

# Clinical frailty as a key characteristic of the patient population of the NHS Nightingale North West COVID-19 temporary emergency field hospital: cohort study April to June 2020

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## Abstract

### Objectives

COVID-19 temporary emergency ‘field’ hospitals have been established in the UK to support the surge capacity of the National Health Service while protecting the community from onward infection. We described the population of one such hospital and investigated the impact of frailty on clinical outcomes.

### Design

Cohort study.

### Setting

NHS Nightingale Hospital North West, April–June 2020.

### Participants

All in-patients with COVID-19.

### Main Outcome Measures

Mortality and duration of admission.

### Methods

We analysed factors associated with mortality using logistic regression and admission duration using Cox’s regression, and described trends in frailty prevalence over time using linear regression.

### Results

A total of 104 COVID-19 patients were admitted, 74% with moderate-to-severe frailty (clinical frailty score, CFS > 5). A total of 84 were discharged, 14 transferred to other hospitals, and six died on site. High C-reactive protein (CRP) > 50 mg/dL predicted 30-day mortality (adjusted odds ratio 11.9, 95%CI 3.2–51.5,  $p < 0.001$ ). Patients with CFS > 5 had a 10-day median admission, versus 7-day for CFS ≤ 5

and half the likelihood of discharge on a given day (adjusted hazard ratio 0.51, 95%CI 0.29–0.92,  $p = 0.024$ ). CRP > 50 mg/dL and hospital-associated COVID-19 also predicted admission duration. As more frail patients had a lower rate of discharge, prevalence of CFS > 5 increased from 64% initially to 90% in the final week (non-zero slope  $p < 0.001$ ).

**Conclusions:** The NNW population was characterized by high levels of frailty, which increased over the course of the hospital’s operation, with subsequent operational implications. Identifying and responding to the needs of this population, and acknowledging the risks of this unusual clinical context, helped the hospital to keep patients safe.

## Keywords

COVID-19, temporary hospital, field hospital, older patients, clinical frailty.

## Introduction

Older people are particularly vulnerable when health services face periods of overwhelming need: they require an equal access to medical care, yet their needs are often overlooked.<sup>1</sup> In the case of the COVID-19 pandemic, this vulnerability is compounded by greater susceptibility to severe infection.<sup>2–4</sup> As we seek to supplement the existing health infrastructure, we must ensure that any new facilities can deliver safe and effective care to older patients.

For older people with COVID-19, decisions regarding the most appropriate setting for care frequently involve an assessment of clinical frailty, incorporating tools such as the Rockwood clinical frailty score, CFS.<sup>5,6</sup> For patients

whose degree of frailty means they would be unlikely to tolerate or survive a critical care admission, care on an acute medical ward is often required. Greater frailty may lead to longer admission, as acute infection destabilises co-morbidities. Frail patients on medical wards may also face increased barriers to discharge in a pandemic: efforts to reduce the risk of infection to other residents in care homes, for example, may necessitate admission for isolation until negative by polymerase chain reaction (PCR) testing. In consequence, much of the added pressure that is placed on the health service by a pandemic relates to the care of frail, older people in medical wards.

In the early stages of the COVID-19 outbreak in China, 'shelter hospitals' were quickly established, with their focus on monitoring patients aged under 65 years with no major comorbidities.<sup>7,8</sup> In other settings, temporary facilities have focussed on supplementing intensive care units (ICUs), by delivering mechanical ventilatory support in stand-alone facilities.<sup>9–12</sup> In the UK, seven Nightingale temporary emergency hospitals were established to treat patients with COVID-19. Operational design varied based on predicted local needs, from the provision of ICU-level care, to acute medical ward-level care. The NHS Nightingale Hospital North West (NNW) was designed to provide additional medical ward capacity for patients not expected to require critical care, and those stepping down from critical care.

In this paper, we describe the population of patients during the first three months of the hospital's operation (April–June 2020), and analyse the risk factors for adverse outcomes and prolonged admission, with a focus on understanding the impact of clinical frailty. This will help guide the future preparation and use of similar hospitals in pandemic responses.

## Methods

### Study design

We conducted a retrospective observational cohort study of all patients admitted to NNW for care of COVID-19 between opening on 13 April 2020 and transition to standby on 17 June 2020, with the aim of assessing the population's demographic and clinical characteristics and identifying potential risk factors for mortality and prolonged admission. Ethical oversight was provided by Manchester University NHS Foundation Trust's Research Office, in the context of service evaluation and quality improvement.

### Clinical context

NNW was constructed in the Manchester Central Convention Centre: a conference hall adapted from a railway station built in 1880 with 17,776 m<sup>2</sup> floor

space. The site was selected for its ability to accommodate the planned maximum 648-bed capacity, with installation of oxygen supply, plumbing and infection prevention and control. Construction of 18 36-bedded wards was led by a partnership of NHS England, the British Army and the private sector, and was structurally completed in 13 days. Functional bed capacity was expanded incrementally as a reflection of the level of demand from referring hospital trusts in the region. Further details of the clinical context are provided as Appendix 1.

### Admission and discharge criteria

To be eligible for admission, patients were required to be SARS-CoV2-PCR positive, or treated as such on the basis of a clinical picture consistent with COVID-19; to be aged 18 or older; to have a National Early Warning Score 2 (NEWS2) of less than 5 and oxygen requirements of less than 40% at the time of transfer; to have an agreed and documented plan for any limitations of care and resuscitation status; and to either have the capacity to make decisions regarding medical and nursing care, or (if lacking this capacity) to have been the subject of a *Best Interest* discussion concerning the location of their care. Patients were not eligible for transfer if they required bariatric equipment, parenteral or nasogastric nutrition or side-room isolation for reasons other than COVID-19; if they required tracheostomy care, one-to-one enhanced nursing care (including for hyperactive delirium or agitation), or had a history of falls as an in-patient in the last 48 h; if anticipated to require blood transfusion; if in end stage renal failure or requiring dialysis; or if pregnant.

Patients were eligible for discharge when afebrile (temperature  $\leq 37.5$  °C) for the preceding 48 h, off supplementary oxygen for the preceding 24 h (or with provision of long-term oxygen therapy at home), and showing an improvement in respiratory symptoms with a normal NEWS2 score. A negative SARS-CoV-2 PCR nasopharyngeal swab result was required unless a patient was to be discharged home to self-isolate with no external package of care and no household members requiring shielding from COVID-19.

### Data collection

Demographic data, admission characteristics and laboratory results were collected from electronic health records (EHR) using a standardised form. Clinical details were extracted from medical notes by clinicians familiar with the patient. Mortality following discharge was calculated using Trust EHRs and general practice records. For patients 65 and older, CFS was determined by assessing the patient's capabilities two weeks before acute hospital admission, using clinical descriptors set out in the CFS electronic application.<sup>6,13</sup> Two assessors (one a consultant

in geriatric medicine, one an experienced trainee in acute general medicine) independently scored each patient using all available records: where assessors disagreed, they reviewed clinical records together to reach a consensus. The kappa coefficient was calculated for inter-assessor reliability in scoring CFS as  $>5$  versus  $\leq 5$ .

Charlson comorbidity indices were calculated from coded diagnoses or documented past medical history.<sup>14,15</sup> Major polypharmacy was defined as the regular use of <sup>3</sup> 10 medications excluding topical preparations.<sup>16</sup>

The index of multiple deprivation was derived from each patient's postcode prior to hospital admission, using the UK Data Service Geoconvert, with quintiles based on 2011 Lower Super Output Area.<sup>17</sup>

Patients were classified as having community-associated COVID-19, hospital-associated COVID-19 (probable or definite) or indeterminate COVID-19 using standard definitions for surveillance, based on timing of symptom onset relative to hospital admission and degree of clinical suspicion.<sup>18</sup>

### Data analysis

Data analysis was performed in StataIC v.14.2 and GraphPad Prism v.7.0, assessing the population's baseline characteristics, frequency of clinical complications and adverse outcomes including death, and times to final oxygen weaning, medical optimization, viral clearance and discharge.

Potential risk factors for death and prolonged admission were evaluated using chi-squared tests and Fisher's exact test, and associations with prolonged clinical recovery milestones and discharge were assessed using

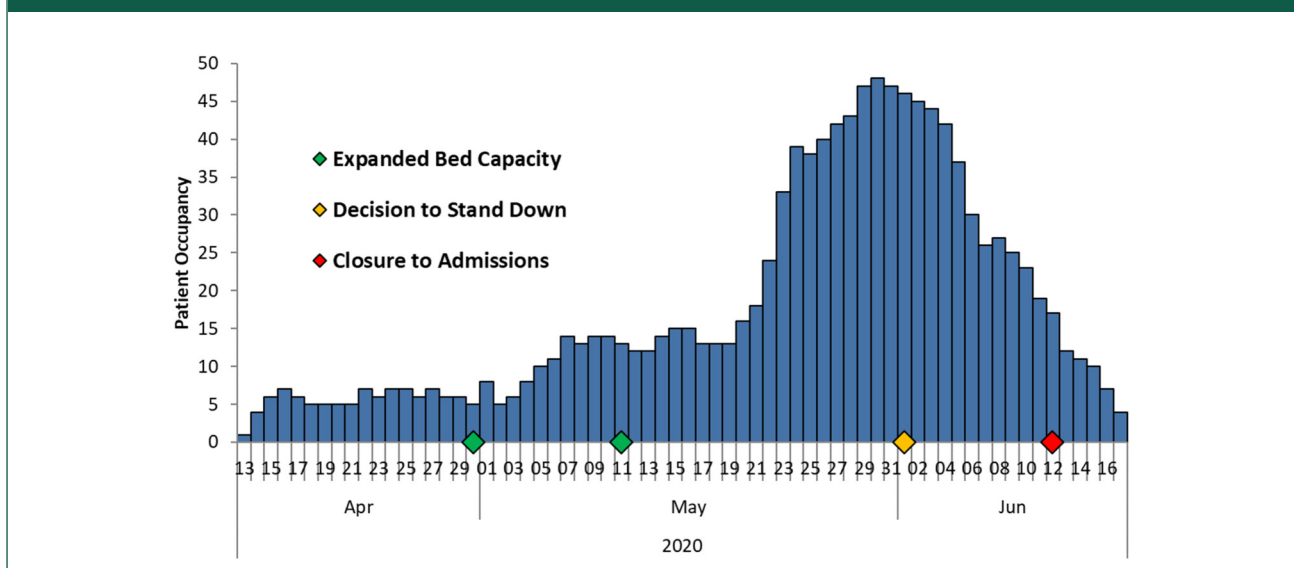
Student's *t*-test or Wilcoxon rank-sum test. Bivariable comparisons and stratification with the Mantel-Hansel test guided identification of potential effect modifiers and confounders. Where clinically appropriate, continuous variables were re-grouped or dichotomized after inspecting their distributions. Risk factors for death were assessed by multivariable logistic regression. Risk factors for duration of admission were assessed by Cox's regression of time from NNW admission to discharge, censoring patients in the event of death or transfer from NNW to another hospital. For each model, a step-wise, additive strategy was used to incorporate potential confounders and effect modifiers, favouring a parsimonious model guided by Akaike's information criteria to appraise the effect of additional variables.

## Results

### Timeline of admissions to NNW

Patient numbers over time are illustrated in Figure 1. The first patient was admitted to NNW on 13 April 2020, with transfers initially limited to patients from Manchester University NHS Foundation Trust. On 23 April, NNW began to accept referrals from other trusts in Greater Manchester, and on 5 May, it began to accept referrals from throughout the North West region. The clinical workforce was expanded to allow additional wards to open on 5 May and 13 May. On 8 May, resources for a full physiotherapy and occupational therapy rehabilitation service were in place, further broadening admission eligibility. Peak occupancy, with 48 patients, was reached on 31 May. On 1

**Figure 1.** Patient occupancy over time, and key events determining hospital capacity.



June, the decision to stand down was made, informed by an assessment of the burden of COVID-19 on acute trusts in the North West at the time. The hospital closed to new admissions on 12 June, and on 26 June, with the discharge and transfer of the remaining four patients, the hospital closed its clinical service and moved into standby.

### Patient population

Of 189 patients referred to NNW, 104 were admitted. Admissions and reasons for being declined admission are summarised in Figure 2, and demographics of admitted patients ( $n = 104$ ) are summarised in Table 1. Median age among admitted patients was 86 years (IQR 79–89); 61 (59%) were female and 97 (93%) were of White British ethnicity.

Using the CFS determined by two assessors (kappa coefficient 0.45; 76% agreement on initial classification as CFS >5 vs.  $\leq 5$ ), 91 of 97 patients 65 and older (94%) had a CFS of 5 (mild frailty) or greater two weeks prior to onset of illness, and 76 (78%) had a CFS of 6 (moderate frailty) or greater – the threshold at which assessments for geriatric syndromes and a comprehensive geriatric assessment are recommended.<sup>6</sup>

Sixty patients (58%) had community-acquired COVID-19. Forty-two (40%) had definite or probable hospital-associated COVID-19; two (2%) were

indeterminate. Clinical characteristics of admitted patients are summarised in Table 2. Sixty-three percent of patients were symptomatic at the time of transfer with 21% requiring supplementary oxygen. Thirty percent had NEWS2 >4. The most common laboratory abnormalities on admission were elevated C-reactive protein (CRP; 73% >10 mg/dL; 23% >50 mg/dL), followed by lymphopenia (35% with lymphocytes <1 × 10<sup>9</sup>/L).

During admission, 39% of patients required antibiotics for intercurrent infection, 26% were diagnosed with delirium and 25% required treatment for electrolyte abnormalities. Thirteen percent were treated for cardiovascular complications and 3% experienced major bleeding, and 1% experienced thromboembolic complications. Two patients (2%) experienced falls, both without injury.

### Predictors of mortality

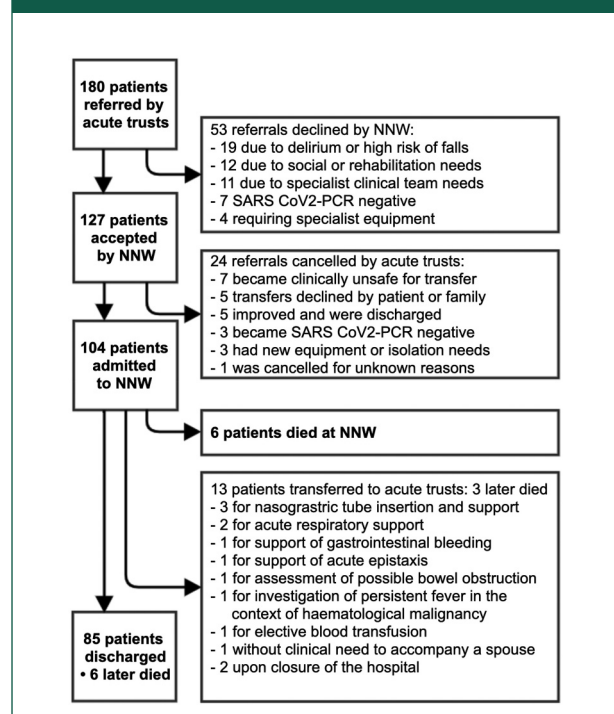
In total, 15 patients died within 30 days of admission to NNW: six died as in-patients; three died after transfer to another hospital for specialist care; six died after discharge (all within 10 days of discharge), giving an overall case fatality of 14%. Among patients aged 65 and older (to allow inclusion of a valid CFS in the analysis) mortality was most strongly associated with CRP >50 mg/dL (odds ratio, OR 11.9, 95%CI 2.7–52.0), obesity (BMI >30 OR 5.0 95%CI 1.3–19.7), diabetes mellitus (OR 3.9 95%CI 1.1–14.0) lymphopenia (OR 3.6, 95%CI 1.0–12.5), and requirement for supplementary oxygen (OR 3.6, 95%CI 1.0–13.5). After adjusting for covariables, CRP >50 mg/dL was associated with death with an aOR of 12.8 (95%CI 3.6–51.5;  $p < 0.001$ ) in an explanatory model that also retained diabetes (aOR 4.4, 95%CI 1.0–18.2,  $p = 0.044$ ) (Appendix 2, Supplemental Tables S1 and S2).

### Duration of admission and clinical milestones

Among 40 patients who received supplementary oxygen during their admissions, the median time to weaning onto room air was 4 days (IQR 2–10; range 0–18 days). Among 87 patients who received a negative SARS-CoV-2 PCR result before discharge, median time to viral clearance was 3 days (IQR 1–10; range 0–21 days). Seventeen patients remained PCR positive at the time of discharge, transfer or death. Median time from admission to medical optimization for discharge was 4 days (IQR 1–9; range 0–21 days). Median time from admission to discharge, transfer or death was 10 days (IQR 5–14; range 1–28 days).

Frailty scores of >5 were associated with longer admission. Patients with CFS >5 had a median length of stay of 11 days compared to 9 days for those with CFS  $\leq 5$ , and 6

**Figure 2.** Patient flow through NNW from referral to clinical outcomes: April–June 2020.



**Table 1.** Demographic and baseline clinical characteristics of patients.

Characteristic	Category	N	Of total	(%)
Age (years)	50–59	5	104	(5%)
	60–69	8	104	(8%)
	70–79	14	104	(13%)
	80–89	53	104	(51%)
	90–99	22	104	(21%)
	100+	2	104	(2%)
Sex	Male	43	104	(41%)
	Female	61	104	(59%)
Ethnicity	White British	97	104	(93%)
	Other ethnicity	7	104	(7%)
Deprivation index	1 <sup>st</sup> quintile (most deprived)	20	100	(20%)
	2 <sup>nd</sup> quintile	21	100	(21%)
	3 <sup>rd</sup> quintile	11	100	(11%)
	4 <sup>th</sup> quintile	26	100	(26%)
	5 <sup>th</sup> quintile (least deprived)	22	100	(22%)
Clinical frailty score	1 Very fit		97	
	2 Well		97	
	3 Managing well	1	97	(1%)
	4 Vulnerable	5	97	(5%)
	5 Mildly frail	15	97	(15%)
	6 Moderately frail	45	97	(46%)
	7 Severely frail	26	97	(27%)
	8 Very severely Frail	4	97	(4%)
	9 Terminally ill	1	97	(1%)
Past medical history*	Obesity (BMI ≥30)	18	101	(17%)
	Smoking	14	92	(15%)
	Hypertension	62	104	(60%)
	Myocardial infarction	21	104	(20%)

**Table 1. (continued)**

Characteristic	Category	N	Of total	(%)
	Congestive heart failure	29	104	(28%)
	Peripheral vascular disease	15	104	(14%)
	Cerebrovascular disease	27	104	(26%)
	Dementia	35	104	(34%)
	COPD	24	104	(24%)
	Connective tissue disease	6	104	(6%)
	Peptic ulcer disease	4	104	(4%)
	Liver disease	5	104	(5%)
	Diabetes mellitus	23	104	(22%)
	Hemiplegia	5	104	(5%)
	Chronic kidney disease	2	104	(2%)
	Solid tumour	18	104	(17%)
	Leukaemia	3	104	(3%)
	Lymphoma	1	104	(1%)
	HIV/AIDS		104	
Place of residence <sup>†</sup>	Home, no package of care	45	103	(44%)
	Home, package of care	26	103	(26%)
	Intermediate care	2	103	(2%)
	Residential/nursing home	30	103	(29%)
		Median	(IQR)	(Range)
Clinical indices <sup>†</sup>	Rockwood clinical frailty score	6	(5–7)	(3–9)
	Charlson comorbidity index	6	(5–7)	(2–11)
	N long term medications	6	(4–9)	(2–20)

\*Conditions defined using thresholds from the Charlson comorbidity index.  
<sup>†</sup>Prior to current illness.

(continued)

days for those under 65. Those with CFS > 5 had about half the likelihood of discharge on a given day (adjusted hazard ratio, aHR 0.52, 95%CI 0.29–0.93,  $p = 0.028$ ). Admission CRP > 50 mg/dL also predicted longer admission (aHR 0.38, 95%CI 0.19–0.75,  $p = 0.005$ ), as did hospital-associated COVID-19 (aHR 0.44, 95%CI 0.27–0.74,  $p = 0.002$ ). The relationships between CFS, hospital-associated COVID-19 and admission duration are illustrated in Figure 3 and summarised in Appendix 2, Supplemental Tables S3 and S4.

### Prevalence of frailty over time

The prevalence of frailty among admitted patients increased over the course of the hospital's operation, with 61% of admitted patients CFS > 5 in the first month, compared to 80% thereafter. Combined with the lower rate of discharge for patients with CFS > 5, this led to a steady increase in the prevalence of frailty, with the percentage of patients with CFS > 5 rising from 64% in the first week to 90% in the final week (a rise of 0.4% per day, non-zero slope  $p < 0.001$ ).

## Discussion

### Principal findings

During NNW's initial period of operation, its patient population was predominantly of an older age group, with high levels of clinical frailty, co-morbidity and polypharmacy preceding their infection with COVID-19. The observed association between elevated CRP and mortality after adjustment for co-morbidities underscores the risks that patients with a more pronounced inflammatory response face, even after apparent clinical stabilisation. Our ability to monitor clinical condition and laboratory markers in an in-patient setting ensured that clinical deterioration could be detected and managed appropriately. The association of greater admission duration with greater frailty, hospital-associated COVID-19, and elevated CRP meant that over time, the patient population showed increasing prevalence of frailty and clinical complexity.

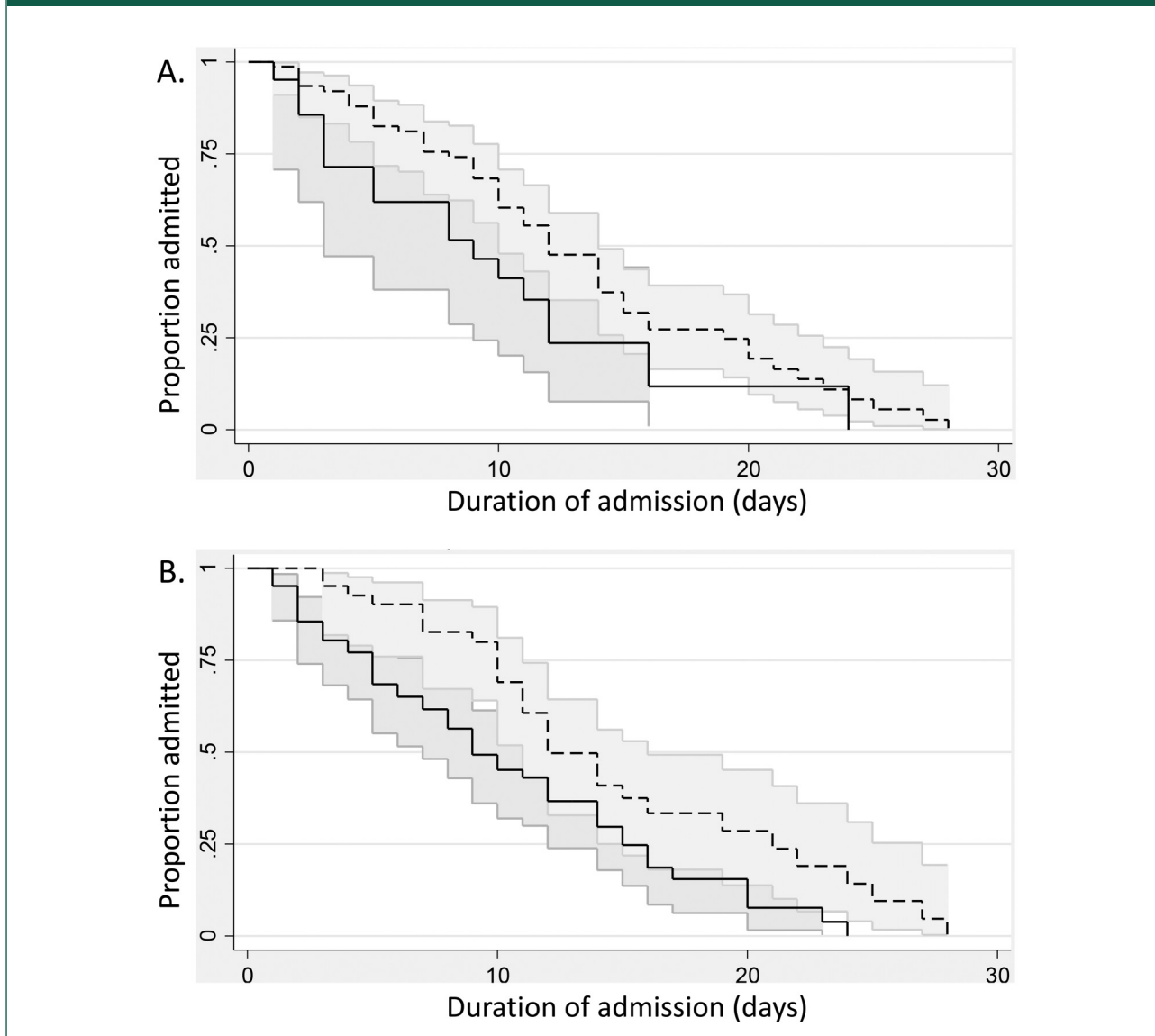
### Local context, strengths and weaknesses

As a facility focussing on the stepdown care of clinically stable patients with COVID-19, NNW faced different clinical challenges to hospitals admitting acutely unwell patients for initial assessment and stabilization. Moreover, the absence of a critical care unit on site, and the difficulty in safely transferring patients requiring escalation to such a unit at another site meant that patients who might require critical care were less likely to be referred than patients for whom frailty and co-morbidities

**Table 2.** Clinical condition of patients upon admission.

Characteristic	Category	N	Of total	(%)
Symptoms	Difficulty in breathing	22	104	(21%)
	Cough	15	104	(14%)
	Falls or reduced mobility	14	104	(13%)
	Confusion	8	104	(8%)
	Fever	5	104	(5%)
	Gastrointestinal symptoms	5	104	(5%)
Vital signs	Asymptomatic	38	104	(37%)
	Temperature >37.5 °C	6	102	(6%)
	Temperature <36 °C	17	102	(17%)
	Respiratory rate ≥24 rpm	7	102	(7%)
	Oxygen saturation <94%	18	102	(18%)
	On supplementary oxygen	21	102	(21%)
	Heart rate >90 bpm	18	102	(18%)
	Systolic blood pressure ≤100 mmHg	10	102	(9%)
	Acutely impaired consciousness	3	102	(3%)
	NEWS2 score >4	31	102	(30%)
NEWS2 score >0	83	102	(81%)	
Laboratory	White cell count <4 × 10 <sup>9</sup> /L	9	101	(9%)
Measures	White cell count >11 × 10 <sup>9</sup> /L	8	101	(8%)
	Lymphocytes <1 × 10 <sup>9</sup> /L	35	101	(35%)
	Platelet <150,000/μL	6	101	(6%)
	Sodium <130 mmol/L	5	101	(5%)
	Creatinine >120 μmol/L	9	102	(9%)
	Total bilirubin >17 μmol/L	6	95	(6%)
	Alanine aminotransferase >45 U/L	7	97	(7%)
C-reactive protein	>10 mg/dL	74	102	(73%)
	>50 mg/dL	23	102	(23%)

**Figure 3.** Time from admission to discharge from NNW by (Panel A) clinical frailty score (CFS  $\leq 5$  solid line; CFS  $> 5$  dashed line) and (Panel B) hospital associated COVID-19 (community-associated or indeterminate association solid line; hospital associated dashed line) among patients aged 65 and older.



might contra-indicate critical care interventions. In consequence, compared to the general hospital population, patients in NNW were more likely to be clinically stable, but older and more frail. This context limits extrapolation to facilities with other models of care, but helps highlight the unique role and limitations a temporary emergency hospital can face when following this model. The small number of deaths at the NNW limits our ability to measure associations between mortality and associated variables, leading to wide confidence intervals in the logistic regression model. Ongoing analysis to identify variables associated with death from COVID-19

across a range of clinical settings will help to understand the wider applicability of our observations.

Local context is important, too, in considering the demographic representativeness of the NNW patient population. In addition to being older, patients were predominantly White British (93%). This is in keeping with the source population of the North West region (in which 86% of all residents and 95% of residents 65 and older identified as White in 2011).<sup>19</sup> Given the complex interplay between ethnicity and risks of COVID-19 infection and severe disease, we again recommend caution in extrapolating our findings to populations elsewhere.<sup>20</sup>

### Relationship to other clinical cohorts

The relationship between frailty and prolonged admission observed here is in keeping with other cohorts of COVID-19 patients and of emergency hospital admissions more widely.<sup>21,22</sup> Other cohorts have found strong evidence that greater frailty is associated with greater risk of death from COVID-19.<sup>21,23,24</sup> The NNW's high prevalence of frailty and low overall mortality reduced the power of this analysis to detect such a relationship. The low mortality we observed was likely a consequence of careful selection of patients in communication with referring trusts, safe clinical care within the hospital and further communication and support from acute trusts when patients required transfer out for investigations or interventions.

### Implications for clinicians and policymakers

Delivering safe care required the supportive management of not only COVID-19, but also of complex medical, nursing and therapeutic needs by a skilled and multidisciplinary team. A model of care that included comprehensive assessment by consultant geriatricians meant that the effects of acute infection and pre-existing frailty could be addressed together. This model took account of the deconditioning and prolonged recovery that frail patients faced after an acute illness, and prioritized support and rehabilitation from a full-time team of occupational and physiotherapists.<sup>24</sup> We also emphasized strong communication links with families at a time when visiting was restricted, with a dedicated family liaison team: this helped patients to remain orientated, to keep their spirits up, and to encourage engagement with rehabilitation.

Delivering this model of care was contingent upon designing and equipping the site, and recruiting and supporting the workforce. The setting – a former railway station with limited natural light – may have increased the risk of disorientation for patients with delirium and dementia (due to disruption of the normal diurnal rhythm), and made safe mobilisation more difficult.<sup>25</sup> However, it allowed a flexible floorplan, and a ward layout with large, open spaces and minimal fixed subdivisions (using portable screens when required for privacy and dignity). This 'Nightingale Ward' design helps patients maintain a greater awareness of their environment, feel less isolated and identify when staff members are free.<sup>26,27</sup> In the context of COVID-19, this layout also favours effective infection control without the use of side rooms: this can reduce the time required to respond to a patient experiencing difficulty breathing, at risk of falling, or otherwise in need of rapid assistance.<sup>28</sup> Future temporary hospitals adopting this layout might seek to incorporate natural lighting to aid orientation and awareness, and spaces for social activities and

communal dining, along with dedicated space for occupational and physiotherapy assessment and rehabilitation.

While the physical structure of the hospital was ready in a matter of days, more time was required to recruit the workforce, adapt clinical protocols to the setting and develop systems of communication and cooperation with referring hospitals. By incrementally scaling up NNW's bed capacity, we were able to assess the hospital's potential and limitations, and adjust admission criteria and clinical protocols accordingly. In October 2020, the facility re-opened to provide care and rehabilitation for older patients without COVID-19.<sup>29</sup> Our experiences in April–June helped anticipate the challenges of providing rehabilitation for older people in this environment, and will help inform the design and use of temporary hospitals for future pandemics and other emergency responses.

We have found that with appropriate planning and integration to the wider response, frail older adults can be safely cared for in a temporary emergency hospital. This provides a model for a rapidly expandable care facility, adapted for the needs of an older population with high prevalence of frailty. This experience, along with recommendations and analysis, have been submitted to NHS England and NHS Improvement, and will form part of a national evaluation of the Nightingale Network.

**Acknowledgements:** We gratefully acknowledge the NHS Nightingale Hospital North West and Manchester University NHS Foundation Trust workforces for planning and delivering care, and recording the information that has made this analysis possible.

#### Declaration:

**Competing Interests:** None to declared.

**Funding:** MTH was funded by the UK Field Epidemiology Training Programme, Public Health England.


**Ethics approval:** Not applicable.


**Guarantor:** Anthony D Redmond.

**Contributorship:** MTH, CN, SS, SM, SB and ADR conceived and designed the analysis. MTH, TS, CN and RD collected the data. MTH, CN and SB contributed analysis tools. MTH, TS, CN and RD performed the analysis. MTH and TS wrote the paper. All authors reviewed and edited the manuscript.

**Provenance:** Not commissioned.

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**Supplemental material:** Supplemental material for this article is available online.

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