with PICS.

While the REACH CoP recommended usage of validated outcome measures such as the TMST, 2-minute walk test (2-MWT) and 6-minute walk test (6-MWT) for functional exercise capacity, this was deemed impractical by PTs providing the intervention, especially in patients with very low functional capacity or severe physical deconditioning. PTs identified the need for further validation of (functional) aerobic capacity tests for patients with PICS, such as cardio-pulmonary exercise testing (CPET) as soon as safely possible to establish training parameters and objectively evaluate (an increase in) exercise capacity.

Additionally, PTs identified limitations regarding financial compensation of PT sessions for patients with PICS. For patients for whom health insurance did not - or only limitedly - cover the expenses of the PT interventions, professionals often had to make difficult choices: to shorten the program or to provide sessions free of charge.

> *"You can design an intervention program with a desired frequency and for a desired duration but with limited coverage, you run out really quickly. Treatment is so dependent on individual circumstances and that makes it difficult. This patient I have, for example I have let him come for 2 additional months without letting him … paying it myself because he has unemployment benefits only and I thought it important to get him back to how he was before"* (REACH PT#7)

Evaluating the application of the positive health concept, professionals indicated that the provided conversational tools were somewhat complicated and time-consuming in daily use, especially when met with patients with limited health literacy.

Health care usage and interdisciplinary referral need

The percentage of participants reporting hospital readmissions (acute and elective) was higher in the intervention group compared to the usual care group at both 3- and 6-month follow up (26.7% vs 9.5% at 3 months and 20.0% vs 6.7% at 6 months). The percentage of participants having planned hospital check-ups was initially similar between groups (3 months: REACH: 93.3% vs usual care: 95.2%) but decreased only in the REACH group at 6 months (REACH: 66.7% vs usual care: 93.3%). In the first 3 months, 212 PT sessions were received by 100% of the participants in the REACH group, versus 265 sessions to 76.2% of the participants in the usual care group. Between 3-6 months after hospital discharge the total PT sessions as well as the percentage of participants receiving PT had decreased (REACH: 152 sessions among 66.7% and usual care: 179 sessions among 73.3%).

A larger percentage of participants in the REACH group received OT compared to the usual care group (REACH 13.3% and 33.3% and usual care: 4.8% and 0% between 0-3 and 3-6 months respectively). The need to refer to OT seemed to increase over time (as the number of sessions and percentage of participants receiving OT increased in the REACH group between 3- and the 6-month follow up), while the percentage of participants needing DT interventions decreased somewhat over time (REACH: 53.3% and 40.0% and usual care: 47.6% and 33% between 0-3 and 3-6 months respectively). Visits of nursing practitioners were more frequent in the first 3 months after hospital discharge (REACH: 162 visits and usual care: 98 visits compared to the period between 3 - 6 months (REACH: 30 visits versus usual care: 27 visits). SLTs were not seen by anyone in the REACH group, and only 3 visits were reported by 1 participant in the usual care group in the period between 3-6 months.

Figure 2a: Health care usage per group at 3 and 6 months, expressed as percentage of participants
GP: general practitioner, PT: physical therapist, OT: occupational therapist, DT: dietitian, SLT: speech and language therapist, NP: nurse practitioner

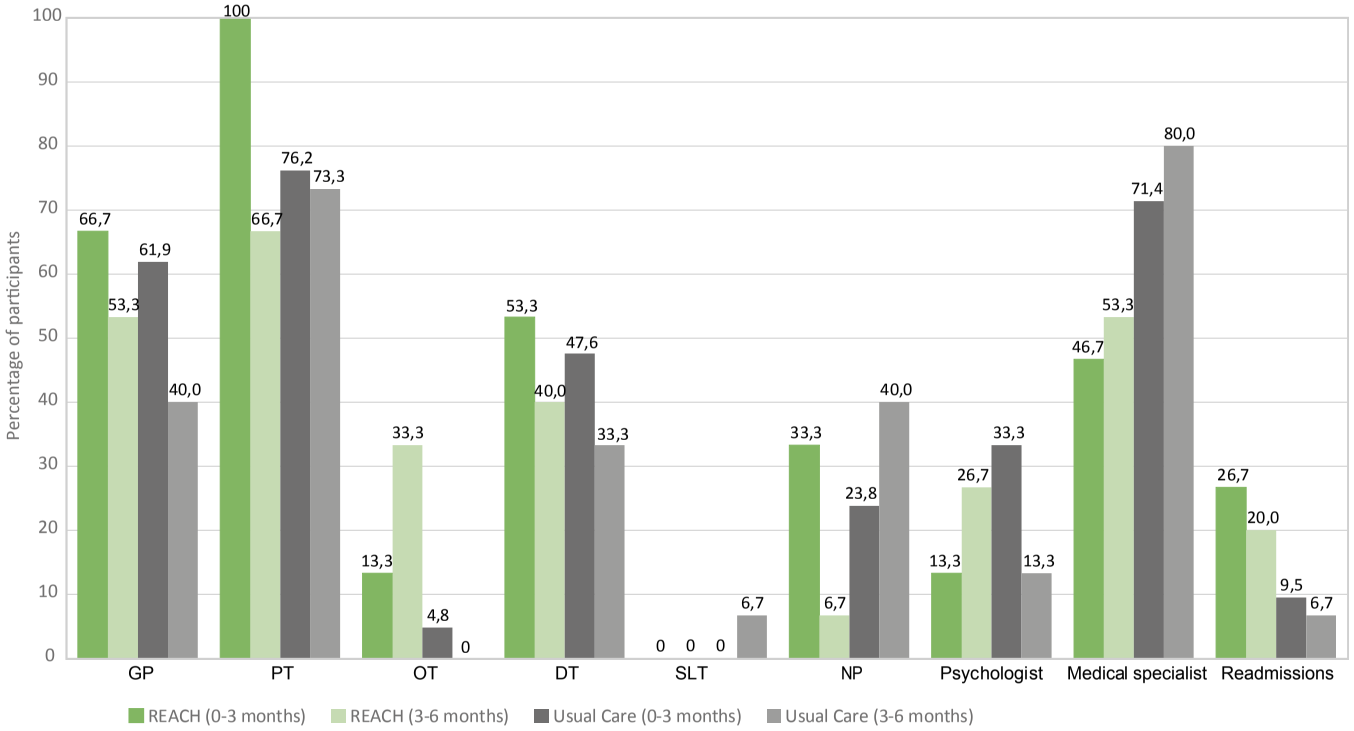
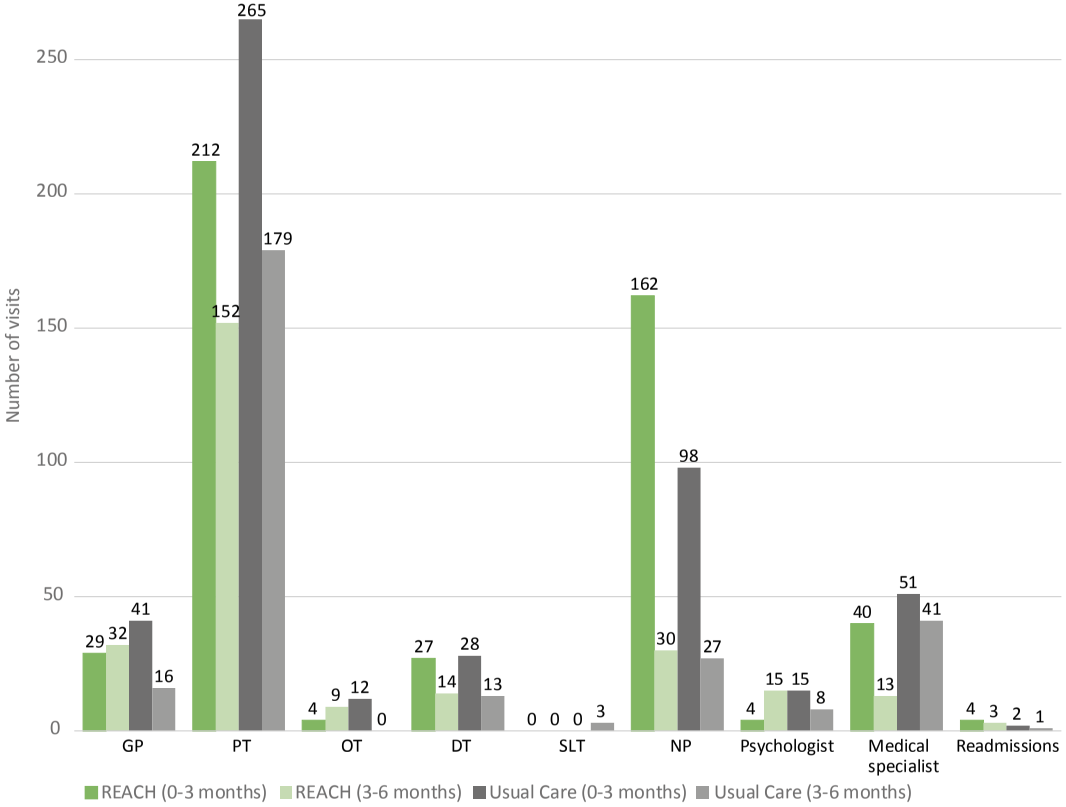


Figure 2b: Health care visits per group at 3 and at 6 months, expressed as total visits
GP: general practitioner, PT: physical therapist, OT: occupational therapist, DT: dietitian, SLT: speech and language therapist, NP: nurse practitioner



The frequency of consultations with medical specialists was lower in the REACH group compared to usual care, at both timepoints (REACH 46.7% [40 visits] and 53.3% [13 visits] vs usual care: 71.4% [51 visits] and 80.0% [41 visits] at 3- and 6-month follow up respectively). Appointments with psychologists occurred more often in the usual care group in the first 3 months (REACH: 13.3% [4 visits] vs usual care: 33.3% [15 visits]) which reversed between groups during the following 3 months (REACH: 26.7% [15 visits] and usual care: 13.3% [8 visits] (Figure 2a, b).

Secondary outcomes

Functional exercise capacity

Functional exercise capacity, measured with the TMST, was established in 72.1% of the participants directly after hospital discharge, in 86.5% at 3 months and in 93.8% at 6 months. Reasons for non-completion were unstable vital signs (elevated resting systolic or diastolic blood pressure or heart rate) or severe physical deconditioning, making the safe execution of the test impossible. Baseline performance was similar between groups (steps, mean [SD], REACH: 54 [18], usual care: 62 [33]). The greatest improvement in outcome was seen at 3 months follow up (steps, mean [SD], REACH: 82 [27] vs usual care: 94 [28]). At 6 months the improvement was still visible but tapered off (steps, mean [SD], REACH: 87 [31] vs usual care: 99 [28]). When comparing to normative values, mean steps improved to the lower limits of available norm values (48) in both groups, at 3- and at 6-month follow-up (Table 2).

Self-perceived health status and health-related quality of life

Table 2 shows the outcomes at all three timepoints on the NRS perceived health. Data show a similar perceived improved health status between timepoints in both groups.

For HRQoL, baseline physical and mental component scores (PCS and MCS) for both groups are well below normative values and show a comparable recovery at 3- and 6 months, with minor differences observed between groups. Notably, neither group reaches normative values for PCS at 6 months.[45]

Return to work

Of the participants who were employed prior to their ICU admission, 71.4% of the REACH participants and 50% of the usual care participants had returned to work (RTW) at 3 months. At 6 months 85.7% of the REACH participants reported

RTW versus 40.0% in the usual care group. These data reflect both partial and complete RTW (Table 2).

Table 2: Secondary outcomes REACH versus usual care

Outcome	REACH			Control (usual care)		
	Discharge	3 months	6 months	Discharge	3 months	6 months
Functional exercise capacity (TMST)	n=15	n=16	n=14	n=16	n=16	n=16
Total steps (Mean/SD/Σ)	54 ± 18, 809	82 ± 27, 1318	87 ± 31, 1213	62 ± 33, 992	94 ± 28, 1496	99 ± 28, 1590
Mean % norm (Mean/SD)						
· Lower limit	0.65 ± 0.24	1.03 ± 0.33	1.05 ± 0.40	0.76 ± 0.39	1.15 ± 0.32	1.23 ± 0.32
· Upper limit	0.48 ± 0.17	0.75 ± 0.24	0.77 ± 0.28	0.55 ± 0.29	0.84 ± 0.24	0.89 ± 0.24
NRS perceived health (0-10)	n=19	n=17	n=13	n=22	n=19	n=17
Median/IQR	5 (3)	7 (2)	8 (2)	6 (2)	7 (2)	8 (1)
HRQoL (SF-36) (Mean/SD)	n=16	n=15	n=15	n=22	n =19	n =15
· PCS	34.1 ± 7.3	44.6 ± 11.1	43.9 ± 10.3	31.3 ± 9.5	40.7 ± 9.4	46.0 ± 7.3
· MCS	42 ± 14.7	47.2 ± 10.2	51.0 ± 8.8	45.4 ± 11.7	52.9 ± 9.7	54.1 ± 7.0
Return to work						
· Total prior employed	n=7			n=10		
· Returned to work (n, %)		5 (71.4)	6 (85.7)		5 (50.0)	4 (40.0)
GPS	n=16	n=15	n=15	n=22	n=20	n=15
· GPS Sum score (mean/SD)	5 ± 4	4 ± 3	3 ± 3	5 ± 4	3 ± 4	2 ± 2
· Risk of PTSD (n, %)	4 (25.0)	1 (6.7)	1 (6.7)	4 (18.2)	3 (15.0)	1 (6.7)

TMST: Two-minute Step Test, Σ: sum SD: Standard Deviation, NRS: Numeric Rating Scale, IQR: Interquartile range, HRQoL: Health-related Quality of Life, SF-36: Short Form 36 (Rand 36), PCS: Physical Component Score, MCS: Mental Component Score, SNAQ65+: Short Nutritional Assessment Questionnaire 65+, GPS: Global Psychotrauma Screen, PTSD: Post Traumatic Stress Disorder

Prevalence of undernutrition and psychotrauma
Results on the SNAQ65+ screening tool showed that 84.2% ($n = 16$) of the intervention group and 83.3% ($n = 20$) of the usual care group fell in the 'undernutrition' category (score 'red') at time of hospital discharge (Table 1). GPS results showed the presence of PTSD symptoms to be highest directly after hospital discharge (REACH: 25%, usual care: 18.2%) and decreasing with each following timepoint. GPS sum scores were the same for both groups at baseline and decreased over time (Table 2).

DISCUSSION

This study confirms the feasibility of the REACH program, an early individualized home-based rehabilitation intervention designed for patients with symptoms of Post-Intensive Care Syndrome (PICS). Our results show that collaboration within an interprofessional network consisting of hospital-based and primary care professionals, is a feasible method to provide rehabilitation interventions across the care continuum for survivors of critical illness. Early, home-based interventions were provided by expert professionals who were able to recognize patients' needs across health domains. Commonly, hospital-based follow-up clinics are set up to identify aftercare needs for patients with PICS, but the timing of the first appointment is often delayed due to functional impairments patients might experience immediately after discharge.[27] As recommendations for rehabilitation interventions in the primary care setting are lacking,[14] we believe our study might serve as an example for the implementation of healthcare interventions for patients with PICS-related symptoms across the care continuum, adding to the experience of a seamless transition from hospital to home.

Participants in the REACH group showed high motivation and adherence to treatment and reported higher satisfaction with PT treatment, when compared to the usual care group. This is contrary to findings of previous studies, which identified the heterogeneity of the population needing rehabilitation interventions after critical illness as a barrier for intervention adherence.[22,23,25,27,49] The extensive and long-term impairments of patients with PICS, potentially amplifying each other across health domains[50] could be explanatory for the fact that previous trials did not find significant differences in outcomes when compared to a control group. As trials need strict protocols and a 'one size fits all' design does not meet the needs of patients with PICS, different study designs and different types of interventions need to be

explored. For this reason, the REACH intervention was characterized by a flexible, patient-centered, and tailored approach, founded in the principle of delivering the right care, at the right place, at the right time and by the right professional[51]. Providing the early interventions in the patients' homes could be another explanation for the low drop-out rate and high adherence to treatment in the REACH group, contrary to findings in studies with a larger, but similar population. Denehy et al.[23] investigated the effectiveness of an outpatient rehabilitation program for survivors of critical illness who were discharged home. Program completion rate was relatively low (41%), which was explained by sample heterogeneity, age, and comorbid disease.[23] Similarly, in a study by Berney et al., [22] the post-ICU intervention was provided in the outpatient department of the hospital. Poor attendance and low adherence were explained by travel distance, poor social support and limited available time.[22] Our study shows that an individualized, home-based rehabilitation intervention increases patient adherence and satisfaction. Early home-based interventions are also likely to contribute to patient motivation and generally improve the transition from hospital to home.[20,27,50]

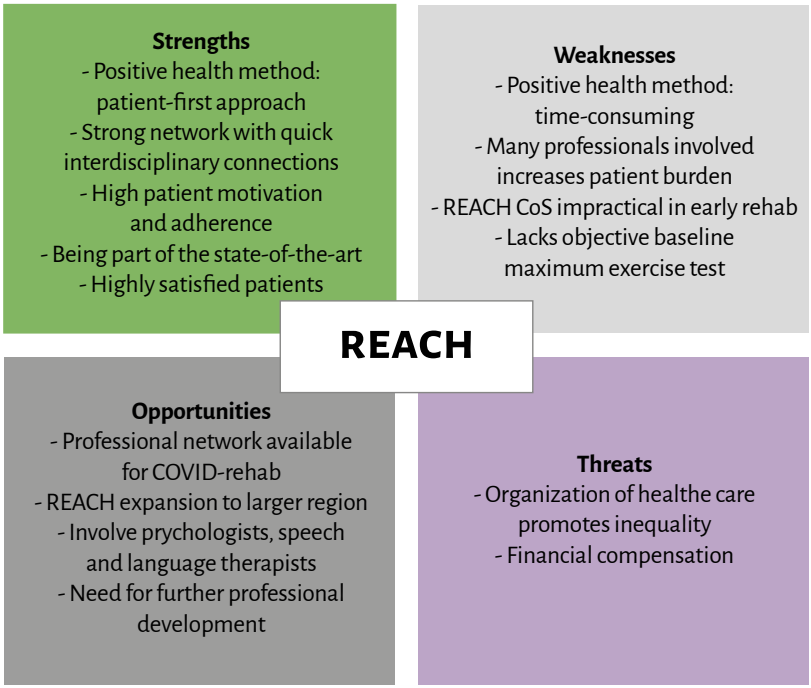
A discussion point, however, is the identification of patients with (symptoms of) PICS at time of ICU- or hospital discharge. In this study we defined PICS as 'new or worsening symptoms in the physical, psychological or cognitive health domain, unrelated to the initial admission diagnosis or underlying conditions, at time of ICU- or hospital discharge'. A definition founded in the umbrella term postulated by the Society of Critical Care Medicine in 20122 and applied in recent publications in absence of alternative diagnostic tools.[33,52,53] As no diagnostic tools for PICS exist at this moment,[54] the population in our study cannot be formally identified as having PICS, although our secondary outcome data show that participants experienced impairments in physical, psychological, and/or cognitive domains. Clinical tools are needed to identify the presence of PICS and the extent of PICS-related disability, and although recently the development and validation of some tools have been investigated, further studies are urgently needed for better definition and understanding of PICS.[54-58] Working with the limitation of a not clearly defined population, we designed a patient-centered intervention embedded within an interdisciplinary collaborative network addressing the complex cluster of problems in patients with PICS conform recent recommendations.[12,33,54]

Professionals within the REACH network showed great enthusiasm towards the opportunities for professional development, even on topics which were outside the scope of their discipline. Given a high prevalence of

undernutrition at hospital discharge (> 80% in this study's population), PT interventions needed to be tuned with nutritional interventions. Our finding is in line with current literature, stating extreme loss of muscle mass in critically ill patients while reversal of the inflammatory, catabolic state takes time and effort.[19,59,60] Within the REACH interdisciplinary network, collaboration between PTs and DTs became a new standard of practice. Similar results were seen regarding the collaboration between PTs and OTs, but the amount of OT sessions received was limited, in both the REACH and usual care group. An explanation for this could be the early start of PT interventions, which in most cases combined with DT consults contributed to an already full rehabilitation schedule for patients. Balancing care provision while preventing to 'overload' patients who are generally characterized by low physical and mental capacity, was a continuing challenge for professionals. Especially if, as recommended by REACH professionals, the interdisciplinary network is expanded with representatives from other disciplines such as psychologists and SLTs, the timing and intensity of the different consultations need to be reviewed considering individual rehabilitation goals.

Additionally, recommendations were made for formalization of collaborative networks including representatives from medical insurance companies and general practitioners. Current organization of primary care PT in the Netherlands and the fact that no ICD-10 diagnostic code exists for PICS or PICS-related symptoms, were identified as barriers for the provision of state-of-the-art rehabilitation interventions as developed within this study (Figure 3). Additionally, prior to the COVID-19 pandemic, PICS was largely unknown to or unrecognized by physicians responsible for referral of patients to rehabilitation professionals in the primary care setting.[3,61,62] An unfortunate result of this situation was that the REACH program could not be made available to everyone in need of rehabilitation after critical illness and hospital discharge. As our study shows, a larger number of visits to expensive medical specialist care (secondary or tertiary line of care) was reported within the usual care group when compared to REACH, while a smaller number of participants reported a higher total of PT sessions in the usual care group, which could be indicative of inefficiently organized healthcare. Current national initiatives towards guideline development and recommendations for recognition of PICS with an ICD-10 code will hopefully pave the way for efficient and equitable health care.[54,63,64]

Figure 3: Strengths, weaknesses, opportunities, and threats (SWOT) of the REACH program



REACH: REhabilitation After Critical illness and Hospital discharge, COS: Core Outcome Set

Collaborating within an interdisciplinary network to develop and provide a novel intervention for a population whose problems were largely unrecognized and inappropriately treated, facilitated REACH-professionals to become exemplars to colleagues within and outside of their own disciplines especially during the COVID-19 pandemic and the concurrent influx of patients with PICS-related symptoms.

Future studies should focus on further development of screening and assessment tools and intervention components for each of the disciplines involved in rehabilitation of patients with PICS. This should be done in co-creation, to ensure that all aspects of PICS can be addressed, and further professional development is encouraged.

Strengths and limitations

Several limitations can be identified in our study.

First, there are some limitations to the recruitment and identification of the population in our study. Referral rate for the study is likely not representative of the true recruitment potential, as we had expected a larger study sample, based on available ICU- and hospital discharge data in the Netherlands. Therefore, it is likely that our study sample does not adequately represent the population in the ICUs of the 7 participating hospitals. Possible explanatory factors are of logistic nature, as eligible patients had to be identified within the ICU, while oral consent could only be obtained in the hospital wards. As one of our previous studies shows, the ward-stay is often experienced as turbulent by the patient and family members, where the psychological effects of the ICU-stay start to sink in while hospital discharge is often organized swiftly.[20] We hypothesize that under these circumstances, recruitment for participation in research studies was difficult. Many patients declined to participate in research. Others did not see a need to continue PT at home, because they thought that they could recover without professional help or patients did not have health insurance covering PT interventions. Another explanation lies in the COVID-19 pandemic and its effect on workload and healthcare organization within the participating hospitals. In the academic hospitals, many scientific studies were initiated related to (recovery from) COVID-19. This likely decreased recruitment potential for our study.

Secondly, convenience sampling, fitting the feasibility design of this study, was applied. As a result of this, baseline differences were observed between groups, with regards to hospital length of stay (significantly shorter in intervention group) and age (a younger usual care group). This sampling method also likely contributed to bias in the reported results on satisfaction with and adherence to PT treatment, and therefore should be interpreted with caution. Additionally, we did not have access to data on pre-ICU functioning nor on severity of disease (APACHE II scores), and therefore important contextual information around our study population is lacking.

Thirdly, though the REACH program caters for 2 out of 3 pillars of the evidence-based practice paradigm (patient values and professional expertise), the scientific foundation is still lacking. The intervention provided did not follow a standardized protocol which might limit possibilities to draw inferences or be instructive towards the design of clinical trials. However, the heterogeneity of the population with PICS supports the need for exploration of different research designs to systematically evaluate patient-centered and

individualized rehabilitation interventions. Also, our intervention was primarily focused on physical rehabilitation and while professionals were trained to observe impairments in the mental and cognitive health domains and referral structures were put in place, we did not succeed in addressing all components of PICS.

Lastly, self-reported questionnaires were used to obtain data on health care usage and return to work. These questionnaires, although used in earlier research, have not been validated and results should therefore be interpreted with caution. Data obtained do not allow us to perform a health economic evaluation comparing costs and outcomes of REACH with usual care, which would be essential to explore in future studies.

Strengths of this study lie in that we provided continuity of care for survivors of critical illness through the establishment of an interdisciplinary collaborative network. The REACH network shows potential for regional and national expansion and its right of existence was proven throughout the COVID-19 pandemic. The high satisfaction rates among the intervention participants indicate that individualized interventions with a patient-centered, holistic approach may be successful in the treatment of the heterogeneous population with PICS. Additionally, professionals in the network expressed feelings of achievement in their daily practice towards treatment of patients with PICS, resulting directly from interdisciplinary team discussions and continuous professional development sessions.

We obtained 6-month follow up data on 79.1% of our participants, despite the restrictive situation imposed to research studies during the COVID-19 pandemic, which provides us with moderate confidence towards our results.

CONCLUSIONS

This study shows that it is safe and feasible to provide an early, home-based, rehabilitation intervention within the organization of an interdisciplinary professional network, for patients with symptoms related to PICS. High adherence to treatment and high satisfaction rates indicate that this treatment approach shows promise in addressing the complex needs of patients recovering from critical illness. Results show a potential impact on physical recovery and efficiency of health care organization, which can be used as a steppingstone towards further development of different components of interdisciplinary rehabilitation programs for patients with PICS, and as support for organization within interdisciplinary collaborative networks. Such networks

can empower professionals to become professional experts and improve the quality of care provided to patients with PICS throughout continuum. Future studies should be directed towards further development and effectiveness testing of different components of interdisciplinary rehabilitation programs, as well as health economic evaluations of care organized within such professional networks.

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Competing interests
The authors declare that they have no competing interests.

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SUPPLEMENTARY FILE: OT SCREENING AND REFERRAL PROTOCOL

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1. Do you experience difficulty with resuming work activities?

☐ No

☐ Yes --> refer to OT

2. Do you experience difficulty with limited energy or fatigue? Or do you feel that fatigue has a negative effect on your daily life?

☐ No

☐ Yes --> refer to OT

3. Do you experience difficulty with performing your daily activities?

☐ No

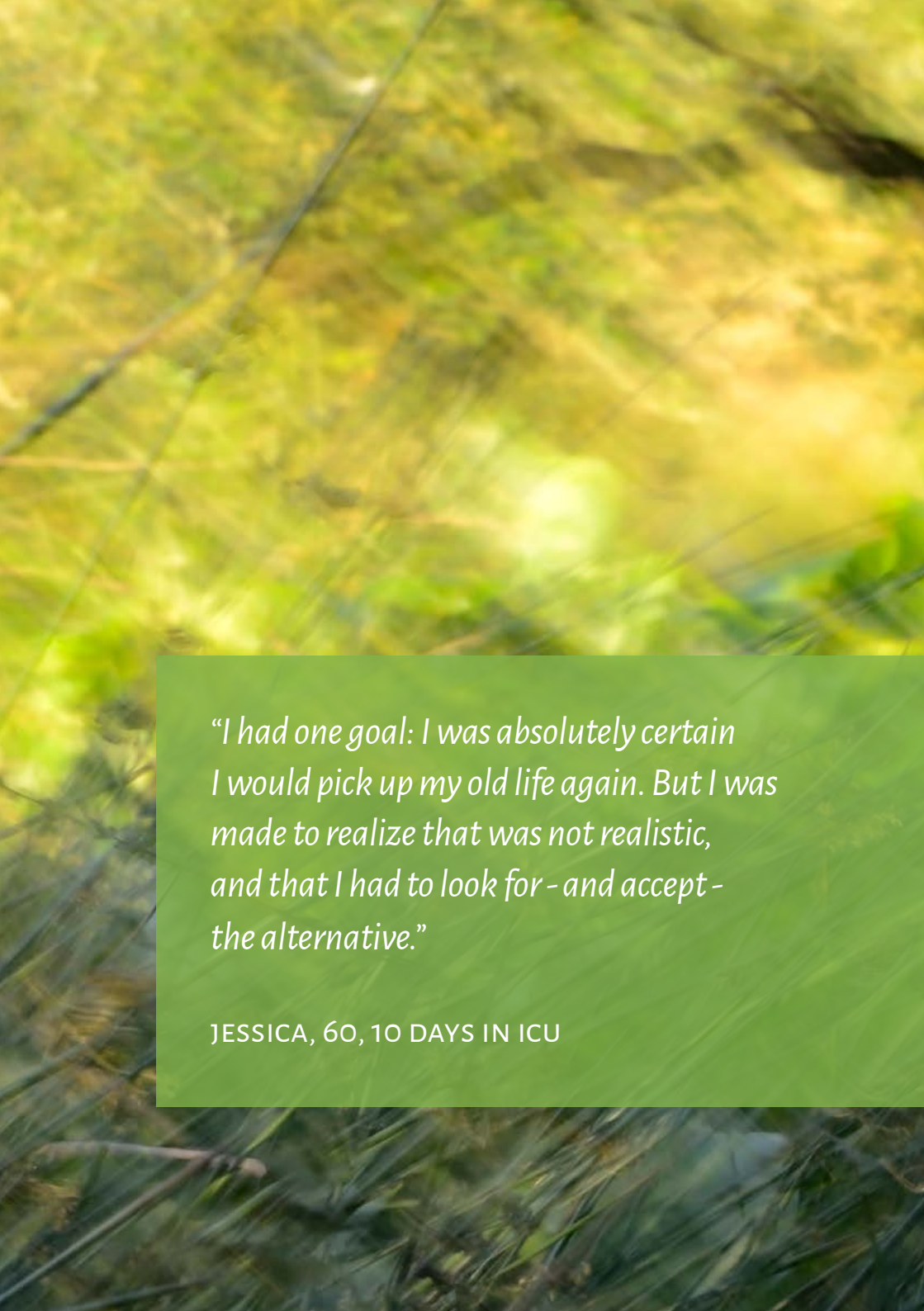
☐ Yes--> refer to OT

4. Do you experience difficulty with your memory and/or concentration?

☐ No

☐ Yes--> refer to OT

In case the answer to any of these questions is 'Yes' discuss referral to OT with the participant. If the participant agrees to referral, contact the nearest REACH-OT.



"I had one goal: I was absolutely certain I would pick up my old life again. But I was made to realize that was not realistic, and that I had to look for - and accept - the alternative."

JESSICA, 60, 10 DAYS IN ICU

CHAPTER 8
General discussion

GENERAL DISCUSSION

Patients who are admitted to the intensive care unit (ICU) with a critical illness, frequently require complex medical interventions, which often end up being lifesaving. Survival of critical illness, however, presents new challenges for patients and their relatives: challenges in the physical, mental, and/or cognitive health domain, referred to as the Post-Intensive Care Syndrome (PICS).[1] While PICS-related symptoms vary between individuals in type, severity and timing, most survivors require rehabilitation interventions starting within the ICU and continuing after ICU and hospital discharge. Understanding patients' rehabilitation needs during discharge planning is essential for the provision of aftercare.

As impairments in activities of daily living, resulting from rapid deterioration in physical functioning, are often the primary complaint patients present with, physical therapy (PT) is generally indicated in the acute phase (in the ICU), and after ICU- and hospital discharge. During the different phases of recovery, PTs remain involved in the physical rehabilitation of patients, often collaborating with other disciplines such as occupational therapists (OTs) and dietitians (DTs). However, the complexity of recovery after critical illness and the distinct characteristics of PICS are insufficiently recognized by rehabilitation professionals, leading to patients receiving suboptimal care after hospital discharge.[2-5] In fact, the essential elements of optimal rehabilitation interventions for patients who are discharged home after critical illness and the way PTs can best support patients along the rehabilitation pathway are still unknown.[6]

Several players are active along the rehabilitation pathway after critical illness: the patients, their relatives, and the rehabilitation professionals. The patient concerns the individual before the critical illness, the person whose life changed dramatically due to an acute critical illness and the person on the road to recovery from that illness. To fully understand their needs, patients should be considered in the context of their environment; their support networks such as family members and friends but also their roles and responsibilities in life. New definitions of health have been proposed to approach the patient within his meaningful context, such as the definition of health by Huber and colleagues: "Health as the ability to adapt and self-manage, in the face of social, physical and emotional challenges".[7] Being able to adapt to challenges and regaining self-management skills ultimately leads to feelings of empowerment. To help patients to achieve empowerment during and after critical illness a true understanding of survivorship is needed.

The general aim of this thesis was to describe, within the context of professional practice, scientific research, and education what characterizes critical illness survivorship and optimal physical therapy interventions during the different stages of the rehabilitation pathway.

MAIN FINDINGS

Understanding survivorship

While research on long-term physical and psychological impairments in patients with PICS has increasingly become available1,8,9, a structured rehabilitation care pathway for patients and relatives does not yet exist in the Netherlands. As previous studies confirmed that suboptimal aftercare was received by patients,[6,10,11] we performed two studies to better understand critical illness survivorship.

In a qualitative study (**chapter 3**), we investigated patient and relative experience of the transition from hospital to home and found that hospital discharge is often perceived as abrupt and inadequate. Transitioning from a situation of continuous monitoring (the ICU) to one where patients are expected to be more independent (the hospital ward) is experienced as a huge step for patients and relatives. On top of this experience, patients describe that the realization of what has happened to them and how this has changed them, only *starts* to sink in after transfer to the hospital ward. It becomes a time where patients and relatives experience great uncertainty while hospital staff prepares for a swift and efficient hospital discharge. A thorough needs assessment[12] is often lacking, potentially resulting in a mismatch between patient needs and care provided. We recommend that discharge strategies are customized for patients and relatives after an ICU admission. A comprehensive needs assessment should be provided at a moment most suitable to the patient, within a context in which he or she feels empowered and conducted by a professional who has expertise with and knowledge of PICS(F).

Chapter 4 describes a longitudinal study on the (recovery of) respiratory muscle strength after hospital discharge. Several studies have highlighted the relationship between mechanical ventilation and respiratory muscle weakness (RMW) in critically ill patients.[13-15] Mechanical ventilation is a common medical intervention provided to critically ill patients, and short-term negative consequences of this intervention on respiratory muscle strength have been identified.[14] RMW is associated with higher mortality rates and failure to wean of the ventilator but until now it has been unclear if, and to what extent, RMW

persists after ICU- and hospital discharge16. In this study (**chapter 4**) we found both inspiratory and expiratory muscle strength to be below predicted values at time of hospital discharge and, although significant improvements were seen at 3- and at 6 months follow-up, not all patients reached predicted values at the 6-month timepoint. We also found that RMW was associated with both exercise capacity and handgrip strength and that older patients, and patients with a longer hospital length of stay were less likely to reach predicted values of respiratory muscle strength. This potentially identifies a subgroup of extra frail patients, in an already vulnerable population.[17] Our findings showed that assessment of respiratory muscle strength is relevant for patients who received mechanical ventilation, even after ICU- and hospital discharge. This would facilitate early identification of patients who might benefit from the inclusion of respiratory muscle training in their rehabilitation program.

Professional empowerment

As Flaws et al.[18] recommend, clinicians assessing the needs of survivors of critical illness, should be competent to determine "what works, for whom, in which circumstances, to deliver their desired outcomes". [18] To be able to provide safe interventions for critically ill patients, PTs and students on clinical rotations need specific competencies[19-24] and higher-level clinical reasoning skills. To prepare PT students for the ICU environment, we investigated if an e-learning module with up-to-date evidence-based content, videos and practical assignments could sufficiently prepare students for clinical tasks in ICU (**chapter 2**). Through a mixed method proof of concept study, data were collected among undergraduate students and ICU PTs with extensive clinical expertise. The e-learning module was perceived positively with regards to accessibility and flexibility of the learning tool, as well as variety of the content and didactic methods. Learning objectives related to understanding of the theoretical concepts and simple application of clinical reasoning skills were achieved. However, students felt insufficiently prepared for dealing with unexpected situations in the ICU – such as wires and lines becoming detached or acting in situations where higher level clinical reasoning skills were required. Blended learning methods, where the theory-based e-learning module is closely integrated with the clinical rotation, are recommended when teaching undergraduate students about PT in the critical care environment.

While evidence has been provided that early rehabilitation interventions within the ICU are safe,[25,26] effective, and improve functional status at hospital

discharge, no distinct recommendations existed on the different elements of optimal PT interventions for survivors who are discharged home.[3,27] Therefore, we investigated, in two separate Delphi studies, if consensus-based recommendations on PT after critical illness could be achieved. In the first Delphi study (**chapter 5**), conducted among an international panel of experts, we explored if consensus could be reached on PT goals, a core set of outcomes for clinical practice and optimal PT interventions for survivors of critical illness. After a 3-round Delphi process with a high response rate across each round, the panel reached consensus on 88.5% of the statements. This study yielded a consensus-based clinical framework for primary care PTs providing interventions to patients with PICS. The framework included recommendations on essential handover information and proposed a core set of outcomes (COS) to be assessed in patients after hospital discharge. This COS contained tests for exercise capacity, muscle strength, ADL function and mobility, quality of life, and pain. PT interventions should be targeted towards regaining physical functioning and include education on PICS and recovery. Consensus-based recommendations highlighted the need for PTs to closely collaborate with professionals from different rehabilitation disciplines, such as occupational therapists, dietitians, and psychologists.

The second Delphi study, conducted among professional experts and patients familiar with the Dutch healthcare system, is described in **Chapter 6**. With this study we aimed to develop consensus-based practice recommendations for PTs involved in the rehabilitation of patients with PICS, specific to the Dutch context. In the Netherlands, rehabilitation interventions for patients with PICS will in most cases be provided by PTs, OTs and DTs working within the primary care setting.[28,29] After hospital discharge, generalized medical care is often coordinated by the general practitioner. Consensus recommendations from this Delphi study included an early risk assessment among patient and relatives for PICS(-F) and a comprehensive handover between hospital PT and primary care PT. Panel recommendations included a PT program consisting of skeletal and respiratory muscle training, aerobic exercises, and pain education supplemented with nutritional and/or psychological interventions as needed.

Chapter 7 reports on the results of a mixed-method, non-randomized pilot study investigating the feasibility of an interdisciplinary, home-based rehabilitation intervention for survivors of critical illness. Results of the studies described in **chapter 5 and 6** formed the basis for the design of our intervention. In a community of practice (CoP) a toolkit for primary care PTs was developed,

consisting of guidelines for the hospital-to-home handover and recommended assessment tools and interventions, enveloped in a patient-centered approach: "positive health".[7] While previous studies had investigated post-ICU exercise programs provided within hospital outpatient departments,[30-32] and limitations have been described from the more common aftercare provided by ICU follow-up clinics,[3,11,33] our study specifically aimed to investigate early, home-based interventions. With regards to patient adherence to protocol and patient and professional satisfaction, our study showed positive results. While the patient-centered approach (positive health) which was applied in our study facilitated *patient* empowerment and self-management, a positive side effect was observed regarding *professional* empowerment. The fact that the PT program was a novel intervention for patients with complex needs, was developed in co-creation with patients and professionals and facilitated interdisciplinary collaboration, contributed to professional development and the feeling of "being part of the state-of-the-art". One of the unanticipated consequences of this positively experienced professional community, was the acknowledgement that continued collaboration seemed essential. This led to formalization of a professional primary care rehabilitation network for patients with PICS (*the REACH network*).

Our study showed that an early, individualized, primary care PT intervention can support patients along the rehabilitation pathway and could serve as a blueprint for provision of continued care for survivors of critical illness, in the different stages of the rehabilitation pathway: from ICU to the ward, from hospital to home towards increasing self-management and ultimately independence. To paraphrase Whittle et al: "Critical illness has become part of a health continuum".[34]

METHODOLOGICAL CONSIDERATIONS

Population

With between approximately 80.000 annual ICU admissions in the Netherlands, of which 86.9% survived and were discharged from hospital in 2018[35] (pre-covid data), the population size of some of the studies described in this thesis, do not seem to match the recruitment potential. This applies mostly to the study population of our prospective cohort study and feasibility study (**chapter 4 and chapter 7**), where we had expected to retrieve data on a greater study sample, as we had secured referrals from 7 participating hospitals in the greater Amsterdam area. Possible explanatory factors are of logistic nature, as

identification of eligible patients had to occur in the ICU departments, while recruitment and obtaining first consent to participation often happened in the wards. As planning of hospital discharge often occurs suddenly – as confirmed in the study described in chapter 2 – this likely explained difficulties in recruitment. During the inclusion phase of both studies with a 6 month follow up, the COVID-19 pandemic and concurrent national lockdown occurred, which greatly impacted all research activities. While the ICU departments nationwide filled up with critically ill COVID patients, little was known about the required follow-up care. Patients and relatives were often too overwhelmed to agree to study participation, and medical specialists in charge often recommended in-patient rehabilitation, which made these patients ineligible for our feasibility study.

Recruitment of participants to our qualitative study on patient and relative experience of hospital discharge after critical illness was conducted via websites for survivors of sepsis and patients and families dealing with PICS(F), as well as via word of mouth. As it is more likely that patients and relatives with negative experiences will respond to a call to participate, recruitment bias will have occurred, and this could have led to an overrepresentation of negative experiences. As time since hospital discharge varied greatly among participants to this study, recall bias could be present, although studies have shown the longer the time between the ICU-stay and the moment of recall, the greater the chance of a *positive* recall, as unpleasant emotions become less powerful.[36] Overall, the patient and relative populations in our two cohort studies, as well as in our qualitative study was representative for the population of critical illness survivors experiencing long-term impairments, as characteristics were similar to other important publications.[8,37-40]

Design

Qualitative methods applied in the studies described in **chapter 2, 3 and 7** followed a structured and predetermined protocol regarding data collection, analysis, and interpretation of the findings.[41] However, with establishing the topic list for data collection during focus groups or interviews, an initial focus is chosen excluding the exploration of other topics. Even though interview guides were updated as new topics and themes emerged during data collection, it is typical for qualitative designs that results presented cannot be generalized to other contexts or populations and should be interpreted within the context of this study design and population.

As is characteristic for prospective cohort studies as described in **chapter 4**, we had to perform analysis and draw inferences on incomplete datasets. While we chose statistical methods designed to deal with missing data,[42] we acknowledge the incompleteness of our dataset as a limitation to our study. Additionally, while we describe the longitudinal course of physical outcomes in patients who have been mechanically ventilated, we were unable to obtain outcome data during or directly after the ICU stay or relevant information on their pre-critical illness functional status. However, within the body of evidence on physical recovery after ICU, our study is the first to report on respiratory muscle weakness in survivors of critical illness in a longitudinal design.

Delphi consensus methodology is commonly used when limited high quality evidence is available on core outcomes and interventions for a certain population. It generates a consensus statement based on expert opinion (level 5[43]) and often provides a recommendation framework to be applied in future studies or gives direction to clinical practice. While our Delphi studies (**chapter 5 and 6**) were executed with rigor and followed methodology available at the time, new guidelines have been published since.[44] These guidelines recommend the use of a 9-point Likert scale and the use of large, heterogeneous Delphi panels – two measures which were not taken by us and therefore identified as limitations to our studies. Our Delphi panels were smaller in size, but heterogeneous in that they included representation from the field of intensive care medicine, nursing, psychology, physical therapy, occupational therapy as well as the survivor's perspective.

Outcomes

Across the studies included in this thesis, several methodological considerations can be identified with regards to the chosen outcomes. Firstly, from none of the study populations which included patients after critical illness, did we obtain information on their pre-ICU health status or severity of disease (APACHE II score). There were several reasons for this. First, participants to our study had been admitted to ICUs in several hospitals in the Netherlands, making it logistically difficult to retrieve information. Second, privacy regulations as well as clinical research directives limit the possibilities to obtain (historical) medical data and the relevance and importance of obtaining such data must be directly related to the study aim.

As this thesis focuses on physical rehabilitation, most of the outcomes reported are related to physical function. We observe that it is limitation to our studies, that we did not obtain outcome data on the experience of delirium

and psychological and cognitive recovery, relevant outcomes for patients (and relatives) with PICS(F). [45-47]

Our longitudinal study on recovery of respiratory muscle strength (**chapter 4**) investigated associations with exercise capacity, for which we used a functional capacity test (two-minute step test, TMST[48]). While this choice allowed us to obtain data on functional exercise capacity in the very early rehabilitation phase, we acknowledge that cardio-pulmonary exercise testing (CPET) is the golden standard for obtaining comprehensive and clinically relevant information on individual exercise capacity. However, in the early recovery phase of severely deconditioned patients with functional impairments, the TMST is a valid and reliable test which can be safely conducted in the home situation.[48,49] In our study, the test showed both responsiveness and feasibility for usage in the population recovery from critical illness at home.

RECOMMENDATIONS AND CLINICAL IMPLICATIONS

This thesis aimed to contribute to optimization of the rehabilitation pathway after critical illness. Through careful screening of patients' and relatives' needs at different moments in the rehabilitation trajectory, both **before** and **after** the hospital discharge, we can smoothen the transition from hospital to home and facilitate a 'soft landing'. Besides learning to understand the impact of the experience of critical illness on patient and family, comprehensive needs assessment should be facilitated during different phases of recovery. This needs assessment should incorporate all health domains as described within the Post-Intensive Care Syndrome: physical, mental, and cognitive.[18,50] Additionally, it should allow for an inventory of problems family members experience as part of PICS-F, i.e., psychological problems and complicated grief. Lastly, to facilitate for individualized and patient-centered rehabilitation programs, patient and relatives' needs should be assessed holistically, according to broader concepts of health, such as the positive health concept.[7]

A structured rehabilitation pathway for patients with PICS, as these exist for patients with complex health care needs resulting from other conditions – such as cardiorespiratory diseases – must include recommendations related to hospital to home transfer, optimal (rehabilitation) interventions and preferred patient-reported outcome measures. Besides this, the role of valued professionals such as social workers and psychologists, speech and language therapists and general practitioners must be further explored.

To reduce the physical and psychological burden on the patient, it is imperative that rehabilitation programs remain well balanced and are adapted regularly dependent on the patients' capacity and changing needs. For this, interdisciplinary communication and collaboration is essential. This thesis yielded positive results regarding professional collaboration when this was organized in an interdisciplinary network. If professionals of different disciplines know each other and have awareness of each professional's specific expertise they are much more inclined to collaborate and refer patients to such a colleague.

While this thesis yielded recommendations for PT treatment modalities, a core set of measurement tools and a home-based early rehabilitation program, questions remain regarding the optimal frequency and the (training) intensity of PT interventions for patients with PICS. It is essential that a training guide with detailed specifications regarding modality type, intensity, frequency, and timing is developed and pilot-tested, ultimately facilitating systematic investigation of protocolized exercise programs. Also, the clinical value of the addition of respiratory muscle training to rehabilitation programs of patients with PICS, should be further investigated. Lastly, a carefully balanced rehabilitation program should be developed, containing physical exercise programs, nutritional, and psychological interventions which complement each other and can be made available to patients and relatives with PICS(F) as needed.

A prerequisite to this, however, is for professionals to have knowledge and understanding of the complexity of PICS and to recognize how the critical illness impacts on the patient's environment (PICS-F). This starts with knowledge of the impact of an ICU-stay and understanding of clinical practice guidelines for safe and feasible PT interventions within the ICU. When preparing undergraduate students for clinical rotations in ICU, blended learning methods should be offered according to the Just in Time principle. Additionally, rehabilitation professionals who interact with and provide treatment for patients with PICS, require specific competencies. To apply patient-centered care through a method such as the positive health method, additional training is needed. Physical therapists are well trained to conduct comprehensive assessments to determine patients' physical needs but should be aware that in the severely deconditioned and possibly sarcopenic patients, exercise interventions must coincide with appropriate nutritional interventions. Also, they should be quick to observe the presence of psychological and cognitive impairments and act appropriately.

The impact of critical illness on patient and relatives has become more and more clear over the past decades. This thesis explored individualized and patient-centered rehabilitation interventions and yielded very positive results: patients and professionals expressed great satisfaction with the rehabilitation program organized within the REACH network. However, to permanently embed this type of care within the primary care setting in the Netherlands, changes into financial reimbursement of PT interventions for patients with complex health needs should be explored. Recently, recommendations have been made regarding the formal recognition of PICS within the International Classification of Diseases (ICD-10)[51] which, if achieved, will lead to broader recognition of PICS and possibilities for structural funding of intervention strategies.

While this thesis aimed to contribute to the *content* of the rehabilitation pathway, the *structural integrity* of this pathway depends on organization and funding of healthcare, policies, and health priorities. For this reason, health economic evaluations of organization of rehabilitation for patients with PICS within interdisciplinary primary care networks (such as described in **chapter 7**) should be executed.

RECOMMENDATIONS FOR FUTURE RESEARCH

If we follow the patient journey, several gaps in research can still be identified.

Healthcare innovation projects should investigate how best to guide patients and families during the transitional phases of the critical care continuum. Development of a (clinical) tool for comprehensive needs assessment can facilitate early identification of impairments and risk stratification.

There is still a gap in research related to interventions for family members of survivors of critical illness. As relatives often struggle with psychological problems as part of PICS-F, it is imperative that clinical studies are conducted investigating feasibility and effectiveness of interventions directed to treatment of PICS-F.

For patients recovering at home, there is a need for further exploration of possibilities for interdisciplinary interventions. Programs comprising different rehabilitation modules which are complementary to each other and well balanced, need to be developed and tested to fit with patients' needs as needs change across the continuum. Studies around this topic can run concurrently with cost-effectiveness studies and health economic evaluations of organization of care in primary care rehabilitation networks.

Physical therapy interventions for patients with PICS need further development and testing. While there is consensus on applicable treatment

modalities, little is known on the optimal frequency and intensity of exercise programs. Additionally, while few studies show that (early) CPET is feasible in this population[34, 52-54] there is a need for further investigation of the usefulness of CPET in post-ICU exercise programs.

Next, (pilot) clinical trials should investigate the effectiveness of inspiratory (and possibly expiratory) muscle training as part of a physical rehabilitation program for survivors of critical illness. As contradictory recommendations exist regarding the clinical definition of respiratory muscle weakness, inadequate assessment of impairments in clinical practice is likely. Further research is necessary to develop clinical practice guidelines for respiratory muscle training in severely deconditioned patients.

Lastly, randomized controlled trials (RCTs) are still the golden standard for experimental studies comparing the effects of new (components to) interventions to a control group. In design, RCTs are restrictive as a standardized protocol needs to be in place, which makes the study results often limited in clinical value and applicability. Complex intervention research provides guidelines for alternative research designs aimed to develop, evaluate, and implement meaningful interventions for patients with complex health needs.[55]

CONCLUSIONS

This thesis aimed to shed light on, and provide recommendations for, an optimal rehabilitation pathway for patients who survive critical illness and are discharged home.

A comprehensive needs assessment conducted when patients transition from ICU to hospital ward and from hospital to home, will help understand the needs of patients and relatives and smoothen the transition experience. PT programs targeting physical impairments can start directly after home discharge and should be connected closely to nutritional and occupational therapy interventions. Professionals should have knowledge of PICS and expertise in treatment of patients who may present with impairments in several health domains. To apply patient-centered care and provide individualized, tailored treatment programs, rehabilitation professionals must understand the strengths and limitations of their professional discipline and seek collaboration. When striving for true patient empowerment and a patient-centered approach, professional empowerment and continuous professional development can manifest itself.

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APPENDIX: SUMMARY

BEYOND SURVIVAL: OPTIMIZING THE REHABILITATION PATHWAY AFTER CRITICAL ILLNESS

Due to technological and medical advancements, an increasing number of patients survive critical illness and admission to the Intensive Care Unit (ICU). In the last 20 years, the evidence base on long-term patient outcomes has grown substantially. After the acceptance of the Society of Critical Care Medicine's definition of post-intensive care syndrome (PICS) in 2012, the extent of the burden of impairments has become increasingly clear. PICS comprises "new or worsening problems in physical, cognitive or mental health status, arising after critical illness, and persisting beyond acute care hospitalization", and is prevalent in most patients who have survived critical illness as well as their relatives (PICS-F).

In recent years, critical care research foci have shifted from how to save lives and *increase chances of survival*, to how to *improve the quality of survival*. During recovery from critical illness, patients might require rehabilitation, which - according to the World Health Organization (WHO) – is defined as: "a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment".

The structure of this thesis follows the rehabilitation pathway of critically ill patients; starting in the ICU (**chapter 2**), transitioning from ICU to the hospital ward and homewards (**chapters 3 and 4**), and addressing the rehabilitation needs after hospital discharge (**chapters 5-7**).
The aim of this thesis was to describe, within the context of professional practice, scientific research, and undergraduate education, what lies *beyond* survival of critical illness and how physical therapists can best support patients during the different stages of recovery.

Chapter 1 provides background information, introduces the rationale to the studies presented and provides the overall aim of this thesis.

Chapter 2 concerns the professional competencies of physical therapists working in the ICU. A mixed-method proof of concept study among

undergraduate physical therapy (PT) students and ICU physical therapists is described. In this study we investigated the feasibility of the application of e-learning in preparation for a clinical rotation in the ICU. As the ICU setting is often experienced as a daunting environment by students and professionals who are new to this specific setting, an e-learning module was developed and tested among a population of students and experts in the field. The e-learning module contained a variety of educational tools, aimed to provide an extensive and realistic overview of physical therapists' tasks and responsibilities in critical care settings. Positive outcomes were obtained regarding the achievement of the course's learning objectives and the flexibility of the e-learning module. Students valued the fact that the course could be taken anywhere and anytime, considering the principle of *Just in Time* learning: taking the course at a moment close to, or during, the clinical rotation for optimal absorption of the course's content. Experts in the field of critical care PT valued the course because of its evidence-based content and design which allowed for easy updating as new clinical or scientific evidence emerges. While the e-learning module facilitated students' preparedness for clinical tasks in ICU, higher clinical reasoning skills and practical handling of critically ill patients connected to monitors, lines and wires could not be achieved through e-learning alone.

Chapter 3 describes a grounded theory study among survivors of critical illness and their relatives, investigating the experiences during the transition from ICU to hospital ward and from hospital ward to home. In this study, semi-structured interviews were conducted with 35 participants (22 patients and 13 relatives) discharged from 16 hospitals in the Netherlands. Using constant comparative methods, several key concepts were identified from our data, representing barriers and enablers for a positive perceived transition from hospital to home. Key concepts representing *barriers* were: "existing in a fragmented reality", "being overlooked", and "feeling disqualified". Enablers for a positive perceived transition were: "feeling empowered", "encountering empathic and expert professionals", "managing recovery expectations" and "family engagement". This study sheds light on the current pitfalls in hospital discharge practice, and advocates for comprehensive needs assessments among patients and relatives before or directly after hospital discharge, so that a smooth and seamless transition can be facilitated.

In **chapter 4** we report on a prospective cohort study investigating longitudinal changes in respiratory muscle strength and factors associated with recovery,

in patients who received mechanical ventilation in the ICU. Inspiratory (MIP) and expiratory (MEP) muscle strength were measured directly after hospital discharge, at 3 months, and at 6 months follow-up. As secondary outcomes we measured functional exercise capacity and handgrip strength at the same timepoints. A total of 59 participants were included in this study with a median mechanical ventilation duration of 10 days. Mixed model analysis showed that for all outcomes, except for MIP, population means reached predicted values at 6 months follow-up. The mean MIP was well below the predicted value at hospital discharge (68.1%), increased to 91.2% and 98.5% of predicted values at 3 and 6 months respectively. We found that older age was significantly associated with decreased MIP and functional exercise capacity. Significant longitudinal associations between MIP/MEP and functional exercise capacity and handgrip strength were observed in both crude and adjusted models, highlighting the need for further investigation of persistent respiratory muscle weakness in critical illness survivors and the potential usefulness of respiratory muscle training as part of post-ICU exercise programs.

Chapters 5 and 6 report on the outcomes of two Delphi studies. In the first Delphi study (**chapter 5**) a group of international experts (N = 10) formed the Delphi panel. In a 3-round Delphi process the panel generated ideas related to a core outcome set (COS) and physical therapy (PT) interventions for critical illness survivors who are discharged home (round 1), after which statements were formed and ranked (round 2 and 3) with the aim to achieve consensus. After 3 rounds, consensus was reached on 88.5% of the statements which were converted in a set of recommendations for primary care PT for patients with PICS. These recommendations emphasized the importance of a detailed handover between the hospital PT and the primary care PT, and usage of a COS related to exercise capacity, muscle strength, ADL function, mobility, quality of life, and pain. Additionally, it was recommended that PT interventions for patients with PICS are targeted towards regaining physical functioning and education on PICS and recovery after critical illness.

Chapter 6 reports on the outcome of a second Delphi study. In the Netherlands, rehabilitation interventions for patients who are discharged from hospital, are often organized within the primary care setting, and for this reason the Delphi panel in this study comprised professional experts and patients (N = 10) familiar with the Dutch healthcare system. The aim was to produce practice recommendations related to primary care rehabilitation interventions

for survivors of critical illness, focused on PT. After three rounds, the panel reached consensus on 95.5% of the statements, related to hospital discharge planning, PT outcomes, and intervention characteristics. This study yielded recommendations to support patients and professionals during the transition from hospital to home, through a comprehensive assessment of rehabilitation needs and compiling detailed handover information for professionals providing the primary care rehabilitation interventions. Recommended PT outcomes and interventions for patients with PICS revolved around (respiratory) muscle strength, pulmonary function, pain education and graded activity, ADL function, and aerobic capacity.

In **chapter 7** we report on a mixed method, non-randomized, prospective pilot feasibility study with a 6-month follow-up. The aim of this study was to investigate the feasibility of an interdisciplinary home-based intervention for patients with PICS. In this study, the intervention group (the REACH group) received a PT intervention initiated immediately after hospital discharge, targeting physical recovery and self-management, embedded within the positive health method. This intervention was complemented by nutritional or occupational therapy (OT) interventions, as needed. The comparison group in this pilot study included patients receiving usual care, which was defined as unrestricted clinical practice. Primary (feasibility) outcomes were safety, optimal dose of the REACH program, patient and professional satisfaction, protocol and treatment adherence, interdisciplinary referral need, and healthcare usage. Secondary outcomes were functional exercise capacity, self-perceived health status, health-related quality of life, return to work, prevalence of post-traumatic stress disorder (PTSD), and risk of undernutrition at time of hospital discharge. Forty-three participants were included in this study (19 in the REACH group, 24 in the usual care group), and 6-month follow-up data were obtained from 79.1% of the sample. Regarding primary outcomes feasibility of the intervention was confirmed through the fact that no adverse events occurred in this study and adherence to protocol and treatment was high in the intervention group. REACH participants showed higher satisfaction with their PT and reported more visits to primary care rehabilitation professionals, and less visits to medical specialists when compared to the usual care group. While one-third of the population in the REACH group received OT, only 4.8% ($n = 1$) of the participants in the usual care group reported having received OT. Qualitative analysis of focus group data among professionals identified the following strengths to the REACH intervention: being able to collaborate

and share knowledge and expertise within an interdisciplinary network and providing state-of-the-art interventions. Analysis of our secondary outcomes showed that prevalence of undernutrition at hospital discharge was very high in both groups (> 80%), while the prevalence of PTSD was highest at hospital discharge (both groups) and decreased over time.

Testing of functional exercise capacity was established in 72.1% of the participants directly after hospital discharge, and in 86.5% and 93.8% at 3- and 6-months follow-up respectively. Similar recovery was seen between groups on all secondary outcomes, but neither group reached reference values for health-related quality of life at 6-months follow-up.

The thesis closes with a general discussion in **Chapter 8**, which summarizes the main findings and discusses methodological considerations to the studies described in chapters 2 to 7. Recommendations are provided to optimize the rehabilitation pathway for patients who survive critical illness and are discharged home. This chapter concludes with clinical implications of the studies described in this thesis and suggestions for future research in the field of post-ICU rehabilitation.

APPENDIX: SAMENVATTING

VOORBIJ HET OVERLEVEN: OPTIMALISEREN VAN HET REVALIDATIE TRAJECT NA KRITIEKE ZIEKTE

Als gevolg van technologische en medische vooruitgang, overleven steeds meer patiënten een kritieke ziekte en opname op de Intensive Care (IC). In de afgelopen 20 jaar hebben ook de wetenschappelijke inzichten over de lange termijn gevolgen voor patiënten, een substantiële groei doorgemaakt. De omvang en impact van deze gevolgen zijn, na het vast- stellen van de definitie van het post-intensive care syndroom (PICS) van de Society of Critical Care Medicine in 2012, steeds beter in kaart gebracht. PICS omvat "nieuwe of verergerende problemen in het lichamelijke, psychische of cognitieve domein, ontstaan na het doormaken van een kritieke ziekte en continuerend na een verblijf op de IC" en komt voor bij een groot aantal patiënten die een kritieke ziekte hebben overleefd alsook bij hun familieleden (PICS-F).

In de afgelopen jaren is de focus in het intensive care onderzoek verschoven van levens redden en het vergroten van de *kans op overleven*, naar het verbeteren van de *kwaliteit van het overleven*. In het herstelproces na een kritieke ziekte hebben veel patiënten revalidatiebehandelingen nodig. Revalidatie is, volgens de Wereldgezondheidsorganisatie (WHO) gedefinieerd als: "een reeks interventies ontworpen om het functioneren te optimaliseren en beperkingen te verminderen bij mensen met gezondheidsproblemen, in interactie met hun omgeving".

De opbouw van dit proefschrift volgt het revalidatietraject dat de kritiek zieke patiënt volgt: beginnend op de IC (**hoofdstuk 2**), de overgang naar de ziekenhuisafdeling en van het ziekenhuis naar huis (**hoofdstukken 3 en 4**), en de optimale aanpak van de revalidatiebehandelingen in de eerste lijn (**hoofdstukken 5-7**).
Het doel van dit proefschrift was om, binnen de context van de beroepspraktijk, wetenschappelijk onderzoek, en bachelor onderwijs, te beschrijven hoe de periode na het overleven van de kritieke ziekte ervaren wordt en hoe fysiotherapeuten patiënten gedurende de verschillende fasen van herstel optimaal kunnen ondersteunen.

Hoofdstuk 1 beschrijft de achtergrondinformatie, de onderbouwing voor de onderzoeksprojecten en introduceert het algemene doel van dit proefschrift.

Hoofdstuk 2 gaat over de specifieke beroepscompetenties van fysiotherapeuten werkzaam op de IC. Het beschrijft een mixed-method, proof-of-concept studie uitgevoerd onder studenten van de internationale fysiotherapie opleiding (European School of Physiotherapy) en internationale experts op het gebied van de IC-fysiotherapie. In deze studie onderzochten wij de haalbaarheid en de toepassing van e-learning in de voorbereiding op een praktijkstage op de IC. Omdat de IC vaak als zeer uitdagend wordt ervaren door studenten en afgestudeerde fysiotherapeuten die voor het eerst met deze afdeling in aanraking komen, ontwikkelden en testen wij een e-learning module onder een groep internationale studenten en experts. De e-learning module bevatte een verscheidenheid aan leermiddelen bedoeld om een uitgebreid en realistisch beeld te geven van de fysiotherapeutische taken en verantwoordelijkheden op de IC. Positieve resultaten betroffen het behalen van de leerdoelen en de flexibiliteit van de e-learning module. Studenten waardeerden het feit dat de module overal en op elk moment kon worden gevolgd, rekening houdend met het principe van *Just-in-Time learning*: de module kunnen volgen vlak voor of gedurende de praktijkstage bevorderde optimale opname van de leerstof. Internationale experts op het gebied van de IC-fysiotherapie waardeerden de cursus vanwege de op wetenschappelijke evidentie gebaseerde inhoud en het ontwerp van de cursus, waardoor snelle en makkelijke aanpassingen mogelijk zijn, op het moment dat nieuwe evidentie beschikbaar komt. Hoewel studenten zich na het volgen van de e-learning module goed voorbereid voelden op de praktische taken op de IC, werd uit dit onderzoek ook duidelijk dat de module als op zichzelf staande cursus onvoldoende toereikend is voor het aanleren van complexe praktische handelingen en klinisch redeneren bij kritiek zieke patiënten op de IC.

Hoofdstuk 3 beschrijft een kwalitatief *grounded theory* onderzoek bij patiënten die een kritieke ziekte overleefd hebben en hun naasten, waarin de ervaringen tijdens de transitie van IC naar de ziekenhuisafdeling, en van de afdeling naar huis werden onderzocht. In dit onderzoek zijn semi-gestructureerde interviews gehouden met 35 deelnemers (22 voormalig IC-patiënten en 13 familieleden), ontslagen uit 16 Nederlandse ziekenhuizen. Met behulp van de constant vergelijkende methode identificeerden wij verschillende kernconcepten uit de data, die de ervaren overgang van ziekenhuis naar huis belemmerden

of juist ondersteunden en daarmee de ervaring positief of negatief beïnvloedden. Deze kernconcepten waren: "bestaan in een gefragmenteerde werkelijkheid", "over het hoofd gezien worden" en "zich gediskwalificeerd voelen". De factoren die een positief ervaren overgang naar huis ondersteunden waren: "empowerment ervaren", "professionals met empathie en expertise", "verwachtingenmanagement" en "de naaste betrekken". Dit onderzoek geeft inzicht in de valkuilen van de huidige praktijk bij ontslag uit het ziekenhuis en pleit voor een uitgebreidere screening van de behoefte aan nazorg onder post-IC patiënten en hun naasten, dat plaats- vindt voor of direct na ziekenhuisontslag, zodat een soepele en naadloze overgang kan worden gerealiseerd.

In **hoofdstuk 4** rapporteren we de resultaten van een prospectieve cohortstudie waarin longitudinale veranderingen in de ademspierkracht en factoren geassocieerd met het herstel werden onderzocht bij patiënten die kunstmatig beademd zijn geweest op de IC. De inspiratoire (MIP) en expiratoire (MEP) spierkracht werden op drie momenten gemeten: direct na ontslag uit het ziekenhuis, na 3 en na 6 maanden. Secundaire uitkomstmaten in dit onderzoek waren functionele aerobe capaciteit en handknijpkracht, gemeten op dezelfde drie momenten. In totaal namen 59 deelnemers, met een mediane beademingsduur van 10 dagen, deel in dit onderzoek. Multilevel analyse toonde aan dat op 6 maanden na ziekenhuis ontslag, alle uitkomsten, behalve de MIP, de normatieve waardes (gecorrigeerd voor leeftijd en geslacht) bereikt hadden. De gemiddelde MIP was bij ontslag uit het ziekenhuis ruim onder de voorspelde waarde (68.1%) en nam daarna toe tot 91.2% en 98.5% van voorspelde waardes op respectievelijk 3 en 6 maanden na ontslag. Vervolgens viel op dat hogere leeftijd significant geassocieerd was met een verminderde MIP en functionele aerobe capaciteit.

Significante, longitudinale associaties werden gevonden tussen MIP/MEP en functionele aerobe capaciteit en handknijpkracht, en deze relaties bleven in alle statistische modellen in stand, zowel in de univariate als de multivariate regressieanalyses. Deze resultaten bevestigen de noodzaak om verder onderzoek te doen naar het herstel van ademspierkracht en naar de toepasbaarheid van ademspiertraining als onderdeel van fysiotherapeutische oefenprogramma's voor patiënten die op de IC beademd zijn geweest.

Hoofdstuk 5 en 6 beschrijven de uitkomsten van twee Delphi studies. In het eerste Delphi onderzoek (**hoofdstuk 5**) werd het Delphi panel gevormd door

een groep internationale experts (*n* = 10). In 3 Delphi rondes genereerde het panel allereerst ideeën over een kernset klinimetrie (Core Outcome Set, COS) en fysiotherapeutische interventies voor patiënten die na een kritieke ziekte en IC-opname naar huis worden ontslagen (ronde 1). Vervolgens werden stellingen geformuleerd en geprioriteerd (ronde 2 en 3) met als doel om consensus te bereiken. Na 3 rondes werd consensus bereikt op 88.5% van de stellingen, die vervolgens werden omgezet in een reeks aanbevelingen voor eerstelijns fysiotherapie voor patiënten met PICS. Deze aanbevelingen benadrukten het belang van een gedetailleerde overdracht tussen de fysiotherapeut werkzaam in het ziekenhuis en de fysiotherapeut verantwoordelijk voor de behandeling in de eerste lijn. Daarnaast werden de volgende uitkomsten aanbevolen om op te nemen in de kern set klinimetrie: inspanningscapaciteit, spierkracht, ADL functie, mobiliteit, kwaliteit van leven, en pijn. Aanbevelingen voor fysiotherapeutische interventies voor patiënten met PICS richten zich op het verbeteren van fysiek functioneren en voorlichting over PICS en herstel na kritieke ziekte.

In **hoofdstuk 6** worden de resultaten van een tweede Delphi studie beschreven. Omdat in Nederland interventies gericht op revalidatie voor IC-patiënten die uit het ziekenhuis worden ontslagen vaak worden georganiseerd binnen de eerstelijnszorg, bestond het Delphi panel in dit onderzoek uit experts uit verschillende beroepsgroepen en ervaringsdeskundigen (*n* = 10) bekend met het Nederlandse zorgstelsel. Het doel van deze studie was om praktische aanbevelingen te genereren met betrekking tot eerstelijns revalidatie, met de focus op fysiotherapie, voor patiënten met PICS. Na drie Delphi rondes bereikte het panel consensus op 95.5% van de stellingen. Dit betrof stellingen gerelateerd aan de planning van ziekenhuisontslag, relevante fysiotherapeutische klinimetrie en fysiotherapeutische interventies. Dit onderzoek resulteerde in aanbevelingen om patiënten en eerstelijns revalidatieprofessionals beter te ondersteunen via een uitgebreide screening van revalidatiebehoeften tijdens de overgang van ziekenhuis naar huis en gedetailleerde overdrachtsinformatie te verzamelen. Aanbevelingen ten aanzien van relevante uitkomstmaten en interventies betroffen het meten en/of verbeteren van de (adem)spierkracht, pulmonale functie, pijn, functioneren in ADL en aerobe capaciteit.

In **hoofdstuk 7** beschrijven we een mixed-method, niet-gerandomiseerde, prospectieve haalbaarheidsstudie met een follow-up van 6 maanden. Het

doel van dit onderzoek was om de haalbaarheid te onderzoeken van een interdisciplinaire eerstelijns interventie voor patiënten met PICS. In deze studie werden twee groepen onderzocht. De interventiegroep (de REACH groep) ontving een fysiotherapeutische interventie die direct na ontslag uit het ziekenhuis werd gestart en gericht was op het verbeteren van het fysiek functioneren en zelfmanagement, met de focus op het concept "positieve gezondheid". De interventie werd, indien nodig, aangevuld met interventies vanuit de diëtetiek en de ergotherapie. Patiënten in de controlegroep ontvingen gebruikelijke zorg, waar verder geen restricties aan verbonden waren. Primaire uitkomsten waren de volgende haalbaarheidsparameters: veiligheid, optimale dosis van de interventie, tevredenheid van de patiënt en behandelaar, naleving van het protocol, therapietrouw, interdisciplinaire verwijzingen en zorggebruik. Secundaire uitkomsten waren functionele aerobe capaciteit, ervaren gezondheid, kwaliteit van leven, terugkeer naar werk, prevalentie van post-traumatisch stressstoornis (PTSS), en risico op ondervoeding op het moment van ontslag uit het ziekenhuis. Drieënveertig deelnemers werden geïncludeerd in deze studie (19 in de REACH-groep, 24 in de controlegroep), en van 79.1% van de populatie werd data verzameld op het eindpunt van de studie (6 maanden).

Analyse van de primaire uitkomsten bevestigen de haalbaarheid van de interventie doordat er geen negatieve bijwerkingen optraden, het protocol goed werd nageleefd en de therapietrouw hoog was. Meer REACH-deelnemers toonden zich tevreden met hun fysiotherapeut in vergelijking tot de controlegroep (92.8% versus 60.0%). REACH deelnemers rapporteerden meer behandelingen door eerstelijns revalidatieprofessionals en minder bezoeken aan medisch specialisten, in vergelijking met de controlegroep. Slechts 4.8% ($n = 1$) van de controlegroep ontving ergotherapie, tegenover 33.3% van de REACH populatie. Kwalitatieve analyse van focusgroep data met fysiotherapeuten identificeerde de volgende positieve ervaringen met het REACH programma: het kunnen samenwerken en delen van kennis en expertise binnen een interdisciplinair netwerk, en het kunnen aanbieden van state-of-the-art interventies. Analyse van de secundaire uitkomsten lieten zien dat de prevalentie van ondervoeding op het moment van ziekenhuis ontslag in beide groepen hoog was (> 80%), terwijl de prevalentie van PTSS het hoogst was bij ontslag uit het ziekenhuis en in de loop van de tijd afnam. Bij 72.1% van de deelnemers bleek het haalbaar om direct na ontslag uit het ziekenhuis de functionele aerobe capaciteit te testen. Op 3- en 6 maanden werd deze data verkregen bij respectievelijk 86.5% en 92.8% van de deelnemers. Vergelijkbaar

herstel werd gezien tussen beide groepen op alle secundaire uitkomsten, maar beide groepen scoorden na 6 maanden nog onder de normwaarden voor kwaliteit van leven.

Dit proefschrift sluit af met een algemene discussie in **hoofdstuk 8**, waarin de belangrijkste bevinden worden samengevat en methodologische overwegingen ten aanzien van de studies beschreven in de hoofdstukken 2 tot 7 worden besproken. Aanbevelingen zijn geformuleerd ten aanzien van optimalisatie van het revalidatietraject voor patiënten die na kritieke ziekte en IC-opname, naar huis worden ontslagen. Dit hoofdstuk sluit af met implicaties voor de klinische praktijk en aanbevelingen voor toekomstig onderzoek op het gebied van revalidatie na een IC-opname.

APPENDIX: PORTFOLIO

Name PhD student: Mel Major-Helsloot
PhD period: 2016 - 2022
Name PhD supervisor: Prof. dr. R.H.H. Engelbert
Name Co-supervisors: Dr. M. van der Schaaf and Dr S.P.J. Ramaekers

PhD training	Year	ECTS
General courses		
Practical Biostatistics. Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2016	1.1
Oral Presentation in English. Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2016	0.8
Scientific Writing in English for publication. Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2016	1.5
Basic course legislation and organization (BROK). Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2016	1.0
Basic course legislation and organization (BROK) re-certification. Netherlands Federation of University Medical Centres (NFU), the Netherlands.	2020	0.2
Qualitative Research methods. Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2017	1.9
Project management. Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2017	0.6
Clinical epidemiology: Randomized Clinical Trials. Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2017	0.6
Research Data Management. Graduate School for Medical Sciences, University of Amsterdam, the Netherlands	2019	0.7
Longitudinal data analysis. Epidm, Amsterdam University Medical Centers, VUMC, Amsterdam.	2019	0.9
Cambridge English Proficiency Assessment. Amsterdam	2016	0.2
Basic and Senior Examiner Qualification	2016	1.0

Seminars, workshops, and master classes	Year	ECTS
Masterclass 'Respiratory muscle training in ICU', the Dutch institute of Allied Health Care (NPI), Amersfoort, the Netherlands	2016	0.3
Interpretation Cardiopulmonary exercise testing(CPET). The physiology academy, Alphen aan den Rijn, the Netherlands	2016	0.3
Basic course ergospirometry, ProCare, Amsterdam. The Netherlands	2019	0.3
Introduction lung and diaphragm ultrasound –Nationaal Trainingsscentrum echografie NT-e, Vianen, the Netherlands	2019	0.3
Wetenschappelijk schrijven en publiceren – Nederlandse organisatie voor Wetenschappelijk Onderzoek (NWO) Laureatendag 2021	2021	0.2

Scientific presentations	Year	ECTS
Surviving critical illness, what's next? Oral presentation. European Region World Physiotherapy, Liverpool, United Kingdom	2016	0.5
Surviving critical illness, what is next? Oral presentation. 4th European conference on weaning and early mobilization, Hamburg, Germany	2016	0.5
Physical therapy after critical illness. Oral presentation. Research meeting department of Rehabilitation Medicine, Amsterdam UMC, the Netherlands	2016	0.5
De intensive care overleven. En dan? Oral presentations. Amsterdam University of Applied Sciences, Research awards	2016	1.5
Zie me, zoals ik ben. Hoe complexiteit niet gezien wordt tijdens ontslag uit het ziekenhuis. Oral presentation. Kick off REACH. Amsterdam UMC, department of rehabilitation medicine, Amsterdam, the Netherlands	2017	0.5
Kwalitatief onderzoek: de waarde voor de fysiotherapeut. Oral presentation. Research meeting Amsterdam University of Applied Sciences, Amsterdam, the Netherlands	2017	0.5
Physical Therapy in the ICU – an undergraduate course. Oral presentation. World Confederation for Physical Therapy congress Cape Town, South Africa	2017	0.5
Preparing the undergraduate for ICU: will an e-learning module do? Oral presentation as part of focused symposium. World Confederation for Physical Therapy congress Cape Town, South Africa.	2017	0.5

Scientific presentations	Year	ECTS
Zie me, zoals ik ben. Hoe complexiteit niet gezien wordt tijdens ontslag uit het ziekenhuis. Oral presentation. Research meeting department of Rehabilitation Medicine, Amsterdam UMC, Amsterdam, the Netherlands	2017	0.5
See me for who I am. How complexity is overlooked during hospital discharge. Oral presentation. 6th Annual Critical Care Rehabilitation Congress, Johns Hopkins, Baltimore, United States	2017	0.5
Surviving critical illness, what is next? Oral presentation. 6th Annual Critical Care Rehabilitation Congress, Johns Hopkins, Baltimore, United States	2017	0.5
See me for who I am. Or: how complexity gets overlooked during rehab transition. Oral presentation. Dutch Rehabilitation Medicine Congress (DCRM), Maastricht, the Netherlands	2017	0.5
Zie me, zoals ik ben. Hoe complexiteit niet gezien wordt tijdens ontslag uit het ziekenhuis. Oral presentation. FCIC - kick off meeting patient federation IC Connect, Utrecht	2017	0.5
Zie me, zoals ik ben. Hoe complexiteit niet gezien wordt tijdens ontslag uit het ziekenhuis. Oral presentation. Amsterdam UMC & KNGF congres: Van kritieke ziekte naar goede gezondheid, Amsterdam, the Netherlands	2018	1.5
Screening & Klinimetrie in de thuissituatie. Oral presentation. REACH Community of Practice.	2018	0.5
Zie me, zoals ik ben. Hoe complexiteit niet gezien wordt tijdens ontslag uit het ziekenhuis. Oral presentation. NVZF congres, Nijmegen	2018	0.5
Mind the gap! Hospital discharge perceived by critical illnes survivors and their families. Poster presentation. 6th European conference on weaning an early rehabilitation, Leuven, Belgium	2018	0.5
De impact van een IC-opname. Oral presentation. Dag vand. Fysiotherapeut, KNGF.	2018	0.5
En dan mag je naar huis. Oral presentation. Dag van de Fysiotherapeut, KNGF	2018	0.5
REACH Research. Oral presentation. REACH Community of Practice.	2019	0.5
REACH Good Clinical Practice. Oral presentation. REACH Community of Practice.	2019	0.5

Scientific presentations	Year	ECTS
REACH Voortgang onderzoek. Oral presentation. REACH Community of Practice.	2019	0.5
When hospital discharge hits home. A qualitative study on discharge experience in survivors of critical illness and their relatives. Poster presentation. Amsterdam Movement Sciences Annual Meeting.	2019	0.5
The REACH study: challenges. Oral presentation. Research meeting department of Rehabilitation Medicine, Amsterdam UMC, the Netherlands	2019	0.5
When hospital discharge hits home. Poster presentation. World Confederation of Physical Therapy congress, Geneve	2019	0.5
Improving ICU aftercare through a regional interprofessional network. Poster presentation. 7th European conference on weaning and early rehabilitation, Amsterdam, the Netherlands	2019	0.5
Rehabilitation after critical illness and hospital discharge (REACH). Oral presentation. Ter Gooi Ziekenhuizen, Hilversum	2019	0.5
Rehabilitation after critical illness and hospital discharge (REACH). Oral presentation. Amsterdam University Medical Centers, VUMC	2019	0.5
Timing it right; ervaringen rondom IC-nazorg vanuit REACH. Oral presentation. IC-revalidatie bespreking. Amsterdam UMC, AMC	2019	0.5
When hospital discharge hits home. A qualitative study on discharge experience in survivors of critical illness and their relatives. Poster presentation. Intensive Care Society State of the Art (ICSSOA) congress, Birmingham, United Kingdom	2019	0.5
Surviving critical illness, what is next? Oral presentation. University hospital Bern, Switzerland.	2019	0.5
Ver van huis na het ziekenhuis. Oral presentation. Dag van de Fysiotherapeut, KNGF, Den Bosch.	2020	0.5
REACH+ project. Ondersteuning revalidatie na ziekenhuisopname. Oral presentation. Professional in the lead lecture, Amsterdam University of Applied Sciences.	2020	0.5
The continuum of care for patients with COVID-19. Oral presentation. Webinar Physiotherapy Alberta & University of Alberta, Canada	2020	0.5
COVID-revalidatie na IC-opname, eerste aanbevelingen vanuit REACH. Oral presentation. REACH webinar	2020	0.5

Scientific presentations	Year	ECTS
Revalidatie in de eerste fase na ziekenhuisontslag van (COVID-19) IC patiënten. Oral presentation. REACH webinar.	2020	0.5
Revalidatie en herstel na COVID-19. Oral presentation. Webinar NVD & KNGF	2020	0.5
Toegankelijk en inclusief onderzoek…en toegankelijke zorg. Oral presentation. Research Meeting. Amsterdam University of Applied Sciences.	2020	0.5
Thuis revalideren na (COVID)IC-opname. Resultaten vanuit de REACH studie. Oral presentation. Refereeravond revalidatie. Amsterdam UMC, Amsterdam.	2021	0.5
Thuis revalideren na (COVID)IC-opname. Resultaten vanuit de REACH studie. Oral presentation. IC-revalidatie bespreking. Amsterdam UMC, AMC	2021	0.5
Functional recovery after critical illness. Results of the REACH longitudinal study. Oral presentation. Research Meeting Amsterdam University of Applied Sciences, Amsterdam	2021	0.5
Dealing with missing data in the REACH longitudinal study. Oral presentation. Rehabilitation in acute care research meeting.	2021	0.5
Functional recovery after ICU. Feasibility of the REACH program. Oral presentation. World Confederation Physical Therapy congress (online)	2021	0.5
Respiratory muscle strength is associated with exercise capacity: a prospective cohort study with 6-month follow-up. Poster presentation. European Society of Intensive Care Medicine congress: LIVES	2021	0.5
Recovery at home: Multidisciplinary rehabilitation interventions for patients with PICS in the community: REACH. Oral presentation. Dutch Rehabilitation Medicine Congress (DCRM) (online)	2021	0.5

(Inter)national conferences	Year	ECTS
3rd European conference on weaning and early mobilization, Copenhagen, Denmark	2015	0.25
Europe Region World Confederation Physical Therapy, Liverpool, United Kingdom	2016	0.25

(Inter)national conferences	Year	ECTS
4th European conference on weaning and early mobilization, Hamburg, Germany	2017	0.25
World Confederation Physical Therapy (WCPT) congress, Cape Town, South Africa	2017	0.25
6th Annual Critical Care Rehabilitation Congress, Johns Hopkins, Baltimore, United States	2017	0.25
6th European conference on weaning an early rehabilitation, Leuven, Belgium	2018	0.25
Dag van de Fysiotherapeut, KNGF, Den Bosch	2018	0.25
World Confederation of Physical Therapy (WCPT) congress, Geneve, Switzerland	2019	0.25
7th European conference on weaning and early rehabilitation, Amsterdam, the Netherlands	2019	0.25
Intensive Care Society State of the Art (ICSSOA) congress, Birmingham, United Kingdom	2019	0.25
Dag van de Fysiotherapeut, KNGF, Den Bosch	2020	0.25
World Confederation of Physical Therapy (WCPT) congress (online)	2021	0.25
European Society of Intensive Care Medicine congress: LIVES	2021	0.25

Teaching		
Lecturing	**Year**	**ECTS**
European School of Physiotherapy, senior lecturing tasks for subjects: Evidence Based Practice (1-4), Physiotherapy in the ICU, BSc thesis supervision, Competence Assessment, clinical supervision, Scientific Writing	2016-2021	0.6 (per week)
Tutoring, Mentoring **Bachelor or Master (thesis) projects**		
Evaluation tools for e-learning modules and student experiences of the e-learning module "Physiotherapy in the ICU" – Szilvia Sydó & Alexandra Pittali, BSc (hons) thesis European School of Physiotherapy	2017	1.0

Teaching		
	Year	**ECTS**
Evaluation of user-friendliness and didactic value of the e-learning module "Physiotherapy in the ICU" – Anna Kohlman, BSc (hons) thesis European School of Physiotherapy	2017	1.0
A qualitative study on how patients' needs and experiences on physical rehabilitation can be improved after ICU stay - Annina Ruokonen & Marion Hamdi, BSc (hons) thesis European School of Physiotherapy	2017	1.0
Bachelor or Master (thesis) projects	**Year**	**ECTS**
What is the best evidence-based protocol with regards to inspiratory muscle training for the population discharged from the ICU and hospital? Marie Alberty & Anna Mohtaschemi, BSc (hons) thesis European School of Physiotherapy	2017	1.0
Physical therapy assessment and interventions for cognitive impairments after critical illness – Cigany Sillevis & Dajinderkaur Singh, BSc (hons) thesis European School of Physiotherapy	2017	1.0
Student and clinician perspectives on and expectations of how a newly developed e-learning module can prepare students for clinical work in ICU. Mareike Appel, Lis Boever & Beth Meluch, BSc (hons) thesis European School of Physiotherapy	2018	1.0
Nutrition and exercise guidelines post-acute hospitalization – Marc Croix Urbina & Jack Liam Goodyear, BSc (hons) thesis European School of Physiotherapy	2021	1.0
Cardiorespiratory complications of SARS-COV-2 infection in ICU patients – Stijn Laan, BSc (hons) thesis European School of Physiotherapy	2021	1.0
Respiratory muscle training for patients recovering from COVID-19 – Hanna van Gerven & Lucia Jonova, BSc (hons) thesis European School of Physiotherapy	2021	1.0
Inspiratory muscle training after critical illness: a pilot study – Romain Collet, MSc project Utrecht University, MSc Epidemiology	2021	1.0
Mentoring research assistants		
Mentoring research assistants (9x) in REACH project, instructing, training and supervision	2019-2020	1.0
Mentoring research assistant qualitative research projects	2017-2021	1.0

Parameters of Esteem	
	Year
Grants NWO research grant 'Doctoral Grant for teachers' 2016-2020	2016
Awards and Prizes Amsterdam University of Applied Sciences / Hogeschool van Amsterdam - Research Award 2016	2016

Publications	
	Year
Peer reviewed	
Major-Helsloot ME, Crous LC, Grimmer-Somers K, Louw QA. Management of LBP at primary care level in South Africa: up to standards? African Health Sciences 14(3):698-707. DOI: 10.4314/ahs.v14i3.28	2014
Major ME, Kwakman R, Kho ME, Connolly B, McWilliams D, Denehy L, Hanekom S, Patman S, Gosselink R, Jones C, Nollet F, Needham DM, Engelbert RHH, Van der Schaaf M. Surviving critical illness: what is next? An expert consensus statement on physical rehabilitation after hospital discharge. Crit Care. 2016 Dec;20(1):354. DOI 10.1186/s13054-016-1508-x	2016
Kwakman RC, **Major ME**, Dettling-Ihnenfeldt DS, Nollet F, Engelbert RH, van der Schaaf M. Physiotherapy treatment approaches for survivors of critical illness: a proposal from a Delphi study. Physiotherapy theory and practice. 2019 Mar 1. DOI: 10.1080/09593985.2019.1579283	2019
Major ME, Van Nes F, Ramaekers SPJ, Engelbert RHH, Van der Schaaf M. Survivors of critical illness and their relatives: a qualitative study on hospital discharge experience, Ann Am Thorac Soc 2019;16:11, pp 1405-1413 DOI: https://doi.org/10.1513/AnnalsATS.201902-156OC	2019
Major ME, Ramaekers SPJ, Engelbert, RHH, Van der Schaaf, M. Preparing undergraduate students for clinical work in a complex environment: evaluation of an e-learning module on physiotherapy in the intensive care unit. BMC Med Educ 20, 130 (2020). https://doi.org/10.1186/s12909-020-02035-2	2020
Major ME, Dettling-Ihnenfeldt D, Ramaekers, SPJ, Engelbert RHH, Van der Schaaf M. Feasibility of a home-based interdisciplinary rehabilitation program for patients with Post-Intensive Care Syndrome: the REACH study. Crit Care 25, 279 (2021). https://doi.org/10.1186/s13054-021-03709-z	2021

Publications	
	Year
Major ME, Van Egmond MA, Dettling-Ihnenfeldt DS, Ramaekers SPJ, Engelbert RHH, Van der Schaaf M. Respiratory muscle weakness persists discharge and is associated with exercise capacity and handgrip strength in survivors of critical illness: a prospective cohort study (submitted: Critical Care, under review 30-11-2021)	
Other	
Major-Helsloot ME, Van der Schaaf M, Moed B, Engelbert RHH. Physiotherapy in the ICU e-learning programme: Development and evaluation of a module as part of an undergraduate international honours degree programme. ICU Management & Practice. 2017;17(4):226-8. https://iii.hm/fav	2017
Van Tol B, Dettling D, Kruizenga H, Pellegrom S, **Major-Helsloot M**, Siebel M, Van der Schaaf M. Het Post Intensive Care Syndroom - casus van een patient. Fysiopraxis 2020:03	2020
Van Tol B, Dettling D, Kruizenga H, Pellegrom S, **Major-Helsloot M**, Siebel M, Van der Schaaf M. Maatwerk: het Post-IC syndroom. NED TIJDSCHR VOOR VOEDING & DIËTETIEK - 2020;75(T)	2020
Pellegrom S, Van Hartingsveldt M, Van Tol B, Dettling D, Kruizenga H, Siebel M, Major M en Van der Schaaf M. Eerstelijns ergotherapie in het post-intensive care syndroom. Ergotherapie Magazine. 2021:5	2021
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'Na de IC wacht het lange herstel' – Het Parool	2020

APPENDIX: CONTRIBUTIONS OF AUTHORS

Chapter 2: Major ME, Ramaekers SPJ, Engelbert RHH, Van der Schaaf M. Preparing undergraduate students for clinical work in a complex environment: evaluation of an e-learning module on physiotherapy in the intensive care unit. *BMC Med Educ* 2020 20, 130.

MEM set up the research protocol, conducted the data collection and analysis, and drafted the manuscript. SPJR provided methodological support throughout the project and assisted in drafting of the manuscript. RHHE supervised the research project and contributed to the drafting of the manuscript. MvdS supervised the research project, provided methodological support throughout the project and contributed to the drafting of the manuscript.

Chapter 3: Major ME, Van Nes F, Ramaekers SPJ, Engelbert RHH, Van der Schaaf M. Survivors of critical illness and their relatives: a qualitative study on hospital discharge experience. *Ann Am Thorac Soc* 2019 16:11, pp 1405-1413

MEM, FvN and MvDS were responsible for study conception and design. MEM drafted the protocol, conducted the interviews, analyzed the data and drafted and revised the manuscript. FvN contributed to the protocol and data analysis and made substantial contributions to draft and revised versions of the manuscript. SPJR contributed to data analysis and made substantial contributions to the manuscript. RHHE contributed to the research protocol and made substantial contributions to the manuscript. MvdS contributed to the research protocol, data analysis and made substantial contributions to draft and revised versions of the manuscript.

Chapter 4: Major ME, Van Egmond MA, Dettling-Ihnenfeldt DS, Ramaekers SPJ, Engelbert RHH, Van der Schaaf M. Respiratory muscle weakness persists and is associated with exercise capacity and handgrip strength in survivors of critical illness: a prospective cohort study. *Under Review (February 2022)*.

MEM set up the research protocol, conducted recruitment, performed measurements and data collection, data entry and analysis and drafted the manuscript. MAvE assisted in setting up the protocol and standard operating procedures, data analysis and drafting of the manuscript.

DSDI assisted in setting up the protocol and initiated recruitment, assisted in data collection, interpretation of the results and drafting op the manuscript. SPJR supervised the research project, provided methodological support and contributed to drafting of the manuscript. RHHE supervised the research projected, provided methodological support, and contributed to drafting of the manuscript. MvdS supervised the research project, assisted in setting up the research protocol and standard operating procedures, contributed to data analysis and interpretation of the results, provided methodological support and contributed to drafting of the manuscript.

Chapter 5: Major ME, Kwakman R, Kho ME, Connolly B, McWilliams D, Denehy L, Hanekom S, Patman S, Gosselink R, Jones C, Nollet F, Needham DM, Engelbert RHH, Van der Schaaf M. Surviving critical illness: what is next? An expert consensus statement on physical rehabilitation after hospital discharge. *Crit Care* 2016 Dec;20(1):354.

MEM drafted the research protocol, executed the research project, maintained all correspondence, analyzed the data, and drafted the manuscript. RK assisted with data analysis and drafting of the manuscript. MEK participated in the Delphi panel and helped to revise the manuscript. BC participated in the Delphi panel and helped to revise the manuscript. DMW participated in the Delphi panel and provided input towards the manuscript. LD participated in the Delphi panel and helped to revise the manuscript. SH participated in the Delphi panel and helped to revise the manuscript. SP participated in the Delphi panel and provided input towards the manuscript. RG participated in the Delphi panel and helped to revise the manuscript. CJ participated in the Delphi panel and helped to revise the manuscript. DMN participated in the Delphi panel and helped to revise the manuscript. MvdS participated in the Delphi panel, assisted with drafting and revising of the manuscript, and was also the primary investigator and project leader. FN was a member of the steering committee and gave input to the manuscript. RHHE was a member of the steering committee, supervisor of the project, and provided feedback towards the final manuscript.

Chapter 6: Kwakman RC, Major ME, Dettling-Ihnenfeldt DS, Nollet F, Engelbert RHH, van der Schaaf M. Physiotherapy treatment approaches for survivors of critical illness: a proposal from a Delphi study. *Physiother Theory Pract* 2019 Mar 1.

RCK executed the research project, maintained all correspondence, analyzed the data, and drafted the manuscript. MEM drafted the research protocol, assisted in data analysis and drafting of the manuscript. DSDI, FN and RHHE were members of the steering committee and assisted with drafting and revising of the manuscript. MvdS assisted with the research protocol, drafting and revising of the manuscript and supervised the project as principal investigator.

Chapter 7: Major ME, Dettling-Ihnenfeldt DS, Ramaekers SPJ, Engelbert RHH, Van der Schaaf M. Feasibility of a home-based interdisciplinary rehabilitation program for patients with Post-Intensive Care Syndrome: the REACH study. *Crit Care* 2021 25, 279.

MEM set up the research protocol, conducted recruitment, performed measurements and data collection, data entry and analysis and drafted the manuscript. DSDI initiated the interdisciplinary collaborative network REACH, helped set up the research protocol and initiate recruitment, assisted in data collection, analysis and drafting of the manuscript. SPJR supervised the research project, provided methodological support and contributed to drafting of the manuscript. RHHE supervised the research project, provided methodological support and contributed to drafting of the manuscript. MvdS initiated the interdisciplinary collaborative network REACH, set up the research protocol, supervised the research project, provided methodological and analytical support and contributed to drafting of the manuscript.

APPENDIX: DANKWOORD

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Terwijl de hoofdstukken van dit proefschrift worden begeleid door een quote van een ervaringsdeskundige, werd elk onderzoeksproject ook gekenmerkt door bepaalde muziek. Johnny Clegg gaf energie aan hoofdstuk drie, DJ Tiësto (old school) loodste me door de hoofdstukken 4 en 7, Diana Ross was mijn lockdown-liefde, terwijl Fat Freddy's Drop en Sir Elton afwisselend de algemene introductie en de discussie begeleidden. Om die reden: Spotify, bedankt.

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I don't know about you, but I am closing this book, to open another.
Ik weet niet hoe u erover denkt, maar ik sluit dit boek, en open een volgende.

APPENDIX: ABOUT THE AUTHOR

What's in a name?
Mel Major was born as Maria Elisabeth Helsloot in Aalsmeer, the Netherlands, on October 3rd, 1970. According to (slightly old-fashioned) catholic traditions, she received an official name (Maria Elisabeth) and a given name: Mariëlla. A very uncommon name at that time, it was changed swiftly to Mariëlle, and simplified further to Marjel at the age of 17. After meeting her husband Thomas Major in 2001 and the consequential move to the African continent, she finally settled on Mel.

Mel's educational career is equally puzzling. She received a MAVO-diploma from the Thomas van Aquino MAVO in 1987 and a HAVO-diploma from the Alkwin Kollege, both in Uithoorn. In 1994 she completed a BSc in Social Work at the Amsterdam University of Applied Sciences. After doing voluntary work in a children's home in Karachi, Pakistan, she was determined to become a physical therapist and in 2002 received her BSc in Physical Therapy at the international academy Thim van der Laan in Utrecht. Seven years followed in southern Africa, working as a physical therapist in hospitals, private practices, and community health centers in Gaborone (Botswana) and Cape Town (South Africa). Her job as senior PT at the Elsies River Community Health Centre in the Cape Town metropole initiated a spark to contribute to the profession and the lives of (underprivileged) patients through scientific research. Hence, in 2010 she completed her MSc (cum laude) in Physiotherapy Science (Stellenbosch University), with a thesis describing her research project on the prevalence, risk factors and management of lower back pain in public health facilities in the Cape Town metropole.

Having returned to the Netherlands with her family, Mel started in 2010 as a lecturer at the European School of Physiotherapy (ESP) in Amsterdam, enjoying a wonderful team of co-workers, the international environment and the occasional South African student who could relate to words as *babelas* and understood the difference between *now*, *just now*, and *now now*. In 2015 she started her collaboration with Dr. Marike van der Schaaf, senior researcher at the department of rehabilitation medicine at the Amsterdam UMC (AMC), through the development of an online course 'Physiotherapy in the ICU' for the ESP curriculum. The re-ignited excitement for ICU rehabilitation and the

fruitful collaboration with Marike, led to the start of her PhD in 2016, receiving a doctoral grant for researchers from the Dutch Research Council (NWO). Currently, Mel continues her research and remains involved in the ICU course at the Amsterdam University of Applied Sciences and combines this with a job as research coordinator at the Netherlands Society of Rehabilitation Medicine (VRA).

In her free time, Mel enjoys running, watching (and refereeing) her daughters' hockey games, traveling, watching rugby, and growing tomatoes. She lives in Uithoorn with her husband Thomas and their daughters Robyn (2004) and Kyra (2007) and their Portuguese 'pavement special' Sugar (2015).

Amsterdam Movement Sciences

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Amsterdam Movement Sciences conducts scientific research to optimize physical performance in health and disease based on a fundamental understanding of human movement in order to contribute to the fulfillment of a meaningful life.