Association of dyspnoea, mortality and resource use in hospitalised patients

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Shareable abstract (@ERSpublications)
In a study of over 67 000 patients, dyspnoea reported by patients during a rapid nursing assessment on admission was associated with two-fold odds of death in 2 years. A low-cost screening tool can be used to identify patients at risk of future harm. https://bit.ly/3izDXy2

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Abstract

As many as one in 10 patients experience dyspnoea at hospital admission but the relationship between dyspnoea and patient outcomes is unknown. We sought to determine whether dyspnoea on admission predicts outcomes.

We conducted a retrospective cohort study in a single, academic medical centre. We analysed 67 362 consecutive hospital admissions with available data on dyspnoea, pain and outcomes. As part of the Initial Patient Assessment by nurses, patients rated "breathing discomfort" using a 0 to 10 scale (10="unbearable"). Patients reported dyspnoea at the time of admission and recalled dyspnoea experienced in the 24 h prior to admission. Outcomes included in-hospital mortality, 2-year mortality, length of stay, need for rapid response system activation, transfer to the intensive care unit, discharge to extended care, and 7- and 30-day all-cause readmission to the same institution.

Patients who reported any dyspnoea were at an increased risk of death during that hospital stay; the greater the dyspnoea, the greater the risk of death (dyspnoea 0: 0.8% in-hospital mortality; dyspnoea 1–3: 2.5% in-hospital mortality; dyspnoea ⩾4: 3.7% in-hospital mortality; p<0.001). After adjustment for patient comorbidities, demographics and severity of illness, increasing dyspnoea remained associated with inpatient mortality (dyspnoea 1–3: adjusted OR 2.1, 95% CI 1.7–2.6; dyspnoea ⩾4: adjusted OR 3.1, 95% CI 2.4–3.9). Pain did not predict increased mortality. Patients reporting dyspnoea also used more hospital resources, were more likely to be readmitted and were at increased risk of death within 2 years (dyspnoea 1–3: adjusted hazard ratio 1.5, 95% CI 1.3–1.6; dyspnoea ⩾4: adjusted hazard ratio 1.7, 95% CI 1.5–1.8).

We found that dyspnoea of any rating was associated with an increased risk of death. Dyspnoea ratings can be rapidly collected by nursing staff, which may allow for better monitoring or interventions that could reduce mortality and morbidity.

Introduction

Dyspnoea, the symptom of breathing discomfort or shortness of breath, is highly distressing for patients. Başoğlu [1] has deemed this symptom so severe as to characterise the freedom from dyspnoea a human right. Using various scales, several authors have described the prevalence of dyspnoea among outpatients undergoing palliative care for terminal cancer [2], patients with recent myocardial infarction or heart disease [3], the general population [4] and outpatients [5], and among patients with respiratory diseases [6–8]. In our previous work, we found that as many as one in 10 patients admitted to the hospital experience dyspnoea on admission [9].

Despite the prevalence of dyspnoea, little is known about patient outcomes associated with dyspnoea on admission to the hospital. Unlike other more complex and resource-intensive methods used to identify the sickest patients in the hospital, a bedside provider can discover a patient's dyspnoea simply by asking the patient to provide a rating. We sought to characterise the patient outcomes and hospital resources associated with dyspnoea. Dyspnoea ratings were obtained by the bedside nurse as part of the Initial Patient Assessment that is administered during the first 12 h of admission. Patients provided a rating of current dyspnoea and a rating of dyspnoea during the 24 h prior to unit admission. Our expectation was that patients with ongoing or recent dyspnoea would be at higher risk of death. Our statistical hypothesis was that there was no difference in mortality between patients with and without dyspnoea. We also asked whether patients with dyspnoea would require more hospital resources, more critical care and longer stays in the hospital, and would have higher rates of readmission to the hospital after discharge.

Methods and study population

Nurses at our institution (Beth Israel Deaconess Medical Center, Boston, MA, USA) collect dyspnoea ratings as part of the Initial Patient Assessment and record it in the medical record. Our study was based entirely on data collected as part of the electronic health record for clinical care and was approved by the Institutional Review Board at the Beth Israel Deaconess Medical Center with a waiver of informed consent.

Study population and data source

We conducted a retrospective cohort study of all consecutive admissions between 25 March 2014 and 30 September 2016 to a single, tertiary care facility with 651 inpatient beds (493 medical/surgical beds). All patients who completed the nurse-administered Initial Patient Assessment were included. Our hospital admits patients ⩾18 years of age; patients who are admitted directly to intensive care units (ICUs) and obstetric units do not complete the Initial Patient Assessment.

Study variables

Assessment of dyspnoea

Starting 25 March 2014, the Initial Patient Assessment performed by nurses at our hospital included questions to patients about breathing discomfort; the Initial Patient Assessment is obtained on the first nursing shift after admission to the hospital. Patients were asked to report 1) their current breathing discomfort at rest on a 0 to 10 scale (10="unbearable"), 2) their worst breathing discomfort in the past 24 h on a 0 to 10 scale and 3) what level of activity produced the worst dyspnoea in the past 24 h. Level of activity was recorded on a four-item categorical scale: resting, light, moderate or heavier activity; nurses use common standardised activity examples to enhance understanding (refer to supplementary figure E1 for the visualisation of the nursing clinical tool). We described our method of assessing dyspnoea on admission in our previous study of the prevalence of dyspnoea [9] and in our study of the nursing staff feedback on the implementation of routine dyspnoea assessment [10].

Outcomes

Mortality and readmissions

The primary outcome of interest was in-hospital mortality. The secondary outcomes of interest included mortality at 1 and 2 years. Mortality was determined using the US Social Security Death Index. All-cause readmission was restricted to patients admitted to our institution at 7 and 30 days, and restricted to patients who survived to discharge.

Inpatient resource use

Additional secondary outcomes included markers of increased hospital resource use, including length of hospital stay, activation of the rapid response team and transfer to the ICU. For patients who survived the initial hospitalisation, we also ascertained whether or not a patient was discharged to home or to a care facility.

Patient demographics and clinical characteristics

Demographic information, including age, race (patient self-identification as Black, White or Other) and sex, was collected for all hospitalised patients. We reported patients' clinical characteristics, including the service of admission, comorbidities (extracted using the Elixhauser method [11]) and severity of illness (using the Sequential Organ Failure Assessment score) [12, 13]. Discharge diagnosis was identified based on billing codes and was further categorised using the Clinical Classifications Software proposed by the Agency for Healthcare Research and Quality [14].

To assess the effect of missing primary data, patients who were "unable to respond" to a dyspnoea assessment on admission (and therefore had missing data on the exposure of dyspnoea measurement) were compared with all other patients.

The patient's self-report of pain was recorded by nurses on admission during the same assessment. We collected and compared level of pain to in-hospital mortality to provide a comparison between dyspnoea and another routinely assessed patient symptom.

Statistical analysis

All statistical tests were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). Based on prior recommendations from the pain literature and our own pilot study [15], we *a priori* grouped dyspnoea ratings into three categories: "no dyspnoea" (rating 0), "mild dyspnoea" (rating 1–3) and "moderate-to-severe dyspnoea" (rating $\geqslant$4) for analysis. While the threshold criteria for these levels were arbitrary, the distinctions allowed us to evaluate whether any dose–response relationship existed between dyspnoea and the outcomes of interest. We tested for significant differences using the Chi-squared test for categorical variables and the Kruskal–Wallis test for continuous variables. We fit generalised linear models with distributions and link functions appropriate for each outcome. Specifically, for binary outcomes (mortality, ICU transfer, rapid response activation, discharge home and readmissions) we used binomial distributions with logit links and for the count outcome of length of stay we used a negative binomial distribution with a log link. In these models, we clustered residuals at the patient level, and adjusted for patient demographics and severity of illness measures. For 2-year mortality, we used Cox regression to estimate if there were any significant differences in the hazard ratio (HR) between patients with no dyspnoea, mild dyspnoea and moderate-to-severe dyspnoea. A two-sided type I error of $\leqslant$0.05 was used to indicate statistical significance for all comparisons.

We proposed two additional analyses *a priori*. First, we tested the hypothesis that pain, another powerful and disruptive symptom for patients, would be associated with increased inpatient mortality using the same analysis as used for dyspnoea. Second, we hypothesised that the association of dyspnoea with outcomes would differ in patients admitted with respiratory or cardiovascular diseases compared with other diagnoses. Diagnoses were determined based upon discharge coding. To test this hypothesis, we conducted subgroup analyses in these groups.

Furthermore, we hypothesised that dyspnoea would provide additional clinical information about a patient's risk of in-hospital death, above and beyond what is captured in comorbidity measures and severity of illness metrics. We used multivariate logistic regressions models to identify the incremental contribution of dyspnoea measurement to these standardised risk assessments. Finally, we tested whether adding routine dyspnoea measurement to models that incorporate severity of illness and comorbidity measures would improve the overall discrimination and calibration. Using multivariable logistic regression, we compared models with and without dyspnoea using Akaike Information Criteria (AIC), Hosmer–Lemeshow goodness of fit and area under the receiver operating characteristic curve.

Finally, we conducted an additional analysis using a cut-off of a dyspnoea value of 3 *a posteriori* as requested through the peer review process, to further explore whether the prior distinction of a cut-off of 4 was meaningfully different than other values of dyspnoea.

Results

We studied a total of 67 362 admissions (figure 1). We have previously reported on the prevalence of dyspnoea and the demographic characteristics of patients who report dyspnoea [9]. The overall cohort comprised 38 255 (57%) females, 20 841 (31%) identified as non-White and the median (interquartile range (IQR)) age was 60 (29) years. Patients were discharged with a wide range of diagnoses, with the five most common being diseases of the circulatory system (10 910 diagnoses (16%)), diseases of the digestive system (8371 diagnoses (12%)), pregnancy complications (8006 diagnoses (12%); described in supplementary tables E1 and E2), neoplasm (7549 diagnoses (11%)), and injury and poisoning (7500 diagnoses (11%)). The median (IQR) length of stay in the hospital was 3 (4) days. At some point during the admission 4265 patients (7%) were transferred to the ICU. 34 073 patients (51%) were admitted from the emergency department. Prior treatment in the emergency department probably reduced dyspnoea and pain before the unit admission assessment reported here; nonetheless, the prevalence of dyspnoea on admission to the medical/surgical unit in these unplanned admissions was 3–4 times the prevalence among planned admissions. Patient characteristics are described in table 1.

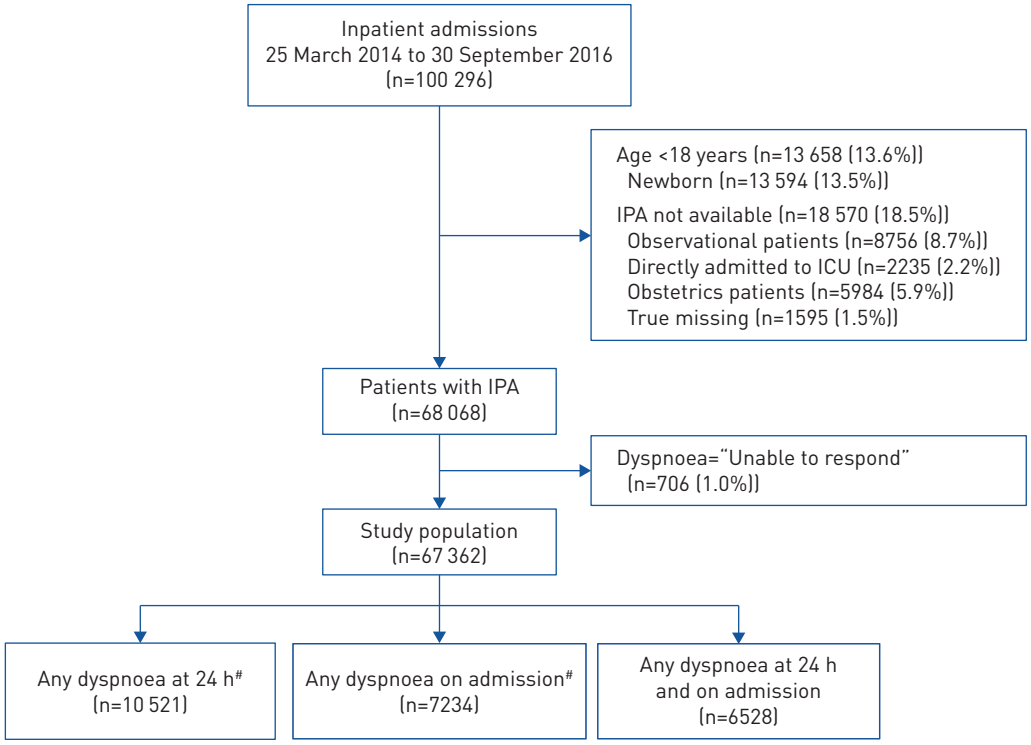

FIGURE 1 CONSORT flow diagram with exclusion criteria. ICU: intensive care unit; IPA: Initial Patient Assessment. #: these boxes are not exclusive of one another ("Any dyspnoea at 24 h" includes all patients who rated dyspnoea >0 at 24 h; should the patient also report dyspnoea >0 on admission, they would be included in "Any dyspnoea at 24 h and on admission").

Mortality

Patients experiencing dyspnoea at the time of admission had different risks for mortality during the hospitalisation. Patients reporting no dyspnoea had an in-hospital mortality of 496/60 128 (0.8%). Patients who reported mild dyspnoea (rating 1–3) had a mortality of 121/4751 (2.6%) (OR 3.1, 95% CI 2.6–3.8). Patients with more severe dyspnoea (rating 4–10) had a mortality rate of 92/2483 (3.7%) (OR 4.6, 95% CI 3.7–5.8) (figure 2). There was a relationship between mortality and non-zero dyspnoea ratings measured as scalar values, shown as a regression line in figure 3, where the area of the shaded circles represents the number of data points at each value (data available in supplementary table E3). After adjustment for patient demographics and severity of illness and comorbidities, patients who reported dyspnoea 1–3 on admission remained at a two-fold increase in odds of in-hospital death (adjusted OR (aOR) 2.1, 95% CI 1.7–2.6; p<0.001) and patients who reported dyspnoea ⩾4 remained at a three-fold increase in odds (aOR 3.1, 95% CI 2.4–3.9; p<0.001). The full adjusted model is available in supplementary table E4.

Patients who had dyspnoea in the 24 h prior to admission had different risks for mortality; 90/4111 patients (2.2%) with mild dyspnoea died while in hospital (OR 2.9, 95% CI 2.3–3.6; aOR 1.8, 95% CI 1.4–2.3) as did 176/6410 patients (2.8%) with moderate-to-severe dyspnoea (OR 3.6, 95% CI 0.0–4.3; aOR 2.3, 95% CI 1.9–2.9). In-hospital mortality of patients with no dyspnoea was 496/56 183 (0.8%).

Finally, for patients who reported dyspnoea in the 24 h prior to admission, we assessed whether the patient's level of activity at the time of the dyspnoea was associated with mortality. Recalled dyspnoea during heavier activity was associated with less mortality than recalled dyspnoea at rest or lighter activity. Any dyspnoea reported at rest was associated with an in-hospital mortality rate of 60/1619 (3.7%); for dyspnoea with light activity 75/2601 (2.8%), with moderate activity 56/2100 (2.7%) and with heavier activity 2/188 (1.1%) (p=0.2 across all categories).

Both mild and moderate-to-severe dyspnoea reported on admission were associated with increased risk of death at 2 years compared with patients who reported no dyspnoea (mild *versus* no dyspnoea: HR 2.1, 95% CI 2.0–2.3; adjusted HR (aHR) 1.5, 95% CI 1.3–1.6; for moderate-to-severe *versus* no dyspnoea: HR

TABLE 1 Dyspnoea on admission by patient characteristics

	Overall	Dyspnoea 0	Dyspnoea 1–3	Dyspnoea ⩾4	p-value
Patients	67 362	60 128	4751	2483	
Female	38 255 (56.8)	34 535 (57.4)	2430 (51.1)	1290 (52.0)	<0.001
Race					<0.001
White	46 521 (69.1)	41 385 (68.8)	3416 (71.9)	1720 (69.3)	
Black	9666 (14.3)	8353 (13.9)	799 (16.8)	514 (20.7)	
Others	11 175 (16.6)	10 390 (17.3)	536 (11.3)	249 (10.0)	
Age years	60 (43–72)	59 (41–71)	67 (55–78)	66 (56–77)	<0.001
English as a second language	6414 (9.5)	5649 (9.4)	533 (11.2)	232 (9.3)	<0.001
Unit of admission					<0.001
Medical	33 988 (50.5)	27 991 (46.6)	3831 (80.6)	2166 (87.2)	
Surgical	16 421 (24.4)	15 411 (25.6)	743 (15.6)	267 (10.7)	
Others	16 953 (25.2)	16 726 (27.8)	177 (3.7)	50 (2.0)	
Emergency department admission					<0.001
Yes	34 073 (50.6)	28 618 (47.6)	3482 (73.3)	1973 (79.5)	
No	33 289 (49.4)	31 510 (52.4)	1269 (26.7)	510 (20.5)	
Day of admission					<0.001
Weekday	55 564 (82.5)	49 857 (82.9)	3773 (79.4)	1934 (77.9)	
Weekend	11 798 (17.5)	10 271 (17.1)	978 (20.6)	549 (22.1)	
Time of admission					<0.001
Day (07:00–19:00)	33 975 (50.4)	30 809 (51.2)	2065 (43.5)	1101 (44.3)	
Night (19:00–07:00)	33 387 (49.6)	29 319 (48.8)	2686 (56.5)	1382 (55.7)	
Primary diagnoses					<0.001
Disease of the circulatory system	10 910 (16.2)	8808 (14.6)	1489 (31.3)	813 (32.7)	
Diseases of the respiratory system	3079 (4.6)	1581 (2.6)	841 (17.7)	657 (26.5)	
Diseases of the digestive system	8371 (12.4)	7715 (12.8)	490 (10.3)	166 (6.7)	
Pregnancy complications	8006 (11.9)	7970 (13.3)	29 (0.6)	7 (0.3)	
Neoplasms	7549 (11.2)	6885 (11.5)	151 (3.2)	187 (7.5)	
Injury and poisoning	7500 (11.1)	6951 (11.6)	388 (8.2)	161 (6.5)	
Diseases of the musculoskeletal system	5072 (7.5)	4899 (8.1)	127 (2.7)	46 (1.9)	
All others	16 875 (25.1)	15 193 (25.3)	1236 (26.0)	446 (18.0)	
Comorbidities[#]					
Hypertension	32 437 (48.2)	27 974 (46.5)	2899 (61.0)	1564 (63.0)	<0.001
Chronic pulmonary disease	11 894 (17.7)	9427 (15.7)	1528 (32.2)	939 (37.8)	<0.001
Depression	11 360 (16.9)	9720 (16.2)	999 (21.0)	641 (25.8)	<0.001
Fluids and electrolytes	11 013 (16.3)	9055 (15.1)	1252 (26.3)	706 (28.4)	<0.001
Anaemia	10 898 (16.2)	9012 (15.0)	1212 (25.5)	674 (27.1)	<0.001
Elixhauser predicted mortality[¶]	0.3 (0.2–0.8)	0.3 (0.2–0.7)	0.6 (0.3–1.6)	0.6 (0.3–1.8)	<0.001
SOFA score[+]					<0.001
0	45 663 (67.8)	41 966 (69.8)	2431 (51.2)	1266 (51.0)	
1–3	18 055 (26.8)	15 115 (25.1)	1926 (40.5)	1014 (40.8)	
4–6	3476 (5.2)	2915 (4.8)	370 (7.8)	191 (7.7)	
>6	168 (0.2)	32 (0.1)	24 (0.5)	12 (0.5)	

Data are presented as n, n (%) or median (interquartile range). SOFA: Sequential Organ Failure Assessment. [#]: the top 5 Elixhauser comorbidities were included; [¶]: Elixhauser predicted mortality is based on Elixhauser comorbidities; [+]: scores range from 0 to 24, with higher scores suggesting higher mortality.

2.5, 95% CI 2.2–2.7; aHR 1.7, 95% CI 1.5–1.8) (figure 4; full model in supplementary table E4). There was no difference in 2-year mortality between mild and moderate-to-severe dyspnoea.

Including dyspnoea in prediction models improved the characteristics of the multivariable logistic regression model for inpatient death over a model with severity of illness and comorbidities alone, but only slightly. The AIC decreased from 6492 to 6412 and the *C*-statistic increased from 0.86 to 0.87, suggesting dyspnoea offers limited benefit for inclusion with quantitatively intense modelling strategies for predicting patient harm.

Hospital resource use

Compared with patients who reported no dyspnoea, patients who reported moderate-to-severe dyspnoea on admission were nearly 3 times more likely to need a rapid response team activation (OR 2.9, 95% CI 2.6–3.2; aOR 1.9, 95% CI 1.7–2.1) or require transfer to the ICU (OR 2.7, 95% CI 2.4–3.1; aOR 1.8, 95% CI

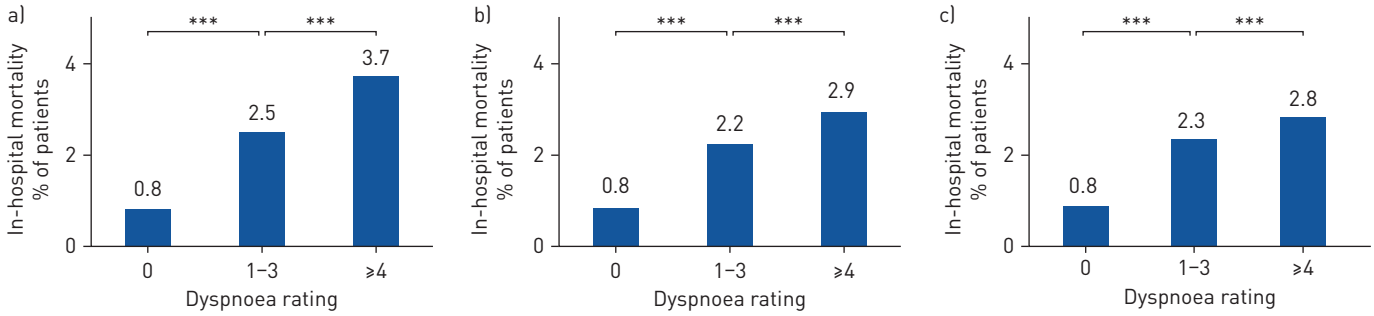

FIGURE 2 In-hospital mortality increases with level of a) self-reported dyspnoea at the time of admission, b) dyspnoea recalled in the past 24 h and c) any dyspnoea (before 24 h and on admission). ***: p<0.001. Reference level is a dyspnoea rating of 1–3.

1.6–2.1), stayed longer in the hospital (incidence rate ratio 1.38, 95% CI 1.36–1.40; adjusted incidence rate ratio 1.1, 95% CI 1.07–1.1) and were more likely to need extended care on discharge (OR 2.2, 95% CI 2.0–2.4; aOR 1.2, 95% CI 1.1–1.3). In addition, patients with any dyspnoea (*i.e.* dyspnoea >0) were 1.5 times more likely to return to the hospital at 7 days (OR 1.5, 95% CI 1.3–1.9; aOR 1.2, 95% CI 1.1–1.5) and 1.6 times more likely to return to the hospital at 30 days (OR 1.6, 95% CI 1.5–1.8; aOR 1.2, 95% CI 1.1–1.4). Figure 5 presents the outcomes related to zero, mild and moderate-to-severe dyspnoea on admission and related to recalled dyspnoea in the past 24 h. Supplementary figure E2 provides the unadjusted and adjusted odds ratios (or incidence rate ratios, in the case of length of stay) of mild dyspnoea compared with zero dyspnoea, followed by moderate-to-severe dyspnoea, for all other outcomes.

Patients who reported having dyspnoea at rest prior to admission used more hospital resources than patients who reported dyspnoea only with physical activities, including having a greater likelihood of rapid response team activation (371/1619 (23%) *versus* 822/4889 (17%); p<0.001) and an increased need for extended care on discharge (971/1619 (60%) *versus* 2768/4889 (56%); p<0.01). There was no difference in readmission at 30 days and 2-year mortality between patients with dyspnoea at rest and patients with dyspnoea with greater activity.

Subgroup analyses

Outcomes among patients with respiratory and cardiovascular diagnoses

Contrary to our expectation, patients discharged with a diagnosis of respiratory disease and who reported dyspnoea ⩾4 on admission had the same risk of in-hospital death as patients with respiratory diagnoses

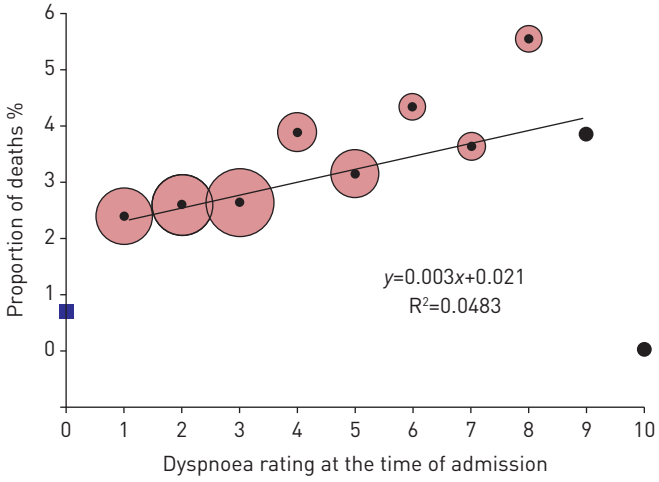

FIGURE 3 In-hospital death by dyspnoea rating on admission. The size of the shaded circles represents the number of patients. The blue square indicates a dyspnoea rating of 0. The number of patients with no dyspnoea is 60 128 (90%). The linear regression excludes dyspnoea rating at 0 and 10, and the fit is weighted by population size.

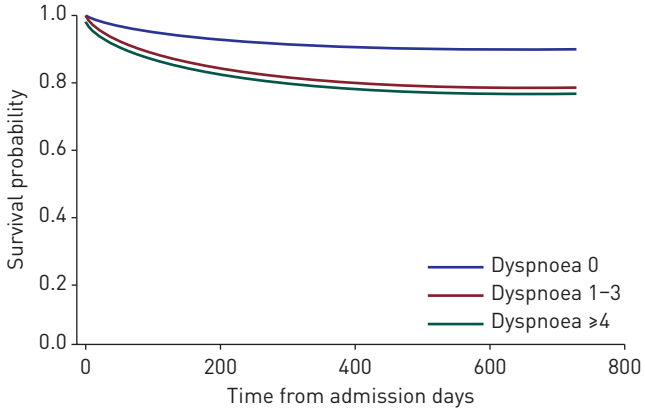

FIGURE 4 Kaplan–Meier curve displaying estimated survival probability in the 2 years following admission, stratified by dyspnoea rating on initial admission to the hospital. Cox proportional hazard analysis showed a two-fold increase in hazard in both mild and moderate-to-severe dyspnoea compared with no dyspnoea. However, there was no difference between mild and moderate-to-severe dyspnoea.

without dyspnoea (26/1498 (1.7%) *versus* 30/1581 (1.9%); p=0.8). Dyspnoeic patients with respiratory diseases were not more likely to be readmitted at 7 or 30 days (7 days: 82/1498 (5.5%) *versus* 74/1581 (4.7%); p=0.12; 30 days: 265/1498 (17.6%) *versus* 258/1581 (16.3%); p=0.5). However, respiratory patients with dyspnoea ⩾4 on admission did have a higher risk of mortality at 2 years (78/657 (19.9%) *versus* 226/2422 (15.6%); p=0.04). For patients discharged with cardiovascular disease, the presence of dyspnoea ⩾4 on admission predicted increased adverse outcomes (in-hospital death: 23/813 (2.8%) *versus* 117/10 097 (1.1%); p<0.001). Among patients discharged without a primary diagnosis of respiratory or cardiovascular diseases, dyspnoea had a strong association with in-hospital mortality (92/2483 (3.7%) *versus* 617/64 878 (0.9%); p<0.001).

Patients who were unable to respond

706 (1%) of patients were described as "unable to respond" when questioned about dyspnoea on admission and were not included in the overall analysis. These patients were older (median (IQR) 77 (26) *versus* 60 (29) years), had shorter length of stay (median 5 (4) *versus* 3 (4) days), and were at increased risk of in-hospital mortality (OR 5.9, 95% CI 4.3–8.1; aOR 2.6, 95% CI 1.8–3.8) and 2-year mortality (OR 4.8,

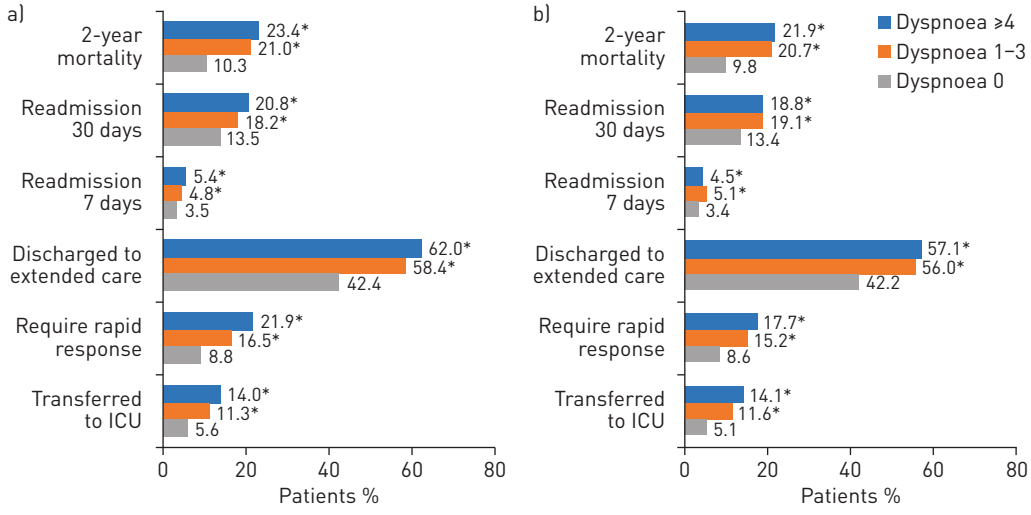

FIGURE 5 Patient outcomes and hospital resources associated with dyspnoea at a) time of admission interview and b) recalled in the past 24 h. ICU: intensive care unit. *: p<0.05. Reference level is a dyspnoea rating of 0.

95% CI 4.1–5.7; aOR 2.5, 95% CI 2.1–3.0) compared with those who were able to respond to the dyspnoea questions (supplementary table E5).

Prevalence of pain and association with outcomes

Pain was prevalent on admission to the hospital with 35 502/67 362 patients (53%) rating pain >0 and 24 348/67 362 patients (36%) rating pain ⩾4. However, the presence of pain, regardless of intensity, was not associated with increased in-hospital mortality (pain 1–3: OR 0.4, 95% CI 0.3–0.6; p<0.001; pain 4–10: OR 0.8, 95% CI 0.7–0.9; reference: pain 0) (supplementary figure E3), thus mortality was somewhat lower in patients reporting pain. Results were null for pain rated at ⩾4 for rapid response activation and readmission at 7 days. However, an initial hospital rating of ⩾4 for pain (compared with a pain rating of 0) was associated with lower risk of subsequent ICU transfer (OR 0.5, 95% CI 0.5–0.6), fewer readmissions at 30 days (OR 0.9, 95% CI 0.8–0.9) and fewer deaths at 2 years (OR 0.6, 95% CI 0.5–0.7) (supplementary figure E4).

Outcomes among patients using an alternative dyspnoea rating threshold of 3

In an *a posteriori* analysis, we evaluated whether our prior proposed cut-off of a dyspnoea rating of 4 was distinct from other possible cut-offs; as an alternative, we used a cut-off of a rating of 3. Patients with dyspnoea ⩾3 on admission were also noted to also be at increased odds of death by in-hospital mortality (OR 4.6, 95% CI 3.7–5.8; p<0.001; aOR 2.7, 95% CI 2.2–3.3; p<0.001) and at 2 years (HR 2.3, 95% CI 2.1–2.5; aHR 1.5, 95% CI 1.4–1.7; p<0.001) (supplementary table E6a and b). We further repeated the analyses with dyspnoea reported in the past 24 h (supplementary table E6c and d) and across all remaining secondary outcomes (supplementary table E7 and supplementary figure E5) using this alternative cut-off.

Discussion

Our study is the first large-scale quantification of risk of adverse outcome associated with dyspnoea among all non-ICU patients at the time of hospital admission. There are two reasons to assess dyspnoea: 1) to identify a common and uncomfortable symptom to improve patient comfort [9], and 2) based on our present findings, dyspnoea at any level can identify patients at increased risk of hospital resource use and death.

Prior large-scale investigations have examined the relationship of dyspnoea to risk of harm in particular categories of patients, *e.g.* those at risk for cardiac disease [16–18], pulmonary disease [19], gastrointestinal disease [20, 21] and others. Other investigations have looked at the relationship of dyspnoea to risk of harm in the general (non-hospitalised) population [8].

In contrast to prior studies of inpatients, our study does not limit the population of interest to a specific diagnosis or category of patients. This universal dyspnoea assessment has important practical consequences: institution of dyspnoea assessment for all patients is more effective, and in some ways easier, than if a diagnosis were required before collecting dyspnoea assessments. Furthermore, our data show that the most important predictions arose in patients who did not have a primary discharge diagnosis of cardiopulmonary disease; these were missed entirely by strategies used in prior studies.

To properly evaluate the benefit of any screening test, one must consider the burden, inconvenience and test characteristics, as well as the effectiveness, risk and cost of possible interventions based on the test results [22]. The bedside measurement of dyspnoea is promising in several ways. First, as we have previously described, the routine evaluation of dyspnoea performed at the time of admission and for each subsequent shift by nurses throughout our hospital is fast, feasible and inexpensive; each evaluation takes <1 min to complete and results are immediately available to care staff [10, 23]. Second, our results suggest that measuring dyspnoea at the bedside is a useful, straightforward way of identifying patients at risk for death during the remainder of the hospitalisation and after discharge. However, we do not yet know whether early intervention in dyspnoea, either in the hospital or on discharge, will improve outcomes for these patients. There are reasons to think this simple assessment will be useful: abnormal vital signs have previously been used in medical emergency team activation to align hospital resources with patients at high risk of clinical decline [24, 25]. The presence of any dyspnoea (*i.e.* a dyspnoea rating of ⩾1) had a specificity of 89% and sensitivity of 30% to identify patients who were at risk of in-hospital death. Patient report of a dyspnoea rating of ⩾4 had a specificity of 96% (at the expense of a sensitivity of 13%); the false-positive rate in our study (96%) was identical to the false-positive rate in the National Lung Cancer Screening Trial, which used far greater resources [26]. The absolute risk of death in our study for patients with dyspnoea on admission is comparable to the risk of death from lung cancer for the control group in the Lung Cancer Screening Trial [26]. Finally, apart from its utility as a signal of future outcomes, the symptom burden of dyspnoea is enough to warrant more aggressive attention and treatment [27]. Given the

low cost of the screening, the burden of the symptom of dyspnoea for patients and the opportunity to obtain a powerful signal of harm to potentially improve outcomes, we see these results as a call to assess and document dyspnoea in all patients, and to investigate interventions to reduce adverse outcomes.

As we and other authors have noted previously, dyspnoea is most commonly associated with increased respiratory demand combined with cardiopulmonary limitations; ambulatory patients frequently moderate their activity to minimise respiratory demand and avoid discomfort [28]. We found that patients who report dyspnoea at rest prior to arrival at the hospital, and consequently are unable to moderate activity to mitigate symptoms, are particularly vulnerable to harm.

Pain is routinely measured across hospitals. We performed the same statistical analyses to test the relationship between pain and adverse outcomes. In contrast to dyspnoea, pain was not associated with adverse outcomes. In fact, patients with pain fared slightly better than those without pain, indicating that the observation was not due to lack of statistical power. We can imagine three possible reasons that pain did not predict adverse outcomes. 1) Many sources of pain (*e.g.* from broken bones) are not associated with critical homeostatic systems; an analysis restricted to visceral pain might yield different results, but this information was not recorded in the Initial Patient Assessment. In fact, the clinical service for >30% of the patients who reported pain ⩾4 was either the general surgery or orthopaedic surgery service (supplementary table E8). 2) Pain is aggressively managed, which may remove much of the signal; this seems less likely as the range of pain ratings was similar to the range of dyspnoea ratings. 3) Pain is so routinely measured that when we measure pain in everyone, we may be enriching our denominator for the less sick patients, simply because of the routine prevalence of pain.

Our study has several limitations. First, it was conducted at a single, tertiary academic health centre. Second, diagnoses were identified based on billing data, which can only be elicited on discharge. These diagnoses were based on the Clinical Classifications Software proposed by the Agency for Healthcare Research and Quality [14] so as to standardise and replicate the designation of diagnoses into groups such as “respiratory diseases” or “cardiovascular diseases”; however, clustering of diagnoses may be overly broad. Third, real-world measurement of dyspnoea may vary depending on how a nurse or physician asks about patient symptoms; we know that in many cases nurses ask a yes/no question and record a 0 for a no answer, and in some cases nurses modify or replace the patient report with their own judgement based on signs [10]. Fourth, the exact timing of dyspnoea assessment in the Initial Patient Assessment is unknown; it is done sometime during the first 12 h in the unit. Furthermore, dyspnoea rating is not documented on arrival in our emergency department. For these reasons, we do not know the patient’s dyspnoea intensity on arrival at the hospital and how dyspnoea has been modified by the first few hours of treatment. Fifth, we hypothesised that a dyspnoea rating of 4 would be a useful cut-off, having based this choice on our research group’s finding that two-thirds of patients deemed dyspnoea <4 “acceptable” [29]. However, in the *post hoc* analyses to evaluate the utility of this cut-off, we found that a cut-off of 3 was associated with similar risks of death. We note that these findings challenge the utility of a cut-off of 4, suggesting that any elevation of dyspnoea is the only major distinction, which may lead to future investigation in both rating use and dyspnoea.

We have shown that a one-time measurement of dyspnoea during the first shift on the hospital unit has a strong predictive value for adverse outcomes; it is likely that repeated dyspnoea assessment at the time of arrival and throughout hospitalisation would further improve risk prediction [30]. This simple assessment can be utilised even in hospitals without the resources to provide more data-intense modelling of illness severity in real-time.

Conclusions

Dyspnoea assessment takes <1 min, based on time–motion data at our institution [10], and is well received by nurses. A patient’s report of any dyspnoea (*i.e.* ⩾1 on a rating scale) on admission or recalled dyspnoea within 24 h prior to arrival to the hospital carried a significant risk of death and adverse outcome, both in the hospital and following discharge. This association was most powerful in patients whose discharge diagnosis did not suggest dyspnoea. Because dyspnoea is prevalent among hospitalised patients [9, 31], is intensely distressing [32] and predicts adverse outcomes, we believe it is important to routinely assess dyspnoea in all patients.

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