EUROPEAN RESPIRATORY *journal*

FLAGSHIP SCIENTIFIC JOURNAL OF ERS

Early View

Original article

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Please cite this article as: Stevens JP, Dechen T, Schwartzstein RM, *et al*. Association of dyspnea, mortality, and resource use in hospitalised patients. *Eur Respir J* 2021; in press (https://doi.org/10.1183/13993003.02107-2019).

Association of dyspnea, mortality, and resource use in hospitalized patients

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Running title: Prevalence of dyspnea among hospitalized patients at the time of admission

Key words: dyspnea, outcomes, mortality, symptoms

Word counts:

Abstract: 290

Main manuscript: 4124

Funding

This project was supported by NR010006 from the National Institutes of Health. The content is solely the responsibility of the authors and does not represent the official views of the funding agency. JPS is also supported by grant number K08HS024288 from the Agency for Healthcare Research and Quality. The content is solely the responsibility of the authors and does not represent the official views of the Agency for Healthcare Research and Quality. JPS is also supported by a grant from the Doris Duke Charitable Foundation.

Take home message: In our single center cohort study of > 67,000 patients, dyspnea reported by patients during a rapid nursing assessment on admission was associated with a 2x odds of death in 2 years. A low-cost screening tool can be used to identify patients at risk of future harm.

Abstract

As many as 1 in 10 patients experience dyspnea at hospital admission but the relationship between dyspnea and patient outcomes is unknown. We sought to determine whether dyspnea on admission predicts outcomes.

We conducted a retrospective cohort study in a single, academic medical center. We analyzed 67,362 consecutive hospital admissions with available data on dyspnea, 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 dyspnea at the time of admission and recalled dyspnea experienced in the 24 hours 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 dyspnea were at an increased risk of death during that hospital stay; the greater the dyspnea, the greater the risk of death (dyspnea=0, 0.8% in-hospital mortality; dyspnea=1-3, 2.5% mortality; dyspnea $\geq$4, 3.7% mortality, $p<0.001$). After adjustment for patient comorbidities, demographics, and severity of illness, increasing dyspnea remained associated with inpatient mortality (dyspnea 1-3, aOR 2.1, 95% CI 1.7-2.6; dyspnea $\geq$4 , aOR 3.1, 95% CI 2.4-3.9). Pain did not predict increased mortality. Patients reporting dyspnea also used more hospital resources, were more

likely to be readmitted, and were at increased risk of death within 2 years (dyspnea=1-3 adjusted HR 1.5, 95% CI 1.3-1.6; dyspnea ≥4 adjusted HR 1.7, 95% CI 1.5-1.8).

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

Introduction

Dyspnea, the symptom of breathing discomfort or shortness of breath, is highly distressing for patients. Basoglu et al. have deemed this symptom so severe as to characterize the freedom from dyspnea a human right.[1] Using various scales, several authors have described the prevalence of dyspnea 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 1 in 10 patients admitted to the hospital experience dyspnea on admission.[9]

Despite the prevalence of dyspnea, little is known about patient outcomes associated with dyspnea 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 dyspnea simply by asking the patient to provide a rating. We sought to characterize the patient outcomes and hospital resources associated with dyspnea. Dyspnea ratings were obtained by the bedside nurse as part of the Initial Patient Assessment that is administered during the first 12 hrs of admission to non-ICU units. Patients provided a rating of current dyspnea and a rating of dyspnea during the 24 hrs prior to unit admission. Our expectation was that patients with ongoing or recent dyspnea would be at higher risk of death. Our statistical hypothesis was that there was no difference in mortality between patients with and without dyspnea. We also asked whether patients with dyspnea 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 collect dyspnea 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 3/25/2014 and 9/30/2016 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 or greater years of age; patients who are admitted directly to intensive care units and obstetric units do not complete the Initial Patient Assessment.

Study Variables

Assessment of dyspnea

Starting 3/25/2014, the Initial Patient Assessment (IPA) performed by nurses at our hospital included questions of patients about breathing discomfort; the IPA 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 where 10 is "unbearable", 2) their worst breathing discomfort in the past 24 hours on a 0 to 10

scale, 3) and what level of activity produced the worst dyspnea in the past 24 hours. Level of activity was recorded on a four item categorical scale - Resting, Light, Moderate or Heavier activity; nurses use common standardized activity examples to enhance understanding (please see e-Figure 1 for the visualization of the nursing clinical tool). We described our method of assessing dyspnea on admission in our previous study of the prevalence of dyspnea [9] and in our study of the nursing staff feedback on the implementation of routine dyspnea 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 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 intensive care unit. For patients who survived the initial hospitalization, 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 gender, was collected for all hospitalized 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, SOFA) [12, 13]. Discharge diagnosis was identified based on billing codes and was further categorized using the clinical classification 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 dyspnea assessment on admission (and therefore had missing data on the exposure of dyspnea measurement) were compared to 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 dyspnea and another routinely assessed patient symptom.

Statistical Analysis

All statistical tests were performed using SAS (v. 9.4, SAS Institute Inc., Cary, NC). Based on prior recommendations from the pain literature and our own pilot study [15], we *a priori* grouped dyspnea ratings into three categories: 'no dyspnea' (rating=0), 'mild dyspnea' (rating=1-3), and 'moderate-to-severe dyspnea' (ratings $\geq$4) for analysis. While

the threshold criteria for these levels were arbitrary, the distinctions allowed us to evaluate whether any dose-response relationship between dyspnea and the outcomes of interest existed. We tested for significant differences using chi-squared tests for categorical variables and Kruskal-Wallis test for continuous variables. We fit generalized 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 hazard ratio between patients with no dyspnea, mild dyspnea, and moderate-severe dyspnea. A 2-sided type I error of 0.05 or less 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 in-patient mortality using the same analysis used for dyspnea. Second, we hypothesized that the association of dyspnea with outcomes would differ in patients admitted with respiratory or cardiovascular diseases as compared to other diagnoses. Diagnoses were determined based upon discharge coding. To test this hypothesis, we conducted subgroup analyses in these groups.

Furthermore, we hypothesized that dyspnea 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 dyspnea measurement to these standardized risk assessments. Finally, we tested whether adding routine dyspnea 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 dyspnea using Akaike Information Criteria (AIC), Hosmer-Lemeshow goodness of fit, and area under the receiver operating characteristic curve (AUC).

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

Results

We studied a total of 67,362 admissions (Figure 1, Consort diagram). We have previously reported on the prevalence of dyspnea and the demographic characteristics of patients who report dyspnea[9]. The overall cohort was 38,256/67,362 (57%) female, 20,841 (31%) nonwhite, and had a median age of 60 years (IQR 29). Patients were discharged with a wide range of diagnoses, with the five most common being diseases of the circulatory system 10,910 (16%), 8371 diseases of the digestive system (13%),

pregnancy complications 8006 (12%), described in e-Table 1-2), neoplasm 7549 (11%), injury and poisoning 7500 (11%). The median length of stay in the hospital was 3 days (IQR 4). At some point during the admission 4265 patients (7%) were transferred to the intensive care unit. About half the patients (34,073 or 51%) were admitted from the Emergency Department. Prior treatment in the ED probably reduced dyspnea and pain before the unit admission assessment reported here; nonetheless, the prevalence of dyspnea on admission to the medical-surgical unit in these unplanned admissions was 3 to 4 times the prevalence among planned admissions. The patient characteristics are described in Table 1.

Mortality

Patients experiencing dyspnea at the time of admission had different risks for mortality during the hospitalization. Patients reporting no dyspnea had an in-hospital mortality of 496/60,128 (0.8%). Patients who reported mild dyspnea (rating 1-3) had a mortality of 121/4,751 (2.6%, OR 3.1, 95% CI 2.6-3.8). Patients with more severe dyspnea (rating 4-10) had a mortality rate of 92/2,483 (3.7%, OR 4.6, 95% CI 3.7-5.8; Figure 2). There was a relationship between mortality and non-zero dyspnea ratings dyspnea measured as scalar values, shown as a regression line in Figure 3, where the area of 'bubbles' represents the number of data points at each value (data available in e-Table 3. After adjustment for patient demographics and severity of illness and comorbidities, patients who reported dyspnea 1-3 on admission remained at a two-fold increase odds of in-hospital death (aOR 2.1, 95% CI 1.7-2.6, $p<0.001$) and patients who

reported dyspnea ≥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 e-Table 4.

Patients who had dyspnea in the 24 hours prior to admission had different risks for mortality; 90/4111 (2.2%) of patients with mild dyspnea 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 (2.8%) of patients with moderate to severe dyspnea (OR 3.6, 95% CI .0-4.3; aOR 2.3, 95% CI 1.9-2.9). In-hospital mortality of patients with no dyspnea was 496/56,183 (0.8%).

Finally, for patients who reported dyspnea in the 24 hours prior to admission, we assessed whether the patient's level of activity at the time of the dyspnea was associated with mortality. Recalled dyspnea during heavier activity was associated with less mortality than recalled dyspnea at rest or lighter activity. Any dyspnea reported at rest was associated with an in-hospital mortality rate of 60/1619 (3.7%) for dyspnea 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-severe dyspnea reported on admission was associated with increased risk of death at 2 years as compared with patients who reported no dyspnea (Mild vs no dyspnea, HR 2.1, 95% CI 2.0-2.3; adjusted HR 1.5, 95% CI 1.3-1.6; for moderate-severe vs no dyspnea, HR 2.5, 95% CI 2.2-2.7; adjusted HR 1.7, 95% CI 1.5-1.8; Figure 4, full model in e-Table 4). There is no difference in 2-year mortality between mild and moderate-severe dyspnea.

Including dyspnea 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 fell from 6492 to 6412 and the C-statistic rose from 0.86 to 0.87, suggesting dyspnea offers limited benefit for inclusion with quantitatively-intense modeling strategies for predicting patient harm.

Hospital resource use

As compared with patients who reported no dyspnea, patients who reported moderate to severe dyspnea on admission were nearly 3 times more likely to need a rapid response team activation (unadjusted OR 2.9, 95% CI 2.6-3.2; aOR 1.9, 95% CI 1.7-2.1) or require transfer to the intensive care unit (unadjusted OR 2.7, 95% CI 2.4-3.1; aOR 1.8, 95% CI 1.6-2.1), stayed longer in the hospital (unadjusted rate ratio 1.38, 95% CI 1.36-1.40; adjusted IRR 1.1, 95% CI 1.07-1.1), and were more likely to need extended care on discharge (unadjusted OR 2.2, 95% CI 2.0-2.4; aOR 1.2, 95% CI 1.1-1.3). In addition, patients with any dyspnea (i.e. dyspnea>0) were 1.5 times more likely to return to the hospital at 7 days (unadjusted OR 1.5, 95% CI 1.3-1.9; aOR 1.2, 95%CI 1.1-1.5) and 1.6 times more likely at 30 days (unadjusted OR 1.6, 95% CI 1.5-1.8; aOR 1.2, 95% CI 1.1-1.4). Figure 5 describes the outcomes related to zero, mild, and moderate-to-severe dyspnea on admission and related to recalled dyspnea in the past 24 hours. eFigure-2 provides the unadjusted and adjusted odds (or IRR, in the case of length of stay) of mild dyspnea as compared with dyspnea of 0, followed by moderate to severe dyspnea, for all other outcomes.

Patients who reported having dyspnea at rest prior to admission used more hospital resources than patients who reported dyspnea only with physical activities, including having a greater likelihood of rapid response team activation (371/1619 (23%)

vs 822/4889 (17%), p<.001), and an increased need for extended care on discharge (971/1619 (60%) vs 2768/4889 (56%), p<.01). There is no difference in readmission at 30 days and 2-year mortality between with dyspnea at rest and patients with dyspnea 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 dyspnea ≥ 4 on admission had the same risk of in-hospital death as patients with respiratory diagnoses without dyspnea (26/1498 (1.7%) versus 30/1581 (1.9%), p=0.8). Dyspneic patients with respiratory diseases were not more likely to be re-admitted at 7 or 30 days (7 days: 82/1498 (5.5%) vs74/1581 (4.7%), p=0.12; 30 days: 265/1498 (17.6%) vs 258/1581 (16.3%), p= 0.5). However, respiratory patients with dyspnea ≥ 4 on admission did have a higher risk of mortality at two years (78/657 (19.9%) vs 226/2422 (15.6%), p=0.04). For patients discharged with cardiovascular disease, the presence of dyspnea ≥ 4 on admission predicted increased adverse outcomes (in-hospital death: 23/813 2.8% vs 117/10097 1.1%, p=<.001). Among patients discharged without a primary diagnosis of respiratory or cardiovascular diseases, dyspnea had a strong association with in-hospital mortality (92/2483 (3.7%) v 617/64878 (0.9%), p=<.001).

Patients who were unable to respond

706 (1%) of patients were described as 'unable to respond' when questioned about dyspnea on admission and were not included in the overall analysis. These patients were older (77yrs IQR (26) vs 60yrs IQR (29) years), had shorter length of stay (5 IQR (4) vs 3 IQR (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 95% CI (4.1-5.7), aOR 2.5 (2.1-3.0)) compared to those who were able to respond to the dyspnea questions (e-Table 5).

Prevalence of pain and association with outcomes

Pain was prevalent on admission to the hospital, with 53% of patients (35,502/67,362) rating pain greater than zero and 24,348/67,362 (36%) of patients rating 4 or higher. 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=<.001; Pain 4-10; OR 0.8, 95% CI 0.7-0.9; reference: pain=0; e-Figure 3), thus mortality was somewhat lower in patients reporting pain. Results were null for pain rated at 4 or more for rapid response activation and readmission at 7 days. However, an initial hospital rating of 4 or more out of 10 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; e-Figure 4).

Outcomes among patients using an alternative threshold of dyspnea ≥3

In an *a posteriori* analysis, we evaluated whether our prior proposed cut-off of a dyspnea ≥ 4 was distinct from other possible cut-offs; as an alternative, we used a cut-off of a rating of 3 or more. Patients with dyspnea ≥3 on admission were also noted to also be at increased odds of death by in-hospital mortality (unadjusted 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 (unadjusted 2.3, 95% CI 2.1-2.5; aHR 2.3, 95% CI 2.1-2.5, p<0.001; e-table 6a,b). We further repeated the analyses with dyspnea reported in the past 24 hours (e-table 6c,d) and across all remaining secondary outcomes (e-table 7, e-Figure 5) using this alternative cut-off.

Discussion

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

Prior large-scale investigations have examined the relationship of dyspnea to risk of harm in particular categories of patients: for example, those at risk for cardiac disease [16-18], for pulmonary disease[19], for gastrointestinal disease [20, 21] and others. Others have looked at the relationship of dyspnea to risk of harm in the general (un-hospitalized) 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 dyspnea assessment has important practical consequences – institution of dyspnea assessment for all patients is more effective, and in some ways easier, than if a diagnosis were required before collecting dyspnea assessments. Furthermore, our data show that the most important predictions arose in patients who do 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, the inconvenience, and the test characteristics, as well as the effectiveness, risk, and cost of possible interventions based on test results [22]. The bedside measurement

of dyspnea is promising in several ways. First, as we have previously described, the routine evaluation of dyspnea performed at the time of admission and for each subsequent shift by nurses throughout our hospital is fast, feasible, and inexpensive; each evaluation takes less than one minute to complete and results are immediately available to care staff [10, 23]. Second, our results suggest that measuring dyspnea at the bedside is a useful, straightforward way of identifying patients at risk for death during the remainder of the hospitalization and after discharge. However, we do not yet know whether early intervention in dyspnea, 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 dyspnea (i.e. a dyspnea rating of 1 or more) had a specificity of 89% and sensitivity of 30% to identify patients who were at risk of in-hospital death. Patient report of dyspnea of 4 or more 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 dyspnea 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 dyspnea is enough to warrant more aggressive attention and treatment [27]. Given the low cost of the screening, the burden of the symptom of dyspnea 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 dyspnea in all patients, and to investigate interventions to reduce adverse outcomes.

As we and other authors have noted before, dyspnea is most commonly associated with increased respiratory demand combined with cardiopulmonary limitations; ambulatory patients frequently moderate their activity to minimize respiratory demand and avoid discomfort.[28] We found that patients who report dyspnea 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 did the same statistical analyses to test the relationship between pain and adverse outcomes. In contrast to dyspnea, 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: a) 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 IPA. In fact, the clinical service for over 30% of the patients who reported pain of 4 or more was either the general surgery or orthopedic surgery service (e-Table 8). b) 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 dyspnea ratings. c) 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 center. Second, diagnoses were identified based on billing data, which can only be elicited on discharge. These diagnoses were based on clinical classification software proposed by the Agency for Healthcare Research and Quality [14] so as to standardize 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 dyspnea may vary depending on how a nurse or physician asks about patient symptoms; we know that in many cases nurses ask a yes-or-no question, and record a zero for a no answer and in some cases nurses modify or replace patient report with their own judgment based on signs.[10] Fourth, the exact timing of dyspnea assessment in the Initial Patient Assessment is unknown – it is done sometime during the first 12 hours in the unit. Furthermore, dyspnea rating is not documented on arrival in our Emergency Department. For these reasons, we do not know the patient’s dyspnea intensity on arrival at the hospital, and how dyspnea has been modified by the first few hours of treatment. Fifth, we hypothesized that a dyspnea rating of 4 would be useful cut-off, having based this choice on our research group’s finding that two-thirds of patients deemed dyspnea below 4 “acceptable” [29]. However, in post-hoc analyses described above 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 a rating of 4, suggesting that any elevation of

dyspnea is the only major distinction, which may lead to future investigation in both rating use and dyspnea.

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

Conclusion

Dyspnea assessment takes less than a minute, based on time-motion data at our institution [10], and is well received by nurses. A patient's report of any report of dyspnea (i.e., 1 or more on a rating scale) on admission or recalled dyspnea within 24 hours 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 dyspnea. Because dyspnea is prevalent among hospitalized patients[9, 31], is intensely distressing [32], and predicts adverse outcomes, we believe it is important to routinely assess dyspnea in all patients.

Acknowledgments

This project was supported by NR010006 from the National Institutes of Health. The content is solely the responsibility of the authors and does not represent the official views of the funding agency. JPS is also supported by grant number K08HS024288 from the Agency for Healthcare Research and Quality. The content is solely the responsibility of the authors and does not represent the official views of the Agency for Healthcare Research and Quality. JPS is also supported by a grant from the Doris Duke Charitable Foundation.

Conflict of interest

No conflict of interest exists for any of the authors.

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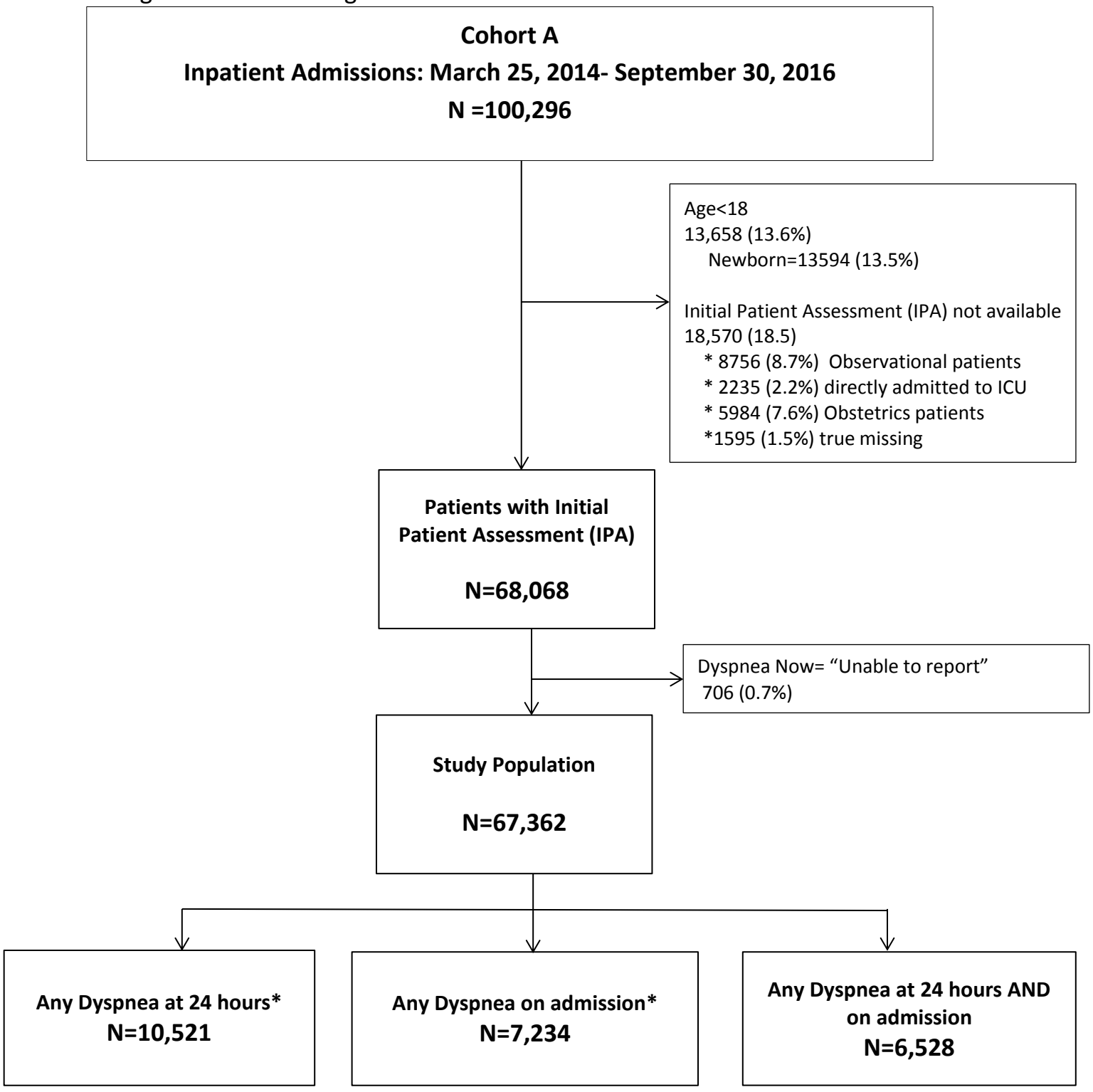
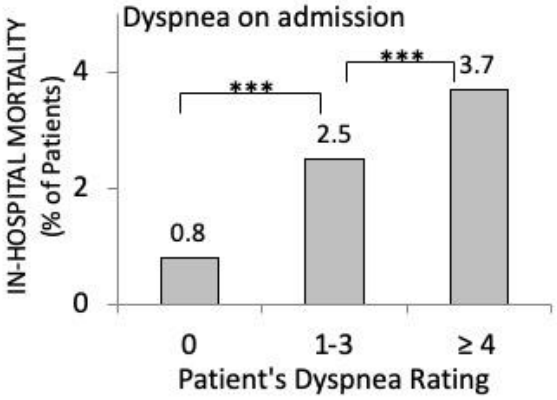
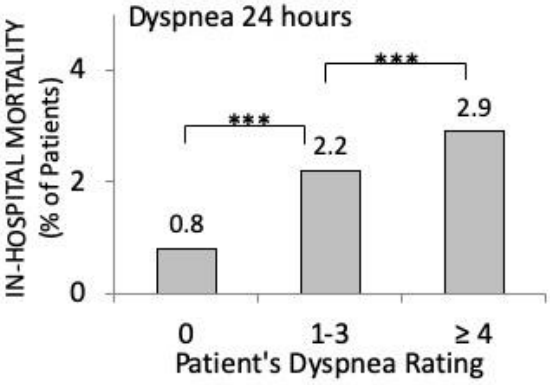
Figure 1. Consort diagram with exclusion criteria.



**Of note, these boxes are not exclusive of one another. "Any dyspnea at 24 hours" includes all patients who have rated dyspnea>0 at 24 hours. Should the patient also report dyspnea>0 on admission, she would be included in the third box, "Any dyspnea at 24 hours and on admission"*





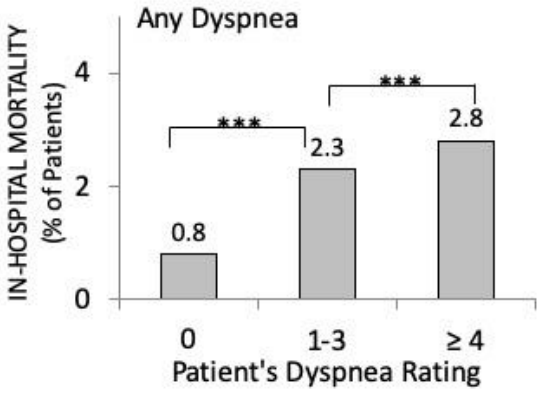


Figure 2. In-hospital mortality increases with level of self-reported dyspnea at the time of admission or dyspnea recalled in past 24 hours. Any dyspnea indicates dyspnea before 24 hours and on admission.
*** indicates p-value <.001, reference level is dyspnea=1-3

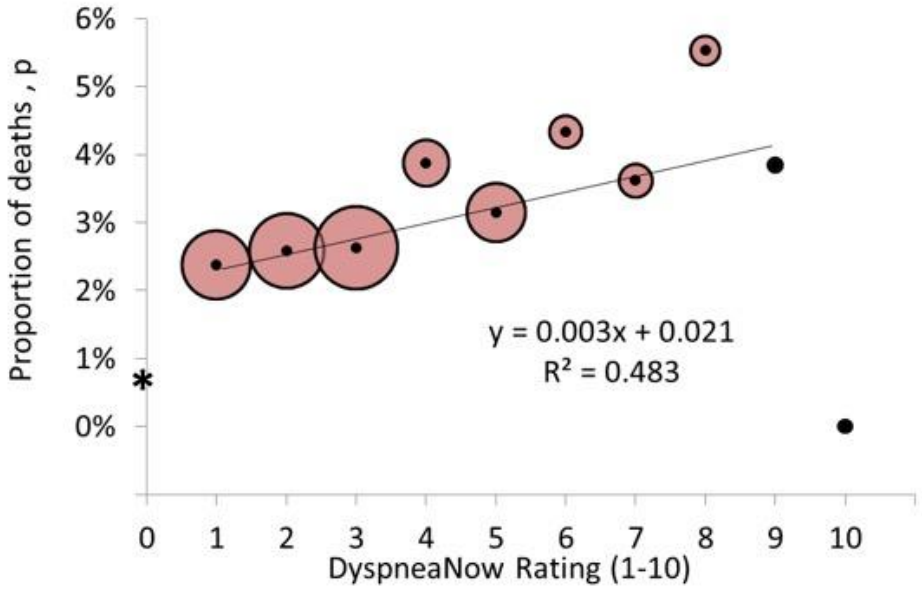


Figure 3: In hospital death by dyspnea rating on admission. Size of the bubble represents number of patients. * indicates dyspnea rating = 0. The number of patients with no dyspnea is 60128 (90%). The linear regression excludes dyspnea rating at 0 and 10 and the fit is weighted by population size.

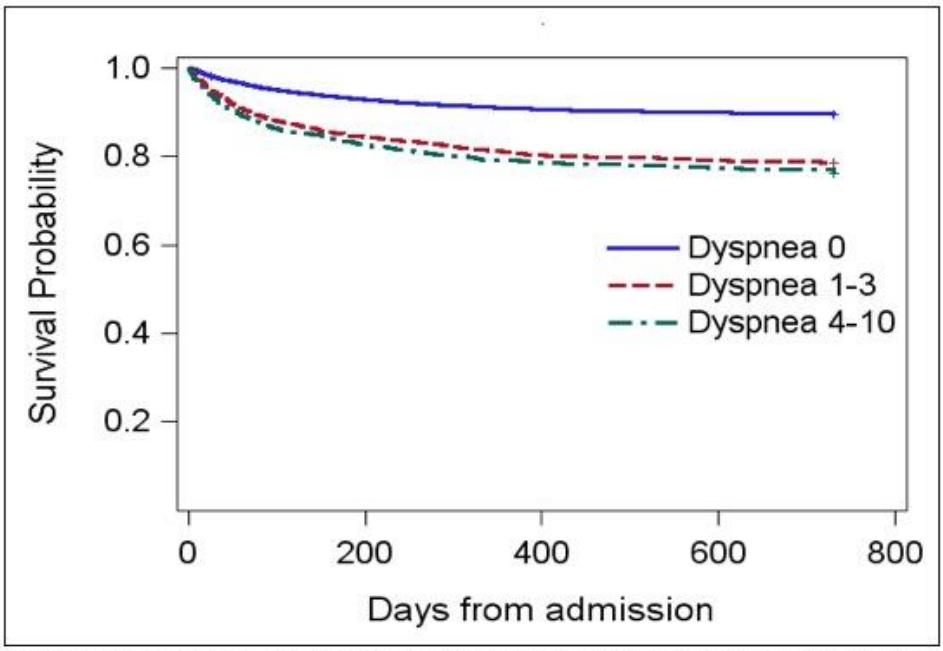


Figure 4. Kaplan-Meier Curve displaying estimated survival probability of mortality in the 2 years following admission, stratified by dyspnea rating on initial admission to the hospital. Cox-PH showed 2 fold increase in hazard in both mild and moderate-severe dyspnea compared to no dyspnea. However, there was no difference between mild and moderate-severe dyspnea.

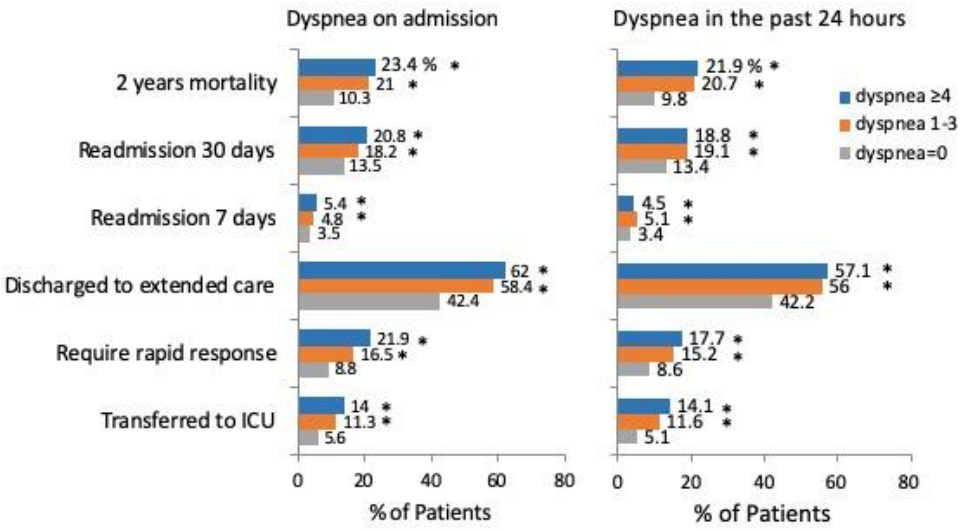


Figure 5. Patient outcomes and hospital resources associated with dyspnea at the time of admission interview and recalled in the past 24 hours. * indicates p-value <.05. Reference level is Dyspnea =0.

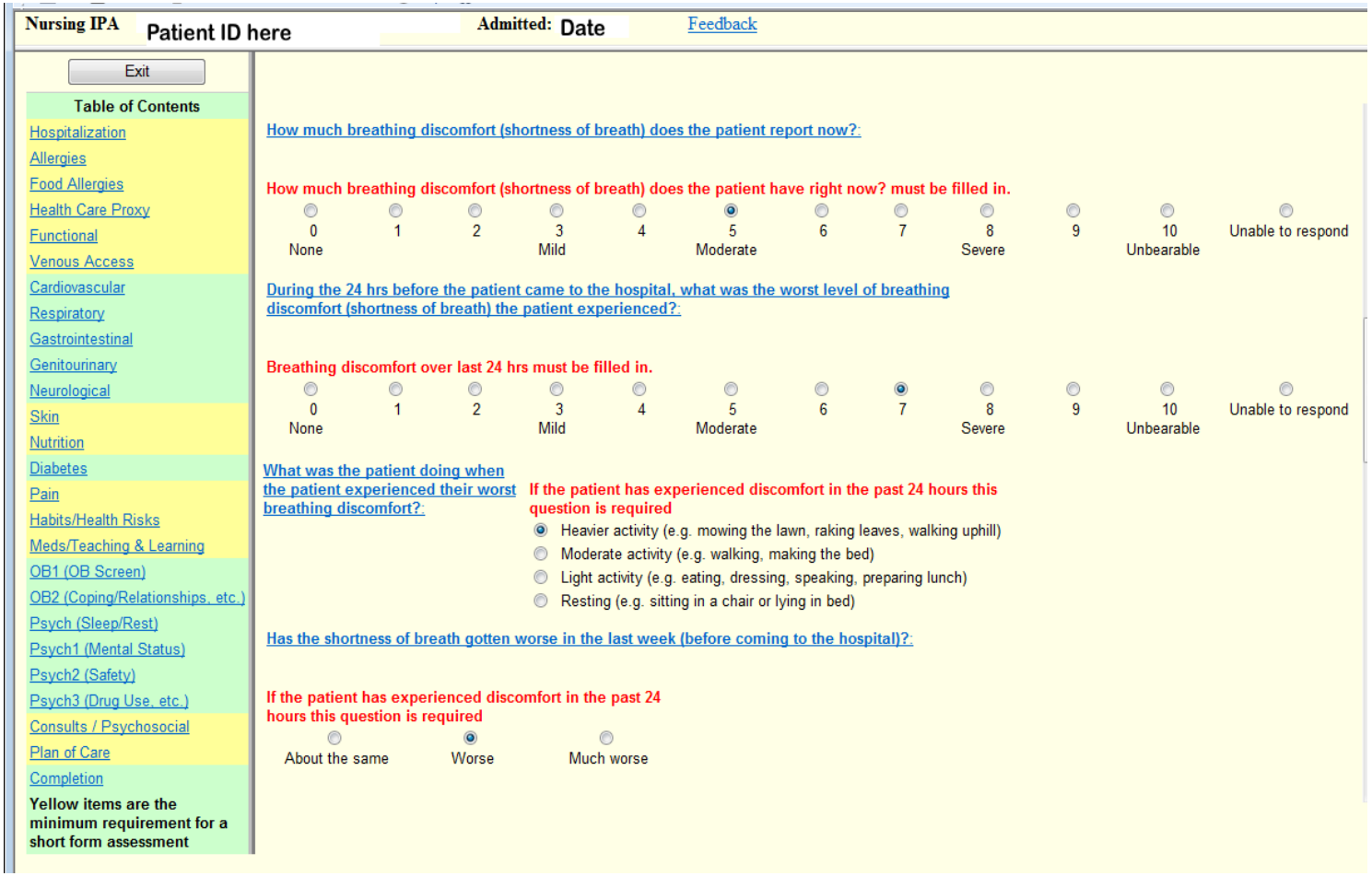
Table 1: Dyspnea on admission by patient characteristics

	Overall (n=67362)		Dyspnea 0 (n=60129)		Dyspnea 1-3 (n=4751)		Dyspnea ≥ 4 (n=2483)		P-value
	n	%	n	%	n	%	n	%	
Female	38256	56.8	34536	57.4	2430	51.2	1290	51.9	<.001
Race									<.001
White	46522	69.1	41386	68.8	3416	71.9	1720	69.3	
Black	9666	14.4	8353	13.9	799	16.8	514	20.7	
Others	11175	16.6	10390	17.2	536	11.3	249	10	
Age**, median [IQR]	60	[43-72]	59	[41-71]	67	[55-78]	66	[56-77]	<.001
English as a second language	6414	9.5	5649	9.4	533	11.2	232	9.3	<.001
Department of Admission									<.001
Medicine	33989	50.5	27992	46.6	3831	80.6	2166	87.2	
Surgery	16421	24.4	15411	25.6	743	15.6	267	10.7	
Others	16953	25.2	16726	27.8	177	3.7	50	2	
ED Admission									<.001
Yes	34073	50.6	28618	47.6	3482	73.3	1973	79.5	
No	22289	49.4	31510	52.4	1269	26.7	510	20.5	
Day of admission									<.001
Weekday	55565	82.5	49858	82.9	3773	79.4	1934	77.9	
Weekend	11798	17.5	10271	17.1	978	20.6	549	22.1	
Time of admission									<.001
Day (7a-7p)	33975	50.4	30809	51.2	2065	43.5	1101	44.3	
Night (7p-7a)	33388	49.6	29320	48.8	2686	56.5	1382	55.7	
Primary Diagnoses									<.001
Disease of the circulatory system	10910	4.6	8808	14.3	1489	31.3	813	32.7	
Diseases of the respiratory system	3079	16.2	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	13.2	29	0.6	7	0.3	
Neoplasms	7549	11.2	6885	11.6	151	7.9	187	7.5	
Injury and Poisoning	7500	11.1	6951	11.5	388	3.1	161	6.4	
Diseases of the musculoskeletal system	5072	7.5	4899	8.1	127	2.6	46	1.8	
All others	16876	25.1	15520	25.8	1236	27	446	17.9	
Comorbidities[a]									
Hypertension (yes)	32437	48.1	27974	46.5	2899	61	1564	62.9	<.001
Chronic Pulmonary Disease (yes)	11894	17.7	9427	15.7	1528	32.2	939	37.8	<.001
Depression (yes)	11360	16.8	9720	16.2	999	21	641	25.8	<.001
Fluids and Electrolytes (yes)	11013	16.4	9055	15.1	1252	26.3	706	28.4	<.001
Anemia (yes)	10898	16.1	9012	14.9	1212	25.5	674	27.1	<.001
Elixhauser predicted mortality[b,**] median [IQR]	0.3	0.2-0.8	0.3	0.2-0.7	0.6	0.3-1.6	0.6	0.3-1.8	<.001
SOFA score [c]									<.001
0	45663	67.8	41966	49.7	2431	51.2	1266	50.9	
1-3	18055	26.8	15115	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	0.2	24	0.5	12	0.4	

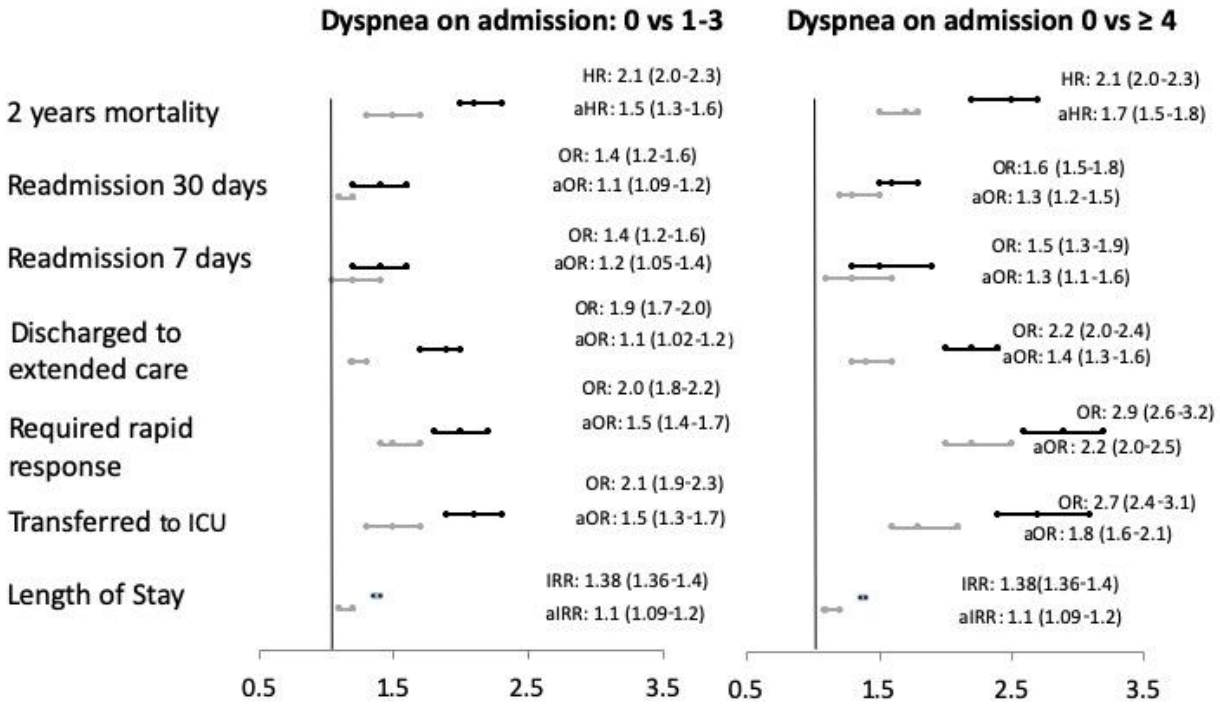
[a]The top 5 Elixhauser comorbidities were included.

[b]Elixhauser predicted mortality is based on Elixhauser comorbidities

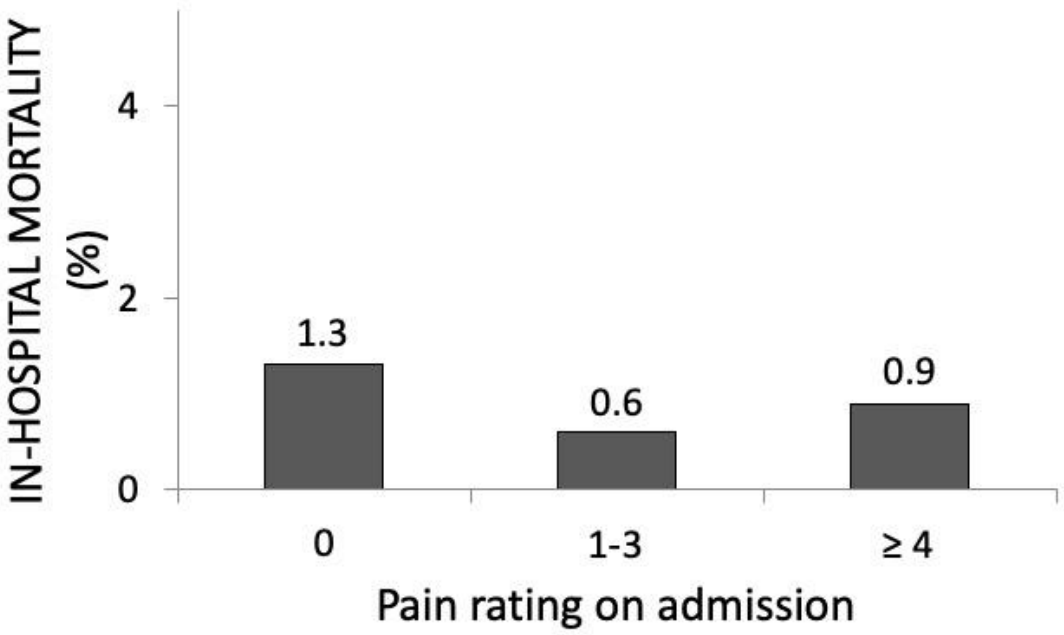
[c]SOFA denotes Sequential Organ Failure Assessment score. Scores range from 0 to 24, with higher scores suggesting higher mortality.
** denotes nonparametric comparisons with median and interquartile range as displayed results



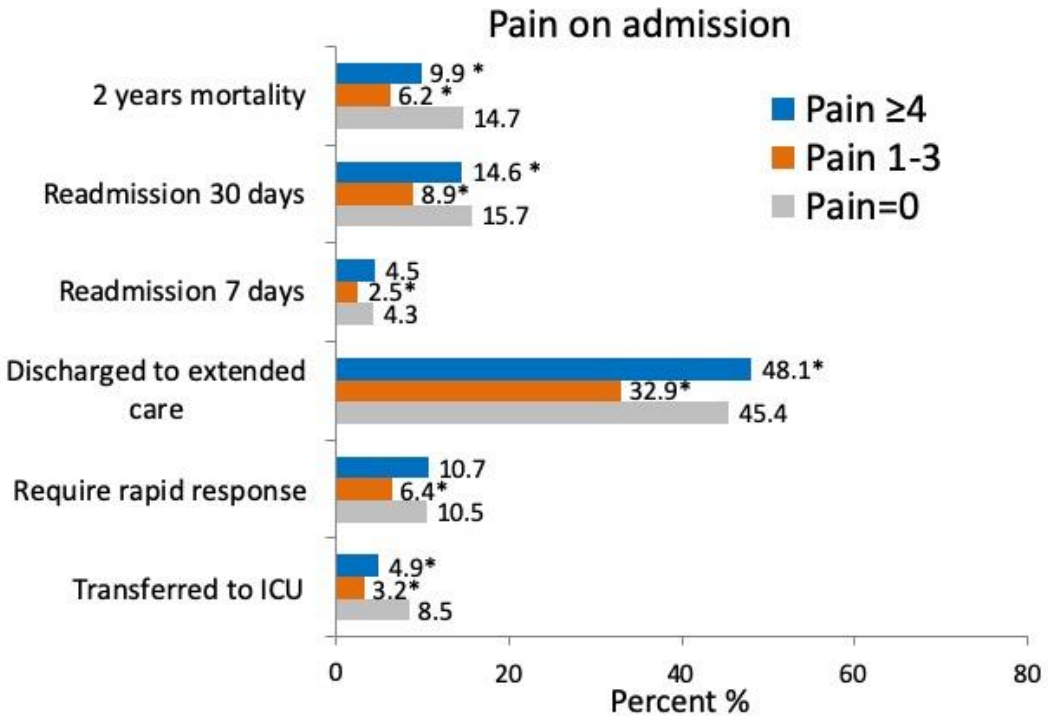
eFigure1. Screenshot of tool that nurses use for measuring dyspnea on 0-10point scale during first nursing shift for all patients admitted to non-intensive care unit beds at our single tertiary care center. The first two 10 point scales are required fields. The activity level and whether the shortness of breath has gotten worse are not completed if patient says 0 to the second scale (breathing discomfort over last 24hrs).



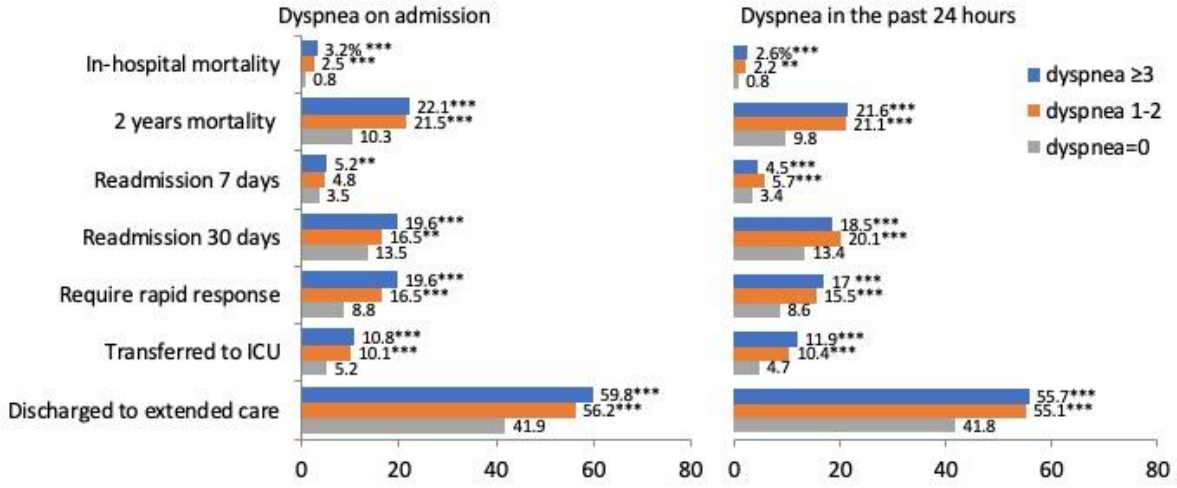
e-Figure 2. Adjusted and Crude Hazard Ratios (HR), Odds Ratios (OR) and Incident Rate Ratios (IRR) for patient outcomes and hospital resources by dyspnea at the time of admission interview



e-Figure 3. In-hospital mortality is unrelated to level of self-reported pain at the time of admission.



e-Figure 4. Patient outcomes and hospital resources associated with pain on admission. * indicates p-value <.05. Reference level is pain=0.



E-Figure 5. Patient outcomes and hospital resources associated with dyspnea at the time of admission interview and recalled in the past 24 hours. *** indicates p <.001, ** indicates p<.01. Reference is dyspnea=0

e-Table1: Diagnoses included under the larger category of "pregnancy complications".

Classification	N	%
Ectopic pregnancy	13	0.17
Contraceptive and procreative management	1	0.01
Diabetes or abnormal glucose tolerance complicating pregnancy; childbirth; or the puerperium	104	1.38
Early or threatened labor	240	3.19
Fetal distress and abnormal forces of labor	167	2.22
Fetopelvic disproportion; obstruction	40	0.53
Forceps delivery	1	0.01
Hemorrhage during pregnancy; abruption placenta;	208	2.76
Hypertension complicating pregnancy; childbirth and the puerperium	755	10.04
Induced abortion	21	0.28
Malposition; malpresentation	311	4.13
Miscellaneous disorders	12	0.16
Normal pregnancy and/or delivery	102	1.36
OB-related trauma to perineum and vulva	1190	15.82
Other complications of birth; puerperium affecting management of mother	1160	15.42
Other complications of pregnancy	657	8.73
Polyhydramnios and other problems of amniotic cavity	834	11.09
Postabortion complications	9	0.12
Previous C-section	585	7.78
Prolonged pregnancy	949	12.61
Spontaneous abortion	16	0.21
Umbilical cord complication	148	1.97

e-Table 2: In-house mortality and dyspnea ratings among patients with pregnancy complications.

	dead n	Total
dyspnea on admission		
0	0	7902
1-3	0	21
≥4	0	7
missing	0	6076
dyspnea on admission	n	
0	0	7902
1-3	0	21
≥4	0	7
missing	0	6076

e-Table3. In-hospital mortality by every rating for dyspnea on admission.

Dyspnea on admission	Number of deaths	Number of patients	Percent death
0	496	60,128	0.82
1	31	1,304	2.38
2	40	1,548	2.58
3	50	1,899	2.63
4	23	593	3.88
5	30	955	3.14
6	13	300	4.33
7	11	304	3.62
8	13	235	5.53
9	2	52	3.85
10	0	44	0.00
Overall	709	67362	1.05

e-table4a. Unadjusted models of in hospital and 2-year mortality

	In hospital mortality	p-value	2-years mortality	p-value
	*OR (95% CI)		*HR (95% CI)	
Dyspnea in the past 24 hours (reference=0)				
Dyspnea 1-3	2.9 (2.3-3.6)	<.001	2.3 (2.1-2.5)	<.001
Dyspnea ≥ 4	3.6 (3.0-4.3)	<.001	2.4 (2.2-2.6)	<.001

e-table4b. Adjusted models of in hospital and 2-year mortality

	In hospital mortality	p-value	2-years mortality	p-value
	*aOR (95% CI)		*aHR (95% CI)	
Dyspnea in the past 24 hours (reference=0)				
Dyspnea 1-3	1.8 91.4-2.4)	<.001	1.5 (1.3-1.6)	<.001
Dyspnea ≥ 4	2.4 (2.0-2.9)	<.001	1.5 (1.4-1.6)	<.001
Age category (reference="18-34")				
35-50 years	3.6 (1.8-7.2)	<.001	4.2 (3.1-5.6)	<.001
51-65 years	6.4 (3.3-12.4)	<.001	8.7 (6.6-11.4)	<.001
> 65 years	11.4 (6.0-21.8)	<.001	18.6 (14.2-24.4)	<.001
Gender (reference=male)				
Female	1.1 (0.9-1.3)	0.58	0.98 (0.93-1.05)	0.62
Race (reference=white)				
Black	0.7 (0.5-0.9)	0.003	0.95 (0.88-1.04)	0.39
Other	1.8 (1.5-2.3)	<.001	0.94 (0.86-1.04)	0.24
Sofa category[a] (ref=0)				
1-3	1.9 (1.6-2.3)	<.001	1.7 (1.6-1.8)	<.001
4-6	3.8 (2.9-4.8)	<.001	3.0 (2.7-3.3)	<.001
>6	19.4 (11.6-32.4)	<.001	5.5 (3.9-7.8)	<.001
Elixhauser predicted mortality[b] %	1.13 (1.11-1.14)	<.001	1.06 (1.06-1.07)	<.001

*Adjusted Odds Ratio (aOR)

*Adjusted Hazards Ratio (aHR)

[a]SOFA denotes Sequential Organ Failure Assessment score. Scores range from 0 to 24, with higher scores suggesting higher mortality.

[b]Elixhauser predicted mortality is based on Elixhauser comorbidities

e-table 5: Dyspnea "Unable to report" vs Respondents

Patient characteristics and outcomes of patients who were “unable to report” dyspnea and a comparison to the population of patients who were able to report dyspnea and are included in our cohort.

	Study cohort n (%)	*Dyspnea unable to report n (%)	P-value
Total	67362	706	
Female	38256 (56.8)	429 (60.7)	0.03
Race			
White	46522 (69.1)	441 (62.4)	<.001
Black	9666 (14.4)	135 (19.1)	
Others	11175 (16.6)	130 (18.4)	
Age, median (IQR)	60 (43-72)	77 (60-85)	<.001
English as a second language	6252 (9.2)	535 (75.8)	<.001
Department of Admission			
Medicine	33989 (50.5)	550 (77.9)	<.001
Surgery	16421 (24.4)	108 (15.3)	
Others	16953 (25.2)	48 (6.8)	
ED Admission			<.001
Yes	34073 (50.6)	561 (79.4)	
No	22289 (49.4)	145 (20.5)	
Day of admission			<.001
Weekday	55565 (82.5)	535 (75.8)	
Weekend	11798 (17.5)	171 (24.2)	
Time of admission			<.001
Day (7a-7p)	33975 (50.4)	275 (38.9)	
Night (7p-7a)	33388 (49.6)	431 (61.1)	
Admission Diagnoses			<.001
Disease of the circulatory system	10910 (4.6)	93 (13.2)	
Diseases of the respiratory system	3079 (16.2)	61 (8.6)	
Diseases of the digestive system	8371 (12.4)	58 (8.2)	
Pregnancy complications	8006 (11.9)	77 (10.9)	
Neoplasms	7549 (11.2)	23 (3.3)	
Injury and Poisoning	7500 (11.1)	98 (13.9)	
Diseases of the musculoskeletal system	5072 (7.5)	10 (1.4)	
All others	16876 (25.1)	286 (40.5)	
Elixhauser predicted mortality[a] % median (IQR)	0.37 (0.27-0.88)	0.81 (0.35-2.28)	<.001
SOFA score [b]			<.001
0	45663 (67.8)	395 (55.9)	
1-3	18055 (26.8)	258 (36.5)	
4-6	3476 (5.2)	51 (7.2)	
>6	168 (0.2)	2 (0.2)	

e-table6a. Unadjusted models of in hospital and 2-year mortality

	In hospital mortality	p-value	2-years mortality	p-value
	*OR (95% CI)		*HR (95% CI)	
Dyspnea on admission (reference=0)				
Dyspnea 1-2	3.1 (2.6-3.8)	<.001	2.3 (2.0-2.5)	<.001
Dyspnea ≥ 3	4.6 (3.7-5.8)	<.001	2.3 (2.1-2.5)	<.001

e-table6b. Adjusted models of in hospital and 2-year mortality

	In hospital mortality	p-value	2-years mortality	p-value
	*aOR (95% CI)		*aHR (95% CI)	
Dyspnea on admission (reference=0)				
Dyspnea 1-2	2.1 (1.6-2.7)	<.001	1.5 (1.4-1.7)	<.001
Dyspnea ≥ 3	2.7 (2.2-2.3)	<.001	1.5 (1.4-1.7)	<.001
Age category (reference="18-34")				
35-50 years	3.7 (1.9-7.4)	<.001	4.3 (3.2-5.8)	<.001
51-65 years	6.8 (3.5-13.1)	<.001	9.1 (6.9-12.0)	<.001
> 65 years	12.3 (6.4-23.3)	<.001	19.8 (15.2-25.9)	<.001
Gender (reference=male)				
Female	1.1 (0.9-1.2)	0.58	0.9 (0.9-1.1)	0.62
Race (reference=white)				
Black	0.7 (0.5-0.9)	0 .003	0.9 (0.9-1.1)	0.39
Other	1.8 (1.5-2.2)	<.001	0.9 (0.9-1.0)	0.24
Sofa category[a] (ref=0)				
1-3	2.0 (1.6-2.4)	<.001	1.7 (1.6-1.8)	<.001
4-6	3.9 (3.0-4.9)	<.001	3.0(2.8-3.3)	<.001
>6	18.5 (10.9-31.5)	<.001	5.4 (3.8-7.6)	<.001
Elixhauser predicted mortality[b] %	1.12 (1.11-1.14)	<.001	1.06 (1.06-1.07)	<.001

*Adjusted Odds Ratio (aOR)

*Adjusted Hazards Ratio (aHR)

[a]SOFA denotes Sequential Organ Failure Assessment score. Scores range from 0 to 24, with higher scores suggesting higher mortality.

[b]Elixhauser predicted mortality is based on Elixhauser comorbidities

e-table6c. Unadjusted models of in hospital and 2-year mortality

	In hospital mortality	p-value	2-years mortality	p-value
	*OR (95% CI)		*HR (95% CI)	
Dyspnea in the past 24 hours (reference=0)				
Dyspnea 1-2	2.9 (2.1-4.0)	<.001	2.3 (2.0-2.6)	<.001
Dyspnea ≥ 3	3.4 (2.9-4.0)	<.001	2.3 (2.2-2.5)	<.001

e-table6d. Adjusted models of in hospital and 2-year mortality

	In hospital mortality	p-value	2-years mortality	p-value
	*aOR (95% CI)		*aHR (95% CI)	
Dyspnea in the past 24 hours (reference=0)				
Dyspnea 1-2	1.9 (1.4-2.7)	<.001	1.5 (1.3-1.7)	<.001
Dyspnea ≥ 3	2.2 (1.8-2.7)	<.001	1.5 (1.4-1.7)	<.001
Age category (reference="18-34")				
35-50 years	3.6 (1.8-7.2)	<.001	4.1 (3.1-5.8)	<.001
51-65 years	6.4 (3.3-12.4)	<.001	8.7 (6.6-11.4)	<.001
> 65 years	11.4 (6.0-21.8)	<.001	18.6 (14.2-24.4)	<.001
Gender (reference=male)				
Female	1.1 (0.9-1.3)	0.58	0.98 (0.93-1.1)	0.73
Race (reference=white)				
Black	0.7 (0.5-0.9)	0 .003	0.96 (0.89-1.04)	0.31
Other	1.8 (1.5-2.3)	<.001	0.95 (0.86-1.04)	0.26
Sofa category[a] (ref=0)				
1-3	1.9 (1.6-2.3)	<.001	1.68 (1.58-1.79)	<.001
4-6	3.8 (2.9-4.8)	<.001	2.97(2.69-3.27)	<.001
>6	19.2 (11.5-32.1)	<.001	5.48 (3.89-7.72)	<.001
Elixhauser predicted mortality[b] %	1.13 (1.11-1.14)	<.001	1.06 (1.056-1.066)	<.001

*Adjusted Odds Ratio (aOR)

*Adjusted Hazards Ratio (aHR)

[a]SOFA denotes Sequential Organ Failure Assessment score. Scores range from 0 to 24, with higher scores suggesting higher mortality.

[b]Elixhauser predicted mortality is based on Elixhauser comorbidities

[a]Elixhauser Predicted Mortality is based on Elixhauser comorbidities
[b]SOFA denotes Sequential Organ Failure Assessment score. Scores range from 0 to 24, with higher scores suggesting higher mortality.

e-table7. Adjusted outcomes across primary and secondary outcomes, using a threshold of a dyspnea rating of 3 rather than 4, first using dyspnea on admission and second using dyspnea in the past 24 hours.

	Dyspnea on admission (ref=dyspnea=0)				Dyspnea in the past 24 hours (ref=dyspnea=0)			
	Dyspnea 1-2		Dyspnea ≥ 3		Dyspnea 1-2		Dyspnea ≥ 3	
	*aOR (95% CI)	p-value	aOR (95% CI)	p-value	aOR (95% CI)	p-value	aOR (95% CI)	p-value
In-hospital mortality	2.05 (1.56-2.72)	<.001	2.69 (2.18-3.32)	<.001	1.92 (1.35-2.73)	<.001	2.22 (1.85-2.66)	<.001
2 years mortality	1.51 (1.36-1.67)	<.001	1.55 (1.41-1.69)	<.001	1.50 (1.32-1.71)	<.001	1.49 (1.39-1.60)	<.001
Readmission 7 days	1.21 (1.11-1.45)	0.04	1.31 (1.12-1.52)	<.001	1.46 (1.19-1.78)	<.001	1.12 (1.01-1.27)	0.04
Readmission 30 days	1.19 (1.07-1.31)	0.04	1.3 (1.19-1.40)	<.001	1.35 (1.14-1.28)	<.001	1.21 (1.14-1.28)	<.001
Require rapid response	1.55 (1.39-1.73)	<.001	1.91 (1.75-2.09)	<.001	1.47 (1.28-0.59)	<.001	1.62 (1.51-1.74)	<.001
Transferred to ICU	1.56 (1.36-1.79)	<.001	1.71 (1.53-1.90)	<.001	1.78 (1.51-0.47)	<.001	2.10 (1.93-2.28)	<.001
Discharged to extended care	1.18 (1.09-1.28)	<.001	1.32 (1.23-1.41)	<.001	1.09 (0.99-1.21)	0.06	1.10 (1.04-1.15)	<.001
	*aHR (95% CI)	p-value	aHR (95% CI)	p-value	aHR (95% CI)	p-value	aHR (95% CI)	p-value
2 years mortality	1.51 (1.36-1.67)	<.001	1.55 (1.41-1.69)	<.001	1.50(1.32-1.71)	<.001	1.49 (1.39-1.60)	<.001

**aOR= Adjusted Odds Ratio*
**aHR=Adjusted Hazard Ratio*
All models were adjusted for age, gender, race, sofa and elixhauser

e-table 8. Service of patients who rated pain ≥4

Clinical service and total numbers of patients per service who reported pain of 4 or greater.

SERVICE	n	%
CARDIAC MEDICINE	796	3.29
CARDIAC SURGERY	142	0.59
DENTAL	1	0
GENERAL SURGERY	3675	15.18
GENITOUROLOGY	585	2.42
GYNECOLOGY	847	3.5
MEDICINE	7697	31.8
NEUROLOGY MEDICINE	567	2.34
NEUROSURGERY	1106	4.57
OBSTETRICS	980	4.05
ONCOLOGY	1411	5.83
ORTHOPEDICS	3624	14.97
OTALARYNGOLOGY	53	0.22
PLASTIC SURGERY	606	2.5
PSYCHIATRY	381	1.57
THORACIC SURGERY	596	2.46
TRAUMA	400	1.65
VASCULAR SURGERY	741	3.06
Total	24,208	100%