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RESEARCH ARTICLE

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Does the level of mobility on ICU discharge impact post-ICU outcomes? A retrospective analysis

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ABSTRACT

Purpose: Mobilisation is a common intervention in Intensive Care (ICU). However, few studies have explored the relationship between mobility levels and outcomes. This study assessed the association of the level of mobility on ICU discharge with discharge destination from the hospital and hospital length of stay.

Materials and methods: A retrospective analysis of data from 522 patients admitted to a single UK general ICU who were ventilated for ≥5 days was performed. The level of mobility was assessed using the Manchester Mobility Score (MMS). Multivariable regression analysed demographic and clinical variables for the independence of association with discharge destination and hospital length of stay.

Results: MMS ≥5 on ICU discharge was independently associated with discharge destination and hospital LOS ($p<0.001$). Patients achieving MMS ≥5 on ICU discharge were more likely to be discharged home (OR 3.86 95% CI 2.1 to 6.9, $p<0.001$), and had an 11.8 day shorter hospital LOS (95% CI −17.6 to −6.1, $p<0.001$).

Conclusions: The ability to step transfer to a chair (MMS ≥5) before ICU discharge was independently associated with discharge to usual residence and hospital LOS, irrespective of preadmission morbidity. Increasing the level of patient mobility at ICU discharge should be a key focus of rehabilitation interventions.

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Intensive Care Unit; Manchester Mobility Score; mobility; outcomes; rehabilitation

IMPLICATIONS FOR REHABILITATION

- Mobilisation in the Intensive Care Unit (ICU) is common practice, however studies to date have not evaluated the impact on acute hospital outcomes.
- Achieving the ability to step to a chair on ICU discharge is an important rehabilitation milestone, and is associated with a shorter hospital length of stay and being discharged home.
- Rehabilitation interventions in the ICU should be targeted at progressing patients towards this milestone.

Introduction

The short and medium-term benefits of rehabilitation and mobility interventions delivered in the Intensive Care Unit (ICU) as a key component of recovery after critical illness have been increasingly researched [1–7]. Mobilisation is established as a central part of rehabilitation practice within ICUs in the United Kingdom (UK) [8], and research has continued to evaluate interventions aimed at progressively increasing level of mobility in ICU [4,5,9–11]. Despite this increasing evidence base the optimum dose, type, and timing of intervention remains uncertain. Considerable heterogeneity of included populations and study design is suggested to contribute to inconsistent outcomes [1–3,12]. The use of outcome measures also varies, with studies seeking to establish wide ranging impacts of interventions delivered in ICU [1,3,12]. Measurements often relate to patient status, for example days alive and out of hospital or health related quality of life, at medium to long term time points after hospital discharge [1,2,9]. However, there are significant confounders to the use of longer term outcome measures for the ICU population. Rehabilitation in ICU is a complex intervention consisting of many component parts [13], requiring the inter-professional collaboration of a number of healthcare professions. The rehabilitation pathway post-ICU and after hospital discharge is also complex and fragmented [14,15], and the complexity of the patient presentation requires multiple domains of health and functioning to be assessed [16]. Long term measures therefore may be less sensitive to the specific interventions delivered in the ICU which targeted individual aspects of recovery within a specific time frame. It may then be predictable that single interventions delivered in the ICU fail to impact outcomes measured with insensitive measures at distant time points.

Studies that report the effect of mobility interventions on shorter term outcomes, for example within ICU and in-hospital, have indicated an improvement [3]. Addressing broader issues of multiprofessional culture, access to rehabilitation throughout the

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ICU admission, and enhancing clinician autonomy has demonstrated improved mobility levels in ICU and positive effects on shorter term post-ICU outcomes [3–6,10,17]. As a commonly employed component of ICU rehabilitation [8], the impact of mobility interventions warrant further investigation. However, data that explores the relationship between the level of mobility achieved in ICU and these shorter term post-ICU outcomes is limited. The aim of this study was to evaluate the association of the level of mobility on ICU discharge with discharge destination and hospital length of stay (LOS).

Materials and methods

This study has been reported according to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines [18]. The completed checklist is available in supplementary material 1. A retrospective analysis of prospectively collected data for all admissions to a single UK general ICU in a tertiary teaching hospital was conducted. Data from consecutive admissions to the ICU aged 18 years or over between 1st February 2018 and 30th June 2022 were included. Data were excluded for patients admitted for less than five days, as these patients were judged less likely to have severe physical consequences of critical illness or a specific requirement for physiotherapy. Data were also excluded if the patient was discharged to another ICU or remained an inpatient at the time of analysis.

Outcomes

Discharge destination from hospital and hospital LOS were collected from the electronic health record. Discharge destination was defined as either discharged to the usual residence or other setting, for example inpatient rehabilitation.

Patient characteristics and clinical variables

Variables judged to potentially influence the outcomes were identified *a priori* based on expert clinical opinion and previously published literature. Descriptions of patient characteristics included sex, age, admission type (emergency or elective), Acute Physiology and Chronic Health Evaluation (APACHE) II [19] score on ICU admission, Clinical Frailty Scale (CFS) [20], Functional Comorbidity Index (FCI) [21], and World Health Organisation Disability Assessment Schedule (WHODAS) 2.0 [22]. Variables describing measures obtained throughout the ICU admission included ventilator days, day to first rehabilitation contact, Medical Research Council Sum Score (MRC-SS) [23] on ICU discharge, and ICU LOS.

The level of mobility on ICU discharge was measured using the Manchester Mobility Score (MMS) [24]. The MMS is a valid and reliable measure used to standardise the description of levels of mobility for the ICU population [24]. Mobility level is recorded on a seven-point scale (1 = Bed based exercise, 2 = Sitting over bed edge, 3 = Passive transfer to chair, 4 = Standing practice, 5 = Step transfer to chair, 6 = Mobilising less than 30 metres, 7 = Mobilising more than 30 metres) [24]. The variable of MMS on ICU discharge was dichotomised (≥5 or ≤4) based on the previously reported impact of the ability to actively step to a chair on patient outcome [11,25]. Days to first rehabilitation contact was defined as the number of days from ICU admission to the patient receiving a mobility intervention of MMS ≥2 [8,9]. The decision to initiate rehabilitation was based on the established local process of a clinical assessment by an ICU physiotherapist, assessing the clinical status and physiological stability of the patient, in line with but not limited to established safety criteria [26].

Statistical analysis

Statistical analysis was performed using SPSS (v28, IBM) for all patients surviving to hospital discharge. Continuous variables were reported as means and standard deviations (SD) where normally distributed, with categorical variables reported as medians and interquartile range (IQR), or counts and percentages. Association between the variables and discharge destination was analysed using Mann-Whitney *U* tests for continuous variables, χ^2 tests for proportions [27], and Kruskal-Wallis ANOVA when comparing two or more groups [28]. The association of the variables to hospital length of stay was analysed through Pearsons correlation for continuous variables [28], Mann-Whitney *U* tests for categorical variables, and Kruskal-Wallis ANOVA for comparing two or more groups. Analysis was completed using all available data and there was no missing data for the primary outcomes.

Variables associated with the outcomes on univariate analysis with a p value <0.15 [29] were entered into multivariable regression models to assess for independence of association. Prior to regression modelling variables were explored for co-linearity. Binary logistic and linear regression analysis identified factors independently associated with discharge destination and hospital length of stay, respectively. A backward elimination (stepwise) process was used to refine the final models. A statistical significance level was set at $p < 0.05$.

Ethics

The project proposal was submitted to the research and development office of the local NHS Trust, and classified as a service evaluation not requiring ethical approval in accordance with guidelines from the UK Health Research Authority. It was registered locally as a service evaluation (Ulysses ID: 6690). Good research governance was observed throughout, with data storage compliant with NHS Trust processes.

Results

Between 1st February 2018 and 30th June 2022 there were 3840 admissions to ICU. Data collection was paused between March and June 2020 due to the COVID-19 pandemic resulting in unavailable data. Of the eligible patients 522 survived to hospital discharge and were included in the analysis (Figure 1). Characteristics for all included patients are displayed in Table 1. Patients were predominantly male (n = 299, 57%), emergency admissions (n = 493, 94%), and of medical specialty (n = 253, 48%). Mechanical ventilation was required for 377 patients (72%), with a mean 6.58 (SD 9.56) days ventilated. Missing data for included variables is detailed in supplementary material 2. There was no loss to follow up to account for.

Discharge destination

There were 398 patients discharged to their usual residence (76%). All variables analysed for association with discharge destination are presented in supplementary material 3. Patients

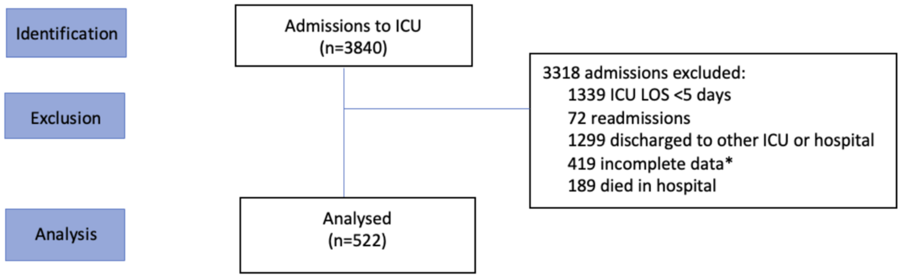

Figure 1. Flow diagram. *pause in data collection due to COVID-19.
A flow diagram summarises the inclusion process for data from all admissions to the intensive care unit. A total of 3840 admissions were identified for potential inclusion. 3318 admissions were excluded, leaving 522 admissions that had data analysed in the final sample.

Table 1. Patient characteristics.

Characteristic	Alive at hospital discharge ($n=522$)
Sex, *n* (%)	
Male	299 (57)
Female	223 (43)
Age, mean (SD)	57.72 (16.96)
APACHE, mean (SD)	16.91 (5.48)
FCI, median (IQR)	1 (1–2)
CFS, median (IQR)	3 (2–4)
WHODAS 2.0 on admission, median (IQR)	3 (0–11.25)
Admitting specialty, *n* (%)	
Medical	253 (48)
Surgical	187 (36)
Trauma/orthopaedics	82 (16)
Elective admissions, *n*(%)	29 (5)
Ventilated patients, n (%)	377 (72)
Ventilator days, mean (SD)	6.58 (9.56)
Days to initial rehab, median (IQR)	4 (2–7)
MMS on ICU discharge, median (IQR)	5 (4–7)
MRC-SS on ICU discharge, median (IQR)	56 (48–60)
ICU LOS (days), median (IQR)	8 (6–14)
Hospital LOS (days), median (IQR)	24 (14–41)
Destination from hospital, n (%)	
Usual residence	398 (76)
Other	124 (24)

APACHE: Acute Physiology And Chronic Health Evaluation; CFS: Clinical Frailty Scale; FCI: Functional Comorbidity Index; ICU: Intensive Care Unit; LOS: Length of stay; MMS: Manchester Mobility Score; MRC-SS: Medical Research Council Sum Score; WHODAS 2.0:World Health Organization Disability Assessment Schedule 2.0.

who were discharged to their usual residence were younger (57.51 vs 62.38 years, $p=0.04$), required fewer ventilator days (3 vs 5, $p<0.001$), had fewer days between ICU admission and receiving their first rehabilitation contact (4 vs 5, $p<0.001$), demonstrated a higher MRC SS on ICU discharge (58 vs 48, $p<0.001$), and were able to achieve an MMS ≥5 prior to ICU discharge ($n=310$, 79% vs $n=88$, 67%, $p<0.001$). They were more frequently admitted as a medical ($n=199$, 79%) or surgical specialty ($n=151$, 81%, $p<0.001$), and had a shorter ICU LOS (8 vs 13 days, $p<0.001$) and hospital LOS (21 vs 40 days, $p<0.001$).

The logistic regression model was statistically significant; χ^2 (6) = 66.009, $p<0.001$. It correctly classified 80% of cases, and explained 26% (Nagelkerke R^2) of the variance in discharge destination. The contribution of each variable to the model is displayed in Table 2. After adjusting for measures of preadmission morbidity and illness severity, achieving an MMS ≥5 on ICU discharge was independently associated with discharge to the usual residence. Patients able to step to the chair before ICU discharge (MMS ≥5) were 3.86 times more likely to be discharged to their usual residence than those who remained more dependent (MMS ≤4, $p<0.001$).

Table 2. Association of variables to discharge to usual residence, results of binary logistic regression modelling.

	OR	95% CI	*p*
ICU LOS	0.98	0.95–1.00	0.49
Age	0.97	0.95–0.99	0.01
Hospital LOS	0.99	0.98–0.99	0.01
Speciality			
Medical	1.68	0.861–3.26	0.13
Surgical	0.56	0.24–1.32	0.19
MMS ≥5	3.86	2.14–6.94	<0.001

ICU: Intensive Care Unit; LOS: Length of stay; MMS: Manchester Mobility Score.

Table 3. Association of variables to hospital LOS, results of linear regression modelling.

	B	95% CI	P
ICU LOS	1.36	1.10–1.61	<0.001
Days to initial rehab contact	−0.91	−1.47 to −0.36	0.001
MMS ≥5 on ICU discharge	−11.83	−17.56 to −6.10	<0.001
CFS	2.80	0.92–4.67	0.004
Speciality	4.54	1.05–8.02	0.011

CFS: Clinical Frailty Scale; ICU: Intensive Care Unit; LOS: Length of stay; MMS: Manchester Mobility Score.

Hospital LOS

All variables analysed for association with hospital LOS are presented in supplementary material 4. There was significant correlation between hospital LOS and WHODAS 2.0 score on ICU admission ($r=0.125$, $p=0.004$), the number of days between admission and receiving the first rehabilitation contact ($r=0.219$, $p<0.001$), MRC SS on ICU discharge ($r=-0.239$, $p<0.001$), ICU LOS ($r=0.465$, $p<0.001$), and number of ventilator days ($r=0.388$, $p<0.001$). Hospital LOS was significantly shorter for patients achieving an MMS ≥5 on ICU discharge (37 vs 20 days, $p<0.001$), patients of a surgical specialty (17.75 days, $p<0.001$), and for patients who did not receive mechanical ventilation (20 vs 26 days, $p=0.02$).

The linear regression model statistically significantly predicted hospital LOS, explaining 32% of the variation; $F_{5,368}$ = 34.963, $p<0.001$. The contribution of each variable to the model is displayed in Table 3. Variables of ICU LOS, MMS ≥5 on ICU discharge, days to initial rehabilitation contact, CFS, and admission speciality added statistically significantly to the prediction, showing independence of association with hospital LOS ($p<0.05$). Patients who achieved an MMS ≥5 on ICU discharge had an 11.8 day shorter hospital LOS ($p<0.001$).

Patient characteristics

The ability to achieve an MMS ≥5 on ICU discharge was a modifiable factor found to be associated with hospital length of stay and discharge destination. The characteristics of patients achieving an MMS ≥5 or ≤4 on ICU discharge are presented in supplementary material 5. There were no significant differences in premorbid state between the groups. Patients discharged from ICU with an MMS ≤4 were more likely to be trauma patients ($p < 0.001$), ventilated for longer (7 vs 3 days, $p < 0.001$), had an increased ICU LOS (13 vs 8 days, $p < 0.001$), and had a lower MRC SS on ICU discharge (42 vs 60, $p < 0.001$).

Discussion

This retrospective analysis concluded the level of mobility achieved on ICU discharge was independently associated with discharge destination and hospital LOS. Patients who were able to step to a chair (MMS ≥5) on ICU discharge where significantly more likely to be discharged to their usual residence and had a significantly shorter hospital LOS (11.8 days). Rehabilitation in ICU is a complex intervention, reflected in the multiple modalities utilised in interventional studies [1–3]. Many studies investigating the effect of early rehabilitation conflate a variety of mobility and exercise interventions [2]. Understanding the relative benefits of rehabilitation components could identify which elements have the greatest impact on outcome.

Due to the rate at which body structures and function are detrimentally affected by critical illness it is recommended that mobility is commenced early after ICU admission [30,31]. Consequently, there has been an increased focus on prioritising delivery of rehabilitation at increasingly early time points after ICU admission [30,32]. However, a recent randomised controlled trial (RCT) delivering protocolised exercise interventions to ventilated patients early after ICU admission demonstrated no improvement in mobility level on ICU discharge [9]. This indicates that despite achieving what has been reported as the important milestone of sitting over the bed edge [33] early rehabilitation does not translate to progressive improvements in patient status. The study results suggest the greatest increase in treatment duration occurred at two extremes, for the most dependent patients (sitting on the edge of the bed) and for those who were functionally very able (mobilising without assistance). This separation was not consistent across all levels of mobility. Additionally, there was no increase in the number of patients standing or transferring to the chair at ICU discharge in the intervention group [9]. This inconsistency may reflect the prioritisation of therapy to those patients receiving mechanical ventilation. In practice this risks reducing therapy resource allocation for patients who are no longer receiving, or do not receive advanced respiratory support. Our analysis suggests that interventions aimed at achieving a step transfer to the chair and mobilising away from the bedspace may be beneficial to the outcome. This requires targeted interventions to continue throughout an ICU admission which are directed by the specific goals of individual patients, and not guided solely by time from admission. Applying this principle to the broader ICU population and not specific patient groups, for example only those receiving mechanical ventilation, would also reflect the heterogeneity of ICU populations and practice within the United Kingdom (UK) [8].

An indication of adverse events during early mobilisation has also been reported [9]. The period including mechanical ventilation is likely to represent the point of greatest physiological instability and illness severity, in which there may be significant risk of physiological harm caused by exercise [34]. Adverse physiological events are therefore likely for patients at this very early time point after admission. The heterogenous response to exercise in this period may be under appreciated when applying protocolised mobility and exercise. Previous studies demonstrating improvements in mobility level utilised clinician-led decision making to initiate and progress mobility throughout the patients ICU admission [4–7]. Quality improvement measures to improve the multiprofessional culture of rehabilitation have been central to improvements in function and hospital LOS [5–7,35], recognising the importance of inter-disciplinary coordination [36]. A point prevalence study of mobility practices in the UK suggested that when the initiation of mobility interventions is reasoned based on physiological parameters, 90% of patients achieved an appropriate mobility goal [8]. The results of our analysis support this progressive goal-directed rehabilitative approach throughout an ICU admission, initiated using clinical rationale, and prioritised above seeking to advance the timeframe in which the intervention is first delivered.

Multiple factors may influence discharge destination and hospital LOS. Half of patients discharged from ICU experience a deterioration in their physical activity in the first 24 h after ICU discharge [37]. Human factors analysis demonstrates dependent patients are more likely to miss rehabilitation interventions or opportunities to mobilise due to the requirement for equipment, multiprofessional staffing resource, and the competing priorities of other patient groups [38]. Our analysis suggests that ensuring patients reach the milestone of stepping to a chair on ICU discharge may decrease this dependency and mitigate the resource and system-based challenges experienced on the transition from ICU to the ward. Additionally, more timely progression towards a mobility level appropriate for discharge to a patient's usual residence could reduce LOS, which is shown to be associated with readmission and mortality [39].

A high proportion of patients admitted to ICU are frail, and this has previously been reported to contribute to poor outcomes related to mortality, discharge destination, and persistent critical illness [40,41]. Critical illness represents a significant stressor to baseline function which precipitates the accumulation of new disability [40–42]. In line with this, frailty as measured by the CFS was a variable independently associated with hospital LOS in this analysis. However, this likely represents the varying influence of external confounding factors on hospital LOS for patients with complex presentations [43], for example requirements for ongoing care provision in the community. There was no significant difference in the CFS of patients achieving MMS ≥5 or ≤4 on ICU discharge in our analysis. Therefore, although hospital LOS may be affected by multiple factors this suggests that the level of mobility achieved on ICU discharge can be considered a modifiable variable, not necessarily confounded by preadmission frailty, and possible to influence through targeted and structured rehabilitation.

The ability to target interventions and identify patients likely to respond to rehabilitation has become a focus of research, with increasing awareness of the individual profiles of ICU patients [16,44,45] and varied trajectories of recovery [33,46,47]. Recent research reported older patients demonstrated a slower progression of mobility level across the first three rehabilitation sessions, and an increase in ICU LOS [33]. However, this increase may be commensurate with complex presentations or in the presence of significant rehabilitation requirements, and is therefore appropriate. Our analysis has reported the significance of achieving a step transfer before ICU discharge, highlighting the clinical relevance of progressing rehabilitation in the ICU to achieve patient specific and targeted goals. Delivering this progression requires consideration of how therapy resources are deployed in practice, and a shift of focus away from measurements of how quickly milestones are achieved.

Outcomes may not be entirely influenced by age alone, with consideration of other variables required. The patients in our sample that were less likely to achieve an MMS ≥5 were those who were ventilated for longer and displayed a lower MRC-SS on ICU discharge. Patients were also more likely to be trauma patients, although this group may have their maximum possible level of mobility limited by orthopaedic restrictions. The ability to identify patients who have not achieved MMS ≥5, have been ventilated for a prolonged period, or have residual ICU acquired weakness (ICU-AW) may help inform prioritisation of rehabilitation interventions and resource allocation for the greatest impact, both in ICU and after discharge. The relationship between the achievement of MMS ≥5 prior to ICU discharge and the outcomes demonstrated in this analysis also offers important considerations for the design and interpretation of rehabilitation trials. The proportion of patients achieving MMS ≥5 in ICU warrants further investigation as an outcome to report the fidelity of research and efficacy of the interventions delivered. The use of hospital LOS as an outcome may also provide a marker of effectiveness that is meaningful in the justification of funding for and delivery of rehabilitation in the ICU [35].

The strengths of this study include the large sample size and sampling method. To minimise bias associated with retrospective analyses the study sampled consecutive admissions and excluded the minimum number of patients possible. There are limitations to acknowledge and inherent in the retrospective nature of this study. Incomplete entries were evident for some variables of interest and not able to be controlled for, and it was conducted using data from a single centre. Although the ability to be discharged to usual residence suggests a lack of need for ongoing inpatient rehabilitation or residential care needs, the analysis was unable to provide descriptions of the level of dependency at hospital discharge.

Conclusion

This retrospective analysis of patients ventilated for more than 5 days in a single UK ICU concluded that the ability to step transfer on ICU discharge as measured by MMS ≥5 was independently associated with hospital LOS and discharge to usual residence. Although commencing rehabilitation in ICU as soon as physiologically appropriate is recommended, studies have previously failed to demonstrate improvements in the proportion of patients achieving key milestones. Exercise and rehabilitation interventions should be targeted to deliver an incremental increase in mobility levels throughout the patients ICU admission to meet these milestones. Future research should investigate specific interventions to facilitate the achievement of increased levels of mobility on ICU discharge, as well as to target interventions to specific patient groups.

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