


BMJ Open Does a screening checklist for complex health and social care needs have potential clinical usefulness for predicting unplanned hospital readmissions in intensive care survivors: development and prospective cohort study

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ABSTRACT

Objectives Intensive care (ICU) survivors are at high risk of long-term physical and psychosocial problems. Unplanned hospital readmission rates are high, but the best way to triage patients for interventions is uncertain. We aimed to develop and evaluate a screening checklist to help predict subsequent readmissions or deaths.

Design A checklist for complex health and social care needs (CHSCNs) was developed based on previous research, comprising six items: multimorbidity; polypharmacy; frequent previous hospitalisations; mental health issues; fragile social circumstances and impaired activities of daily living. Patients were considered to have CHSCNs if two or more were present. We prospectively screened all ICU discharges for CHSCNs for 12 months.

Setting ICU, Royal Infirmary, Edinburgh, UK.

Participants ICU survivors over a 12-month period (1 June 2018 and 31 May 2019).

Interventions None.

Outcome measure Readmission or death in the community within 3 months postindex hospital discharge.

Results Of 1174 ICU survivors, 937 were discharged alive from the hospital. Of these 253 (27%) were classified as having CHSCNs. In total 28% (266/937) patients were readmitted (N=238) or died (N=28) within 3 months.

Among CHSCNs patients 45% (n=115) patients were readmitted (N=105) or died (N=10). Patients without CHSCNs had a 22% readmission (N=133) or death (N=18) rate. The checklist had: sensitivity 43% (95% CI 37% to 49%), specificity 79% (95% CI 76% to 82%), positive predictive value 45% (95% CI 41% to 51%), and negative predictive value 78% (95% CI 76% to 80%). Relative risk of readmission/death for patients with CHSCNs was 2.06 (95% CI 1.69 to 2.50), indicating a pretest to post-test probability change of 28%–45%. The checklist demonstrated high inter-rater reliability (percentage agreement ≥87% for all domains; overall kappa, 0.84).

Conclusions Early evaluation of a screening checklist for CHSCNs at ICU discharge suggests potential clinical

Strengths and limitations of this study

- To our knowledge, this is the first study to develop a simple screening checklist to identify patients with complex health and social care needs at intensive care unit (ICU) discharge.
- The study used mixed-methods research involving patients and carers in addition to population-level data when deciding what items should be included in the screening checklist.
- A limitation was that the checklist was derived by consensus, and not all clinimetric properties were explored.
- We evaluated the checklist's performance using prospective data collection over 12 months in a single ICU, but did not have information about reasons for readmissions and how many might be avoidable.
- The checklist would benefit from evaluation in other ICUs, and an exploration of whether it can trigger interventions to decrease unplanned readmissions.

usefulness, but this requires further evaluation as part of a care pathway.

INTRODUCTION

Survivors of critical illness frequently experience new physical, cognitive and psychological disabilities which have been called the 'post-intensive care syndrome' (PICS).¹ A high prevalence of physical and neurocognitive impairments, and symptoms of anxiety, depression and post-traumatic stress contribute to the poor quality of life reported by many patients. Intensive care populations are heterogeneous in terms of demographics, pre-existing health status, cause of critical

illness and illness severity.² Pre-existing health status, in particular, strongly influences post-critical illness quality of life and utilisation of healthcare resource.³⁻⁵ There is increasing recognition that PICS requires greater recognition by clinicians, healthcare providers and policy-makers, in part because many patients do not fit into existing models promoting rehabilitation and recovery.⁶⁻⁸ However, despite being recommended in many guidelines and clinical standards the optimum model for supporting intensive care unit (ICU) survivors is unknown.⁶ Until now, randomised trials testing a range of interventions have largely shown no effect on patient-centred outcomes.^{9 10} A possible explanation is that populations are too heterogeneous, such that the effect of single or even complex interventions are dependent on individual patient characteristics. Methods for classifying patients into relevant subgroups or phenotypes at ICU discharge are needed to enable personalised medicine approaches to be developed and tested.

We recently showed that around 25% of all ICU survivors experienced unscheduled hospital readmission within 90 days of discharge after a hospitalisation requiring ICU admission.^{2 3} Using a mixed-methods approach, which included in-depth interviews with patients and carers, we described two broad groups of patients in whom unscheduled readmissions occurred.¹¹ First, patients in whom a medical complication or condition occurred that clearly required rehospitalisation; this group we considered 'medically unavoidable'. Second, patients who typically had pre-existing health issues such as multimorbidity, mental health problems, mobility issues, or requiring frequent hospitalisations and/or in whom social/carer support was 'fragile'. We considered these patients had 'complex health and social care needs (CHSCNs)'. Importantly, these patients and their carers described an experience of recovery that could have been improved with better personalised support during the post-ICU period.¹¹

Given the importance of unscheduled readmissions to patients, carers, clinicians and providers we hypothesised that a triage tool based on these findings applied during ICU care or at the time of ICU step-down might usefully identify patients at the highest risk of subsequent rehospitalisations. This could form part of a care pathway to support patients with CHSCNs designed to decrease readmission risk and improve patient recovery. A valid and reliable tool could also provide stratification and/or prognostic enrichment in future trials of ICU rehabilitation interventions. Our aims in this study were: to describe the development of a screening tool; to assess its reliability in clinical practice and finally, to describe the predictive validity of the tool at ICU discharge for subsequent unscheduled hospital readmission or death within 90 days.

METHODS

The study was undertaken as part of a quality improvement project at a single academic teaching hospital

between 1 June 2018 and 31 May 2019, funded by a Health Improvement Scotland award (iHUB). We used the Transparent Reporting of a multivariable prediction model for Individual Prognosis or Diagnosis guidance for reporting studies of predictive tests (<https://www.tripod-statement.org/>).

Setting and context

The setting was a National Health Service (NHS) Board region (population c.800 000) in the UK served by three publicly funded hospitals, which provided all critical care services. All patients admitted to the 18-bed general adult ICU in the major acute hospital (Royal Infirmary, Edinburgh, Scotland) were potentially eligible. The ICU case mix included medical, surgical, trauma and obstetric patients. The hospital services included the regional liver, kidney and pancreas transplant centre. Cardiac surgery, neuro-intensive care, burns/plastics and oncology (including haem oncology) patients were cared for in separate ICUs. Following discharge, patients were cared for by their specialty teams on general wards until discharged from the hospital to the care of publically funded primary care physicians and community services. Emergency care in the region is provided almost exclusively by the NHS. Previous studies showed that around 80% of patients were discharged directly home from the acute hospital, with a minority being discharged to predominantly public-funded rehabilitation or other healthcare facilities.¹² No formal ICU follow-up service was provided following hospital discharge during the study.

Development of screening tool

The content of the screening tool was based on our previous mixed-methods research.^{2 11 13} Briefly, in quantitative population-level research, we found that multimorbidity and polypharmacy were associated with unscheduled readmission risk, as was a history of multiple hospitalisations during the 12 months prior to index ICU admission.^{2 14} In concurrent mixed-methods research, in which qualitative methods dominated, findings were strongly concordant with the population level findings. Specifically, some patients experienced readmissions in the context of complex health and social care issues that predated their ICU admission.¹¹ Importantly, these patients often felt these issues contributed to readmission events, and that better support and anticipatory care might have decreased readmission risk. In addition, qualitative methods found pre-existing psychological and mental health issues, drug and alcohol dependency, and significant mobility issues contributed to many readmission events. Finally, 'fragile' social support including living alone, social isolation, or carer status were considered important by many patients and carers, including high carer strain. From these findings, we developed an ICU survivor 'phenotype' characterised by CHSCNs, which we described in detail previously.¹¹

Using a consensus and iterative approach, including testing with ICU admissions in real time, we developed

a screening checklist for these features of complexity. We agreed definitions that aimed to decrease variation between assessors, given items were semi-subjective and required extraction from medical records. The final item checklist, and guidance for dichotomising patients' status against each component, is shown in [table 1](#).

Patient assessments against the six domains were undertaken by experienced ICU nurses familiar with local electronic and other patient records. Through an iterative process involving discussion and consensus the research group developed definitions that aimed to consistently classify patients against each domain using the checklist items. There was no formal weighting of items as the checklist was a semi-objective tool for use by a trained assessor. Once the screening checklist had been completed, the assessor classified each patient as positive or negative. This required the presence of risk in at least two domains and usually multiple domains. This was a pragmatic decision reached by consensus by the development team for testing in this early development and evaluation study. We recognised that a single domain would include a high proportion of patients, but the requirement for three or more domains could miss patients with relevant CHSCNs. We were also uncertain of the relative prevalence of the different domains prior to the start of the study.

Prospective screening, classification and data collection

For this study, all assessments were undertaken by two nurses following admission to ICU (JT and LB). As the outcome occurred following screening, both nurses were blinded to outcomes.

We prospectively screened all patients admitted between 1 June 2018 and 31 May 2019. All patients were classified in real time during their stay in the ICU using the screening tool by one of the two nurse investigators. Any patient admitted to the ICU was eligible irrespective of their need for mechanical ventilation, other organ support or length of stay. The only patients excluded were those residing in a different health board (who were expected to be discharged to that region), patients admitted following solid organ transplantation (who had a well-developed recovery pathway), and prisoners. Only patients who subsequently survived their ICU admission and were discharged to the general wards were included in subsequent follow-up and screening tool evaluation. Data were collected for all eligible patients, and accounted for in the study flow diagram ([figure 1](#)). Similarly, readmission or death in the community was available for all patients from the hospital information system as this was a unified regional health board data management system with no other unscheduled care healthcare providers. The only exception could have been patients who moved away from the region during the 3-month follow-up in whom any readmissions were not captured by the regional data management system. However, this was considered an unlikely and rare situation. For patients screened as positive, the prevalence of each of the checklist components

was recorded. Data were collected to a bespoke Excel database, and stored on a secure NHS server.

Outcome

The primary outcome of interest was at least one unscheduled readmission event to hospital or death in the community within 90 days of hospital discharge following the hospitalisation episode that required ICU admission. As all unscheduled healthcare was provided by the same NHS Board, the electronic health record was known to capture all hospitalisations, with the exception of patients who may have moved away from the region. These were mostly excluded as non-resident at ICU admission. Electronic health records were used to identify all days in the hospital from ICU discharge until 90 days following hospital discharge. Readmissions were identified, and the timing, number of days in the hospital, and number of separate hospitalisations calculated during the period of interest. Where necessary, episodes were checked and validated by inspecting clinical details in the electronic record.

Screening tool performance

Our primary aim was to determine the discriminant properties and potential clinical usefulness of a screening checklist for risk of unscheduled readmission or death in the community within 90 days of index hospital discharge. We calculated the absolute and relative risk of unscheduled readmission or death within 90 days for patients screened positive and negative using the checklist. We explored clinical usefulness by calculating the sensitivity, specificity, positive (PPV) and negative predictive values (NPV), and positive (+LR) and negative likelihood ratios (-LR) for the checklist as a predictor of subsequent readmission. For patients screening positive, the prevalence of the different checklist items was described.

Reliability of screening tool

As the checklist was semi-objective, we explored reliability by measuring the inter-rater agreement between the two nursing assessors after the iterative development of the final guidance for classification. At this time in development, the nurse assessors had several months of experience using the screening tools to classify patients in real time independently. In an initial round, the nurse assessors compared their independent classification of patients, and used this to refine the classification process. A subset of 80 patients was then selected at random. Each assessor independently classified all 80 patients for each checklist item and overall status while blinded from readmission status and the data recorded by the other assessor. Kappa coefficients were calculated to assess the level of agreement of all binary variables. We used the following classification for the degree of inter-rater agreement based on the kappa value (range 0–1.0): <0.20 poor; 0.21–0.40 fair; 0.41–0.60 moderate; 0.61–0.80 good; 0.81–1.00 very good.¹⁵ Analysis was done using SPSS V.24 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows).

Table 1 The six domains used in assessing the presence of complex health and social care needs, plus the guidance used in ascertaining status from records

Domain	Includes	Does not include	Guidance notes
Multiple admissions during previous 12 months	<ul style="list-style-type: none"> ▶ 3 or more admission in 12 months, including the current admission ▶ Any hospital admission (including mental health inpatient, emergency department admissions and obstetric admissions) 	<ul style="list-style-type: none"> ▶ Does not include: <ul style="list-style-type: none"> – Outpatient attendances – Hospital at home – General practitioner/ community services 	<ul style="list-style-type: none"> ▶ The 12 months predating the date of screening is the period of interest ▶ The current admission is included in the admission count, meaning 2 further admissions in the preceding 12 months fulfils this criterion
Multimorbidity (4 or more comorbidities)	<ul style="list-style-type: none"> ▶ The list of recognised comorbidities is as per the Elixhauser comorbidity index 	<ul style="list-style-type: none"> ▶ A morbidity should be based on a documented condition and not inferred from prescribed medication 	<ul style="list-style-type: none"> ▶ Morbidity status should be ascertained from any available information source including eHealth records, key information summaries, correspondence, general practitioner records
Polypharmacy (4 or more regular medications)	<ul style="list-style-type: none"> ▶ A regular medication is defined as medications which the patient has been taking for >3 months 	<ul style="list-style-type: none"> ▶ Does not include short-term medications, for example, antibiotics, analgesics ▶ Does not include any equipment ▶ Does include inhalers, creams or nutritional supplements 	<ul style="list-style-type: none"> ▶ Evidence should be sought that medications were received for >3 months and are not short-term
History of mental health or substance abuse problems	<ul style="list-style-type: none"> ▶ Include historical episodes, even if no longer a current issue ▶ Only record based on documentary evidence in a valid data source ▶ Mental health issues such as anxiety should be included even if no evidence of therapy as long as clearly documented ▶ Any documented concurrent use of antidepressant or psychiatric medication for mental health issues is strong evidence for this domain 	<ul style="list-style-type: none"> ▶ Does not include dementia or cognitive complaints ▶ Does not include learning disabilities 	<ul style="list-style-type: none"> ▶ Judgements should be based on clear documentation of the mental health or substance abuse problem, rather than medication, wherever possible ▶ Conditions include: depression, anxiety, schizophrenia, bipolar disorder and others ▶ Substance abuse can include liver cirrhosis if the cause is alcohol
Requiring assistance/help with activities of daily living (ADLs)	<ul style="list-style-type: none"> ▶ Package of care or help to stay at home ▶ Someone making meals, washing/dressing 	<ul style="list-style-type: none"> ▶ Does not include household aids like trolleys/walking aids ▶ Does not include someone simply doing shopping or cleaning 	<ul style="list-style-type: none"> ▶ Evidence from any data source, including medical record, nursing records, correspondence
Lives alone/fragile social circumstances	<ul style="list-style-type: none"> ▶ Includes: <ul style="list-style-type: none"> – Lives alone – Homeless – Sofa surfing or 'unstable' living situation 		<ul style="list-style-type: none"> ▶ Any housing situation which is unstable or isolating and may require input ▶ If patient was a long-term inpatient preadmission (eg, an inpatient mental health facility), try to ascertain social circumstances prior to being an inpatient

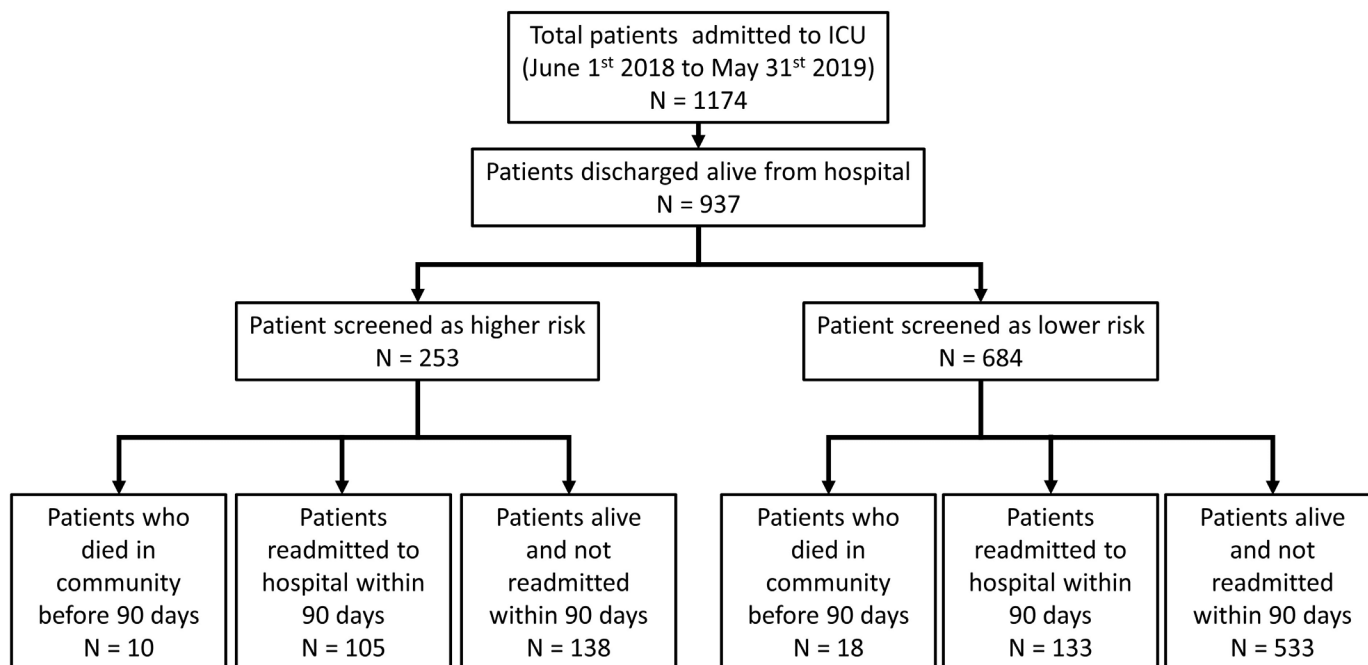


Figure 1 Description of the population studied in terms of the outcome of the screening tool, and subsequent rates of unplanned hospital readmission or death in the community. ICU, intensive care unit.

To explore reasons for disagreement we reviewed all cases in which the two raters disagreed; any common themes or reasons were identified.

Patient and public involvement

Patients and relatives were involved in qualitative interviews and focus groups during the research that underpinned the development of the screening checklist and the items to be included.¹¹ Participants also provided their views of the importance of identifying patients with CHSCNs, and whether interventions might decrease unplanned readmissions. We did not involve patients directly in the design of this evaluation of the screening checklist, but their views on the importance of providing coordinated support to prevent unplanned readmissions underpinned the research question. This study was undertaken concurrently with a quality improvement project, not reported here, of support pathways for patients classified as having CHSCNs. Patients and their relatives were involved in the design of the support pathway and their views about it were gathered through interviews.

RESULTS

Between 1 June 2018 and 31 May 2019 there were 1174 admissions to the ICU eligible for inclusion. Of these, 937 patients were discharged alive from the hospital; of these the screening tool classified 684 (73%) as negative and 253 (27%) as positive for CHSCNs in ICU. Between hospital discharge and 90 days postdischarge, for patients screened as positive 10 (4%) died in the community, 105 (42%) were readmitted to hospital and 138 (55%) were alive without a readmission to hospital. For patients screened as negative 18 (3%) died in the community, 133

(19%) were readmitted to hospital and 533 (78%) were alive without a readmission to hospital (see figure 1). Characteristics of the patients screened as positive who were discharged from the hospital alive are shown in table 2.

Screening tool performance

Among the 937 patients discharged alive from the hospital 266 (28%) experienced an unscheduled readmission (N=238) or died in the community (N=28) within 90 days. Among the positive patients, 115/253 (45%) experienced readmission or died in the community; among the negative patients, 151/684 (22%) experienced readmission or died in the community. The relative risk of readmission or death in the community for positive vs negative patients was 2.06 (95% CI 1.69 to 2.50; p=0.0001).

For screening for readmission risk or death in the community within 90 days, the checklist had a sensitivity of 43% (95% CI 37% to 49%), specificity 79% (95% CI 76% to 82%), PPV 45% (95% CI 41% to 51%), NPV 78% (95% CI 76% to 80%), +LR 2.10 (95% CI 1.71 to 2.57) and -LR 0.71 (95% CI 0.64 to 0.80). The accuracy (overall probability that a patient is correctly classified) was 69% (95% CI 66% to 72%). For individual patients, using the screening checklist altered the pretest probability of readmission or death in the community from 28% to 45% for those screened as having CHSCNs and to 22% for those screened as not having CHSCNs.

The prevalence of the different domains in the checklist is described in table 2.

Reliability of screening tool

The kappa values describing the agreement between the two nursing assessors for a subset of 80 randomly selected

Table 2 Characteristics of patients classified as positive for complex health and social care needs (N=253) who were discharged alive from the hospital

Variable	
Median age (minimum to maximum)	56 (18–89)
Social deprivation (Scottish Index of Multiple Deprivation Quintile 1 or 2)* number (per cent)	162 (64)
Sex (proportion male) number (per cent)	145 (57)
Domains on screening checklist for CHSCNs	
Multiple admissions during 12 months prior to ICU admission number (per cent)	119 (47)
Multi-morbidity number (per cent)	165 (65)
Polypharmacy number (per cent)	185 (73)
Previous mental health issues or substance abuse number (per cent)	134 (55)
Live alone/fragile social circumstances number (per cent)	87 (34)
Requiring assistance/help with activities of daily living (ADLs) number (per cent)	34 (14)

*The Scottish Index of Multiple Deprivation (SIMD) is a national relative measure of deprivation based on residential address. SIMD looks at the extent to which an area is deprived across seven domains: income, employment, education, health, access to services, crime and housing. Quintile 1 and 2 are the most deprived quintile regions (see: <https://www.gov.scot/collections/scottish-index-of-multiple-deprivation-2020/>). CHSCNs, complex health and social care needs; ICU, intensive care unit.

patients within the cohort are shown in table 3. The agreement proportion for all domains was >90% for all domains with the exception of lives alone/fragile social circumstances (87%). The kappa value was very good (≥ 0.81) for all domains, with the exception of lives alone/fragile social circumstances (0.70; good agreement). The

raters agreed with the overall classification for 92% of cases, with a very good kappa agreement (0.84).

For the 'lives alone/fragile social circumstances' category disagreements appeared to relate mostly to the availability of information in the medical record and its interpretation. Disagreements about overall classification arose mostly around cases where this was more subjective based on the numbers of positive domains.

DISCUSSION

We developed a simple screening tool based on routine healthcare data designed to identify patients with CHSCNs at ICU discharge. We found the screening tool had high inter-rater reliability for all individual components and for overall dichotomisation of ICU survivors into those with or without CHSCNs. Over a 12 months prospective evaluation we found that using the tool around the time of ICU discharge could identify patients with a twofold greater risk of readmission or death in the community (45% vs 22%; overall population rate 28%). Community death rates were low (<5%), and the majority of events were unplanned readmissions to hospital.

The six domains of the screening tool were based on population level data driven risk prediction models² and mixed methods analysis of patient interviews,¹¹ which were integrated using robust mixed methods methodology.¹³ Definitions for each domain were developed by consensus and refined by testing in clinical practice. This approach maximised content and face validity. Given there are no other similar tools against which to compare performance, our primary measure of criterion validity was predictive accuracy. The tool identified 27% of all ICU survivors as having CHSCNs at the time of ICU discharge, suggesting it is relevant to routine care. For predicting subsequent unplanned hospital readmission or death in the community, if the checklist identified CHSCNs the pretest to post-test probability for an individual patient

Table 3 Inter-rater agreement for a subset of 80 randomly selected patients

Variable	Number (percentage) positive		Agreement percentage	Kappa (SE)
	Rater 1	Rater 2		
Multiple hospital admissions	30 (38)	26 (33)	95	0.89 (0.05)
Multimorbidity	31 (39)	34 (43)	91	0.82 (0.07)
Polypharmacy	36 (45)	37 (46)	99	0.97 (0.03)
Previous history of mental health issues or history of substance abuse	44 (55)	40 (50)	95	0.90 (0.05)
Requiring assistance with activities of daily living	5 (6)	4 (5)	99	0.88 (0.12)
Lives alone/fragile social circumstances	22 (28)	26 (33)	87	0.70 (0.09)
Overall classification positive	48 (60)	48 (60)	92	0.84 (0.06)

of readmission or death in the community changed from 28% to 45%. For patients screened as not having CHSCNs the probability changed to 22%. The test statistics (sensitivity, specificity, PPV, NPV and LR) did not indicate sufficient discrimination to justify use as a diagnostic method for a disease. However, we believe the context in which we developed and tested the checklist suggest it could be clinically useful for a number of reasons. First, the checklist is intended to assist in early triage to provide person-centred support from ICU discharge; identifying CHSCNs identified a doubling of readmission risk and the likely need for more holistic support. Second, rehabilitation and wider health and social care support are scarce resources, such that a structured tool identifying needs can help direct the 'right resource to the right patient' early in the recovery journey. Third, the major component of the outcome, unplanned readmissions, is complex and unlike a classic binary disease rule in/out condition; specifically readmissions have multifactorial causes some of which may be avoidable, but others clinically necessary and appropriate. Finally, the checklist is cheap, simple, and does not require additional or invasive procedures. We believe the checklist merits further evaluation as part of care pathways at a key early care transition, which could enable appropriate anticipatory discharge planning to be initiated, for example, early targeted involvement in critical care recovery programmes.¹⁶

The most prevalent risk factors were comorbidity and polypharmacy, which frequently coexist, and evidence of frequent previous hospitalisations. These were associated with readmission risk in previous population-level cohort studies in ICU populations,^{2 14} following sepsis,^{17 18} and are also strong predictors in other chronic conditions and general populations.¹⁹ These factors indicate a trajectory of declining health, and have face validity for identifying patients with CHSCNs in whom early planning of care and support needs is likely to be beneficial following critical illness. There was a high prevalence of mental health issues (55%), which were mostly pre-existing chronic problems such as anxiety, depression and substance abuse. These patients may benefit from referral to mental health, addiction or other relevant services. This may not be considered early following ICU discharge unless included in a care pathway approach, risking patients being discharged without optimising support, especially if patients are discharged to diverse teams across the acute hospital based on their ICU admission diagnosis.

We assessed reliability using inter-rater agreement. We found all domains had very good agreement, with the exception of 'lives alone/fragile social circumstances' which had good agreement. This domain was less prevalent than most others (34%), and consistency may have been lower as it was based on available hospital records and the reliability study was not undertaken in real-time (so clarification with family/friends was not possible). The very good overall agreement (92%) indicated the tool had a high decision consistency. This was important given the semi-subjective interpretation of some of the

tool domains, and especially the simple dichotomy into positive and negative cases. The change in pretest to post-test probability for positive cases (28%–45%) in the overall cohort was superior to published data-driven algorithms using routine data,²⁰ and is immediately available to staff. Of relevance, many patients who do not subsequently experience readmission may also benefit from interventions to support their CHSCNs.

To our knowledge, this is the first description and evaluation of a screening tool at ICU discharge for subsequent high hospital readmission risk among critical care survivors. Development and preliminary clinimetric evaluation of another screening tool, the post-ICU presentation screen and rehabilitation prescription for intensive care survivors, has been recently reported but focusses on identifying and describing rehabilitation needs in the early post-ICU hospital period.²¹ Unscheduled hospital readmissions are prevalent among survivors of critical illness, typically ranging from 15% to 30% within 30–90 days according to the population studied^{2 18 22–24}; overall healthcare utilisation is also greater than matched non-critical care populations.^{3 25} Predicting patients at highest risk early during hospital-based recovery provides a system-level opportunity to intervene to decrease risk. A systematic review of discharge interventions during the hospital to home period found they are effective for decreasing readmission in a range of populations²⁶; importantly in this review interventions initiated early were most effective. In addition to timing, a qualitative study found the process of care prior to discharge was of major importance, especially in relation to early planning and better coordination and communication.²⁷ The patients with CHSCNs identified by our screening tool are likely to gain benefit from early optimisation of chronic disease management, self-management promotion and addressing social care issues such as home support. This is likely to require changes to existing care pathways from the time of ICU discharge in many healthcare systems. Our inclusion of living alone and/or fragile social circumstances in the screening checklist is supported by a systematic review of risk factors for acute care hospital admissions, which identified living conditions as an important contributor to readmission risk.²⁸ A scoping review of literature exploring patients' support needs following critical illness also highlighted changing social support needs as important to recovery, especially during the transition from the hospital to home.²⁹

Our study has a number of strengths. Our screening tool was developed from patient-focussed research and we assessed validity and reliability using a range of approaches. We prospectively evaluated performance in a large cohort of cases, which included all ICU discharges over a 12-month period. Potential weaknesses include a population restricted to a single large hospital in one healthcare system, and wider evaluation is required. All assessments were undertaken by two trained assessors, and confirming reliability and performance with a wider range of assessors is important. In addition, we did not set

out to formally test all clinimetric properties of the checklist or explore the relative contribution or importance of each domain to prediction. We chose the presence of two or more domains as identifying CHSCNs pragmatically by consensus rather than using formal statistical modelling. This will require further studies.

In conclusion, we found a simple screening tool to identify ICU survivors with CHSCNs at the time of ICU discharge changed the pretest to post-test probability of subsequent unplanned hospital readmission or community death from 28% to 45% for patients classified as having CHSCNs. This represented double the risk of those patients screened without CHSCNs. The screening tool demonstrated high inter-rater reliability for both the individual components and the overall classification. The screening tool requires evaluation in a larger population across a range of hospitals. This could include evaluation as part of a personalised care pathway from ICU discharge to identify patients at highest risk of readmission who could be targeted for coordinated anticipatory care planning for the hospital to home period.

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Contributors TSW conceived the study, applied for funding, helped manage the study, was involved in data analysis and drafted the manuscript. EP was involved in data collection, data analysis, and reviewed and approved the final manuscript. ED conceived the study, applied for funding, helped manage the study, was involved in data analysis, and reviewed and approved the final manuscript. JT was involved in data collection, data analysis, and reviewed and approved the final manuscript. LB was involved in data collection, data analysis, and reviewed and approved the final manuscript. RAP was involved in data analysis, and reviewed and approved the final manuscript. CW was involved study design, in data analysis, and reviewed and approved the final manuscript. JM conceived the study, applied for funding, helped manage the study, was involved in data analysis, and reviewed and approved the final manuscript. TSW acts as guarantor for the study and its contents.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. The project was reviewed and approved by the local Quality Improvement/Governance group, who considered the project was service development/evaluation. Consistent with local guidance, the project did not therefore require review by an ethics committee or individual patient consent. All patient identifiable data were held on secure NHS computers, and managed in line with local Information Governance procedures. Anonymised data were used in the context of a quality improvement study and service evaluation. All data were held within the NHS.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. De-identified data are held in a secure NHS server within NHS Lothian. These can be made available to other researcher on direct request to the authors.

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