OPEN

Outcome Predictions at Two Time Points among Surrogates and Physicians of Mechanically Ventilated Patients

Benjamin Dufour, BA[1]
Hannah M. Duehren, MD[2]
Ashley Eaton England, MA[3]
Kevin Keuper, MD[2]
Thomas V. Quinn, MD[4]
Raj C. Shah, MD[5]
Quyen M. Diep, MS[6]
James Gerhart, PhD[7]
Jared A. Greenberg, MD, MSc[8]

OBJECTIVES: The decisions surrogates and physicians make for incapacitated critically ill patients depend in part on their expectations for patient recovery. We sought to determine whether the accuracy of surrogate and physician outcome predictions made during the ICU stay improves over time.

DESIGN: Survey study.

SETTING: Academic Medical Center.

SUBJECTS: Surrogates and physicians of 100 mechanically ventilated patients from March 2018 to April 2019.

INTERVENTIONS: At the end of the first week of mechanical ventilation and 1 week later, participants indicated on visual analog scales (0–100%) expectations that the patient would require mechanical ventilation in 1 month, require artificial nutrition in 1 month, be alive in 3 months, and be living at home in 3 months. Patient status was determined at 1 and 3 months.

MEASUREMENTS AND MAIN RESULTS: Area under the receiver operating characteristic curves (AUROCs) were determined for each outcome, at each time point. Patients who died within the first month were considered to require mechanical ventilation and artificial nutrition in the primary analysis. AUROCs for initial surrogate predictions were 0.61 (95% CI, 0.50–0.72) for mechanical ventilation, 0.67 (95% CI, 0.56–0.78) for artificial nutrition, 0.66 (95% CI, 0.55–0.7) for survival, and 0.61 (95% CI, 0.50–0.73) for living at home. AUROCs for initial physician predictions were 0.60 (95% CI, 0.49–0.71) for mechanical ventilation, 0.72 (95% CI, 0.61–0.0.83) for artificial nutrition, 0.69 (95% CI, 0.59–0.80) for survival, and 0.76 (95% CI, 0.66–0.85) for living at home. Average expectations among surrogates and physicians were highly stable over time; adjustments made to expectations did not result in more accurate predictions for the measured outcomes ($p > 0.05$).

CONCLUSIONS: Among surrogates and physicians of patients who were mechanically ventilated for 1 week, outcome predictions were better than would be expected by chance and not significantly improved 1 week later.

KEYWORDS: decision-making; ICUs; mechanical; prognosis; receiver operating characteristic; ventilators

Historically, nearly one third of critically ill patients in the United States have required support from mechanical ventilators (1). Patients who require mechanical ventilation for at least 1 week have poorer outcomes than patients who require shorter durations of mechanical ventilation (2). Mechanically ventilated patients are often incapacitated because of the effects of sedating medications and critical illness itself, leaving their family members or surrogates to make medical decisions on their behalf (3, 4). When making decisions, surrogates are instructed to account for prognostic

DOI: 10.1097/CCE.0000000000001235

KEY POINTS

Question: Among surrogates and physicians of patients requiring at least 1 week of mechanical ventilation, do predictions for post-ICU outcomes become more accurate throughout the ICU admission?

Findings: In this survey study, initial predictions that patients would be free from mechanical ventilation, free from artificial nutrition, alive, and living at home in the months after ICU admission were more accurate than would be expected by chance and not significantly improved 1 week later.

Meaning: The information surrogates and physicians gain by witnessing the clinical trajectory of an ICU patient may not always lead to more accurate long-term prognoses.

information provided by the medical team and their own understanding of the patient's goals, values, and preferences (5–7).

One challenge with decision-making for mechanically ventilated patients is that their long-term outcomes may be difficult to predict (8, 9). Patients may experience "chronic critical illness" if they are unable to be liberated from mechanical ventilation during an ICU stay, a condition associated with physical limitations, distressing symptoms, and high mortality rate (10, 11). Usually, ICU clinicians rely primarily on their judgment to predict patient outcomes (12). These predictions are more accurate than would be expected by chance alone (8, 13, 14). However, in many cases, clinicians may feel uncertain about the patient's prognosis, which may impede communication of a prognosis to the patient's surrogates (15, 16). Even when clinicians convey a confident prognosis, surrogates may make decisions according to their own understanding of the patient's condition and overall goals of care (13, 17–19).

To attempt to overcome some of the inherent uncertainty with predicting outcomes for mechanically ventilated patients, physicians and surrogates may decide to track a patient's clinical course over time before reaching a more definitive decision, an approach commonly referred to as a time-limited trial (20, 21). However, it is unclear whether the time spent witnessing a patient's course results in more accurate predictions. A limitation of prior studies examining the predictive abilities of physicians and surrogates is that predictions were made at a single time point, often within the first week of a patient's ICU admission (8, 13, 14, 22). Predictions for survival to hospital discharge may become more accurate over time when consensus is reached among members of the patient's care team. However, incorrect predictions and discordant predictions among members of the care team are common (23, 24).

Extending our prior work that compared differences in physician and surrogate preferences for life-sustaining care, the current study aimed to assess the accuracy of their predictions of post-ICU patient outcomes. In this study, we surveyed physicians and surrogates of ICU patients at the end of the first week of mechanical ventilation and 1 week later. We hypothesized that participant predictions made at the second time point would be more accurate than those made at the first time point. In previous studies involving this cohort, we found that preferences for continuing mechanical ventilation vs. focusing primarily on patient comfort were more closely associated with expectations for good patient outcomes among physicians than surrogates (25). At the same time, both surrogates and physicians tended to agree less strongly over time that mechanical ventilation should be continued with the goal of maximizing survival (26).

METHODS

Study Design and Participants

This prospective cohort study was conducted at Rush University Medical Center (RUMC), an academic, tertiary care medical center in Chicago, IL. Participants provided informed consent as approved by the RUMC Institutional Review Board (IRB) ("Associations between expectations for the future and decisional uncertainty among surrogates of patients requiring prolonged mechanical ventilation," #17092502, date of approval October 22, 2017). Procedures followed were in accordance with the ethical standards of the RUMC IRB and with the Helsinki Declaration of 1975.

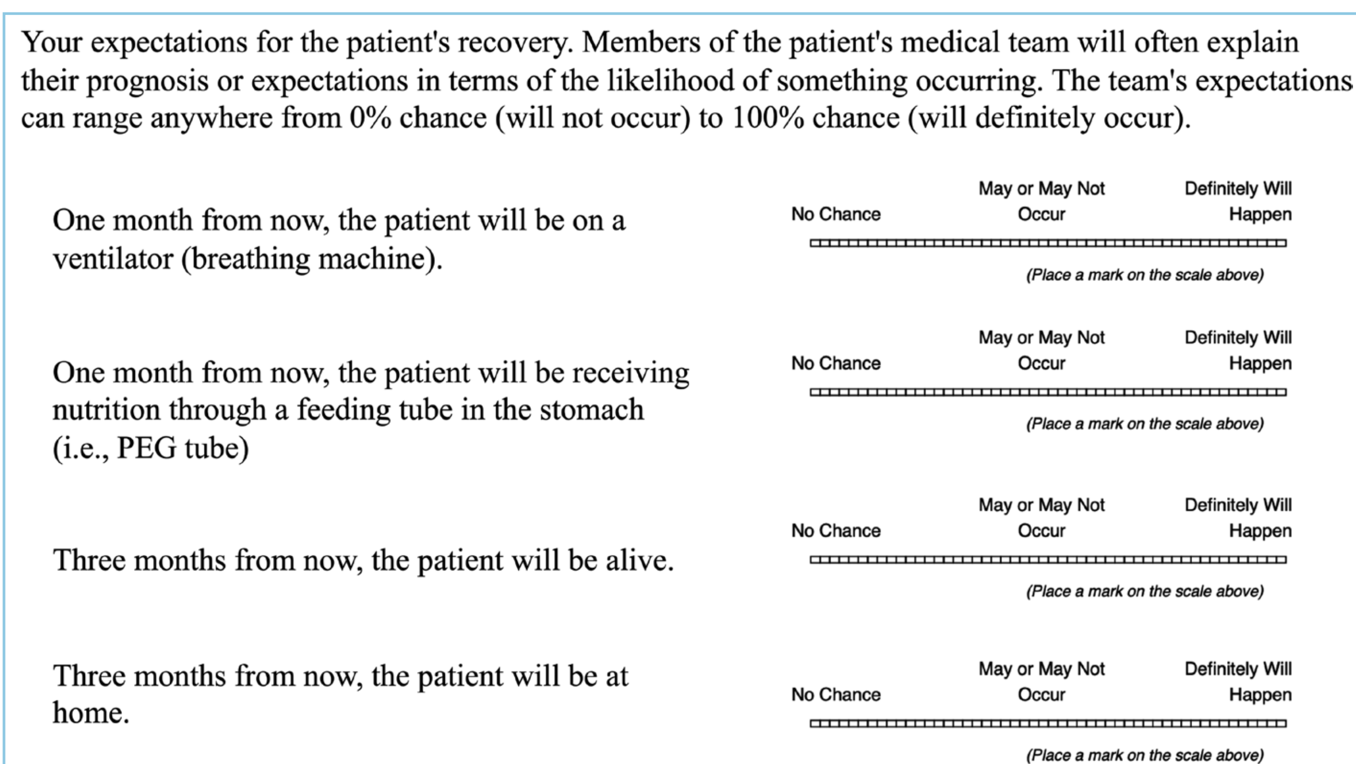
As previously described, from March 1, 2018, to April 11, 2019, we screened patients in four specialty-specific adult ICUs (medical, cardiac, surgical, and neurosciences), each with 25–28 beds (26). We excluded patients: 1) who required mechanical ventilation only for upper airway obstruction or progression of neuromuscular disorder, 2) for whom an extubation or transition to comfort measures was imminently planned, 3) who were admitted to the ICU already requiring mechanical ventilation for more than 14 days, 4) who had decision-making capacity at the time of enrollment, and 5) for whom the primary physician recommended that we not approach the surrogate.

We included surrogates after eligible patients had required mechanical ventilation for at least five consecutive days, anticipating that surrogates may take 2 days to consent to participate and complete the survey. We excluded surrogates: 1) who were not fluent in the English language, 2) who were not competent to make decisions for the patient, and 3) who did not self-identify as participating in the decision-making process for the patient. At the time of surrogate survey completion, one of the patient's physicians (attending or fellow on either the ICU or pulmonary consultation service) was enrolled.

Surrogate and Physician Expectations for Patient Outcomes

We focused on four post-ICU outcomes that are important to critically ill patients and their families who often act as surrogate decision-makers: 1) need for mechanical ventilation, 2) need for artificial nutrition, 3) survival, and 4) living at home (10, 27, 28). Unlike other important patient outcomes, such as level of pain or anxiety, the four chosen outcomes could easily be determined during follow-up with a "yes" or "no" answer by a patient's surrogate.

We used an approach similar to that of previous investigators to measure surrogate and physician expectations for outcomes among critically ill patients (13, 22). The header of the survey was "Your expectations for the patient's recovery." We prefaced the prognostic questions with the statement: "Members of the patient's medical team will often explain their prognosis or expectations in terms of the likelihood of something occurring. The team's expectations can range anywhere from 0% chance (will not occur) to 100% chance (will definitely occur)." We asked participants to place marks on visual analog scales (VAS) to reflect the degree to which they agreed with four prognostic statements (**Fig. 1**). Scales ranged from "No Chance" to "Definitely Will Happen" with the phrase "May or May Not Occur" in the middle. Surveys


Your expectations for the patient's recovery. Members of the patient's medical team will often explain their prognosis or expectations in terms of the likelihood of something occurring. The team's expectations can range anywhere from 0% chance (will not occur) to 100% chance (will definitely occur).

One month from now, the patient will be on a ventilator (breathing machine).

No Chance — May or May Not Occur — Definitely Will Happen

(Place a mark on the scale above)

One month from now, the patient will be receiving nutrition through a feeding tube in the stomach (i.e., PEG tube)

No Chance — May or May Not Occur — Definitely Will Happen

(Place a mark on the scale above)

Three months from now, the patient will be alive.

No Chance — May or May Not Occur — Definitely Will Happen

(Place a mark on the scale above)

Three months from now, the patient will be at home.

No Chance — May or May Not Occur — Definitely Will Happen

(Place a mark on the scale above)

Figure 1. Measurement of participant expectations for patient outcomes. Participants were asked to place marks on visual analog scales (VAS) to reflect the degree to which they agreed with four prognostic statements. Expectation responses were converted into scores ranging from 0 (no chance) to 100 (definitely will happen). For the online version of the survey, participants could see the expectation score as they moved the cursor along the VAS. PEG = percutaneous endoscopic gastrostomy.

were completed using the online program Research Electronic Data Capture or hardcopy based on participant preference (29, 30).

Participating surrogates completed the first expectations survey upon enrollment (at the end of the first week of mechanical ventilation). One week later, participants were asked to complete the expectations survey a second time if the patient was still hospitalized at RUMC. These time points were chosen as they may coincide with the time frame that physicians and surrogates consider tracheostomy placement (31, 32). We did not ask participants to complete surveys a second time if respective patients were actively transitioning to comfort measures. Once a participating surrogate completed a survey, the participating physician was asked to complete the survey within 24 hours. If the physician was no longer providing direct care for the patient at the second time point, he or she was asked to review the patient's medical records before completing the survey. At RUMC, attending physicians typically worked in 1-week blocks. Fellow physicians typically worked in 4-week blocks with 1 day off per week. Participating surrogates were contacted 1 month and 3 months after second survey completion to determine the patient's status.

Statistical Analysis

Surrogate and physician VAS responses were converted into expectation scores ranging from 0% to 100%, with higher scores indicating greater agreement with the referring statements. Internal consistency of the four expectation scores was assessed using Cronbach's α and the strength and direction of associations were assessed with Spearman correlations. We compared surrogate and physician expectations for the same patient using the paired Wilcoxon signed rank test. We determined whether the distribution of expectation scores for each outcome (i.e., survival prediction) differed significantly among groups (i.e., patients who ultimately survived or not) using the Mann-Whitney *U* test.

Using logistic regression analysis, we considered the following four patient outcomes: 1) alive and not requiring mechanical ventilation at 1 month, 2) alive and not requiring artificial nutrition at 1 month, 3) alive at 3 months, and 4) living at home at 3 months. The primary predictor variables were the respective expectation scores. In our multivariable analysis approach, we followed the purposeful variable selection method as proposed by Hosmer and Lemmeshow (33). We first built a full model for surrogate participants with age, gender, race, religion, level of religious observance, and level of education and a second reduced model with variables with p values < 0.25. We then added back the omitted variables one at a time to test for significance before arriving at our final model that included one surrogate characteristic, age. In the multivariable analysis of physicians, each participant was grouped by a unique identifier and we considered role (attending vs. fellow) as a predictor variable. We calculated the area under the receiver operating characteristic curves (AUROC) as measures of participants' predictive accuracy for each of the four outcomes. AUROCs from the unadjusted models were similar to those that accounted for surrogate age and physician role (**Supplemental Table 3**, http://links.lww.com/CCX/B482). Thus, we present unadjusted AUROCs as our primary findings. We determined whether AUROCs at week 1 were significantly different than AUROCs at week 2 for participants who completed surveys at two time points (34).

RESULTS

Participants

Of the 192 surrogates who were approached for informed consent at the end of the patient's first week of mechanical ventilation, 100 (52%) agreed to participate and completed the first survey (mean 9 d from intubation, SD = 2 d) (**Fig. 2**). During the following week, 12 patients died or transitioned to comfort measures, and 10 patients were discharged. One week after initial survey completion, the remaining 78 surrogates were approached to complete a second survey of whom 70 completed the survey (mean 16 d from intubation, SD = 2 d). Characteristics of the participating surrogates and physicians are displayed in **Table 1**.

Characteristics of the 100 respective patients are displayed in **Table 2**. Patients were diverse with respect to the racial/ethnic group and ICU type. There were 29 patients who were successfully extubated and 49 who received a tracheostomy. Most participants

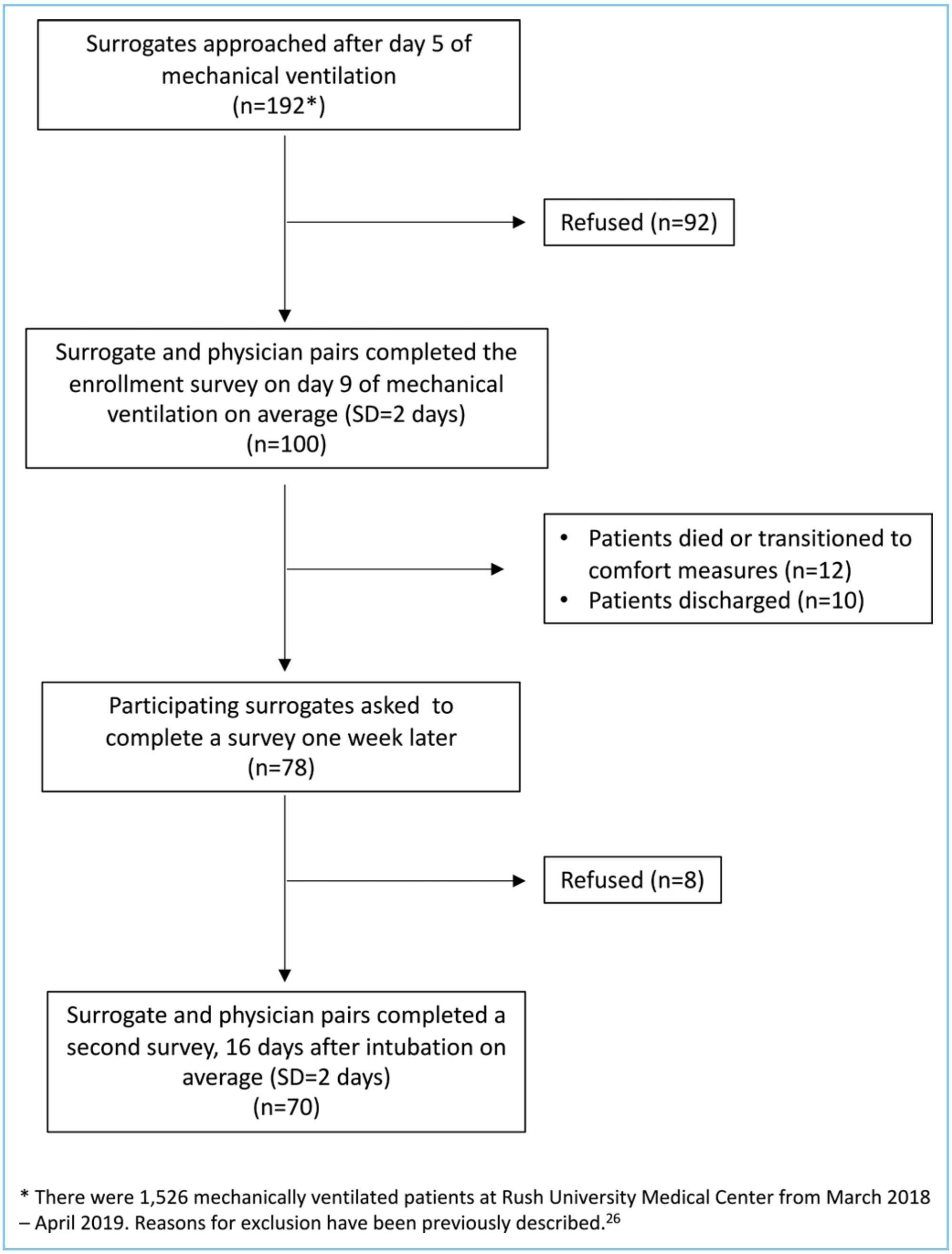


Figure 2. Enrollment.

either were discharged to long-term acute care hospitals (n = 43) or did not survive the hospital stay/were discharged to hospice (n = 28). At the 1-month follow-up, there were 32 patients who were deceased, 14 patients who still required mechanical ventilation, and 36 who still required artificial nutrition. The mechanical ventilation outcome was unknown for two patients and the artificial nutrition outcome was unknown for one patient. At the 3-month follow-up, there were 42 patients who were deceased, 33 patients were living at home, 21 who were living at a facility, and 4 whose status was unknown.

Participant Expectations and Patient Outcomes

Correlations between survey responses among participating surrogates and physicians are displayed in **Supplemental Tables 1** and **2** (http://links.lww.com/CCX/B482), respectively. For both surrogates and physicians, expectations for survival were positively correlated with expectations for being at home and negatively associated with expectations for requiring mechanical ventilation and artificial nutrition. Cronbach's α coefficients ranged from 0.70 to 0.80 for the four prognostic statements among surrogates and physicians, indicating internally consistent scores for each of the measures.

At the end of the first week of mechanical ventilation, the median expectation that the patient would still require mechanical ventilation in 1 month was 46% (interquartile range [IQR] 10–50) among surrogates and 50% (IQR 28–71) among physicians ($p < 0.001$ for difference). The median expectation that the patient would require artificial nutrition at 1 month was 49% (IQR 13–53) among surrogates and 70% (IQR 50–94) among physicians ($p < 0.001$ for difference). The median expectation that the patient would be alive at 3 months was 91% (IQR 69–95) among surrogates and 65% (IQR 44–77) among physicians ($p < 0.001$ for difference). The median expectation that the patient would be at home at 3 months was 75% (IQR

TABLE 1.
Participating Surrogate and Physician Characteristics

Participant Characteristic	Surrogate *n* = 100	Physician *n* = 45
Relation to patient, *n* (%)		
Child	37 (37)	NA
Spouse/partner	28 (28)	NA
Parent	17 (17)	NA
Other	18 (18)	NA
Experience level, *n* (%)		
Attending physician	NA	32 (71)
Fellow physician	NA	13 (29)
Age (yr) (SD)	50 (15)	39 (8)
Gender, *n* (%)		
Female	65 (65)	21 (47)
Male	35 (35)	20 (44)
Not answered	0 (0)	4 (9)
Race/ethnicity, *n* (%)		
Black, non-Hispanic	37 (37)	3 (7)
White non-Hispanic	35 (35)	18 (40)
Hispanic	19 (19)	3 (7)
Asian	2 (2)	17 (38)
Other/not answered	7 (7)	4 (8)
Religion, *n* (%)		
Christian	67 (67)	17 (38)
Jewish	3 (3)	1 (2)
Hindu	0 (0)	10 (22)
Muslim	0 (0)	5 (11)
Other	9 (9)	8 (18)
Not answered	21 (21)	4 (9)
Religious observance, *n* (%)		
Very observant	36 (36)	3 (7)
Somewhat observant	36 (36)	26 (58)
Not observant	11 (11)	11 (24)
Not answered	17 (17)	5 (11)
Education level, *n* (%)		
Graduate/professional school	19 (19)	NA
College graduate	24 (24)	NA
High-school graduate or some college	48 (48)	NA
No or some high school	3 (3)	NA
Not answered	6 (6)	NA

TABLE 2.

Patient Characteristics. Patients Were Grouped According to Whether Respective Surrogates and Physicians Completed Surveys at One or Two Time Points

Patient Characteristic	One Time Point *n* = 30	Two Time Points *n* = 70	*p*
Age (yr) (SD)	60 (15)	57 (17)	0.43
Gender, *n* (%)			
Female	13 (43)	37 (53)	0.38
Male	17 (57)	33 (47)	
Race/ethnicity, *n* (%)			
White non-Hispanic	11 (37)	33 (47)	0.29
Black non-Hispanic	15 (50)	23 (33)	
Hispanic	3 (10)	13 (19)	
Asian	1 (3)	1 (1)	
Location prior to hospitalization, *n* (%)			
Home, independent	21 (70)	44 (63)	0.88
Home, dependent for activities of daily living	7 (23)	21 (30)	
Healthcare facility	2 (7)	5 (7)	
Comorbid conditions, *n* (%)			
Diabetes	7 (23)	19 (27)	0.69
Congestive heart failure	7 (23)	17 (24)	0.92
Active malignancy	5 (17)	16 (23)	0.49
Chronic lung disease	5 (17)	13 (19)	0.82
Chronic kidney disease	2 (7)	11 (16)	0.33
ICU type, *n* (%)			
Medical/cardiac	15 (50)	37 (53)	0.03
Surgical	2 (7)	18 (26)	
Neurologic	13 (43)	15 (21)	
Successful extubation, *n* (%)	8 (27)	21 (30)	0.73
Intubation to successful extubation (d), median (IQR)	12 (10–14)	10 (9–13)	0.57
Tracheostomy, *n* (%)	11 (37)	38 (54)	0.11
New do-not-attempt resuscitation or care limitations, *n* (%)	12 (40)	15 (21)	0.06
Hospital length of stay (d) (SD)	19 (8)	32 (14)	< 0.001
Hospital disposition, *n* (%)			
Long-term acute care hospital	13 (43)	30 (43)	0.11
Deceased or hospice	13 (43)	15 (21)	
Acute rehabilitation hospital	1 (3)	12 (17)	
Skilled nursing facility or subacute rehabilitation facility	2 (7)	7 (10)	
Home	1 (3)	6 (9)	

IQR = interquartile range.

50–92) among surrogates and 41% (IQR 24–61) among physicians ($p < 0.001$ for difference). The frequencies of patient outcomes (*dotted lines* in **Fig. 3**) fell within the IQR of expectations for all outcomes among physicians but not surrogates. Expectation scores among participants, grouped according to the ultimate outcomes of respective patients, are displayed in **Supplemental Figure 1** (http://links.lww.com/CCX/B482).

AUROCs for initial predictions that the patient would require mechanical ventilation in 1 month were 0.61 (95% CI, 0.50–0.72) and 0.60 (95% CI, 0.49–0.71) among surrogates and physicians, respectively. AUROCs for initial predictions that the patient would require artificial nutrition in 1 month were 0.67 (95% CI, 0.56–0.79) and 0.72 (95% CI, 0.61–0.83) among surrogates and physicians, respectively. AUROCs for initial predictions that the patient would be alive in 3 months were 0.66 (95% CI, 0.55–0.77) and 0.69 (95% CI, 0.59–0.80) among surrogates and physicians, respectively. AUROCs for week 1 predictions that the patient would be at home in 3 months were 0.61 (95% CI, 0.50–0.73) and 0.76 (95% CI, 0.66–0.85), among surrogates and physicians, respectively.

Change in Participant Expectations and Patient Outcomes

Changes in expectation scores for the 70 surrogate/physician pairs who completed two surveys are displayed in **Supplemental Figure 2** (http://links.lww.com/CCX/B482). For both surrogates and physicians, for all outcomes, the average change in expectations from week 1–2 was less than 5%. Furthermore, for both surrogates and physicians, for all outcomes, the average change in expectations was not significantly associated with outcomes. As such, AUROCs for week 2 expectations were not significantly different from those at week 1 for both surrogates and physicians for all outcomes (**Table 3**). Findings were similar when we examined two subgroups – participants who completed two surveys and patients who survived at least 1 month (Supplemental Table 3, http://links.lww.com/CCX/B482).

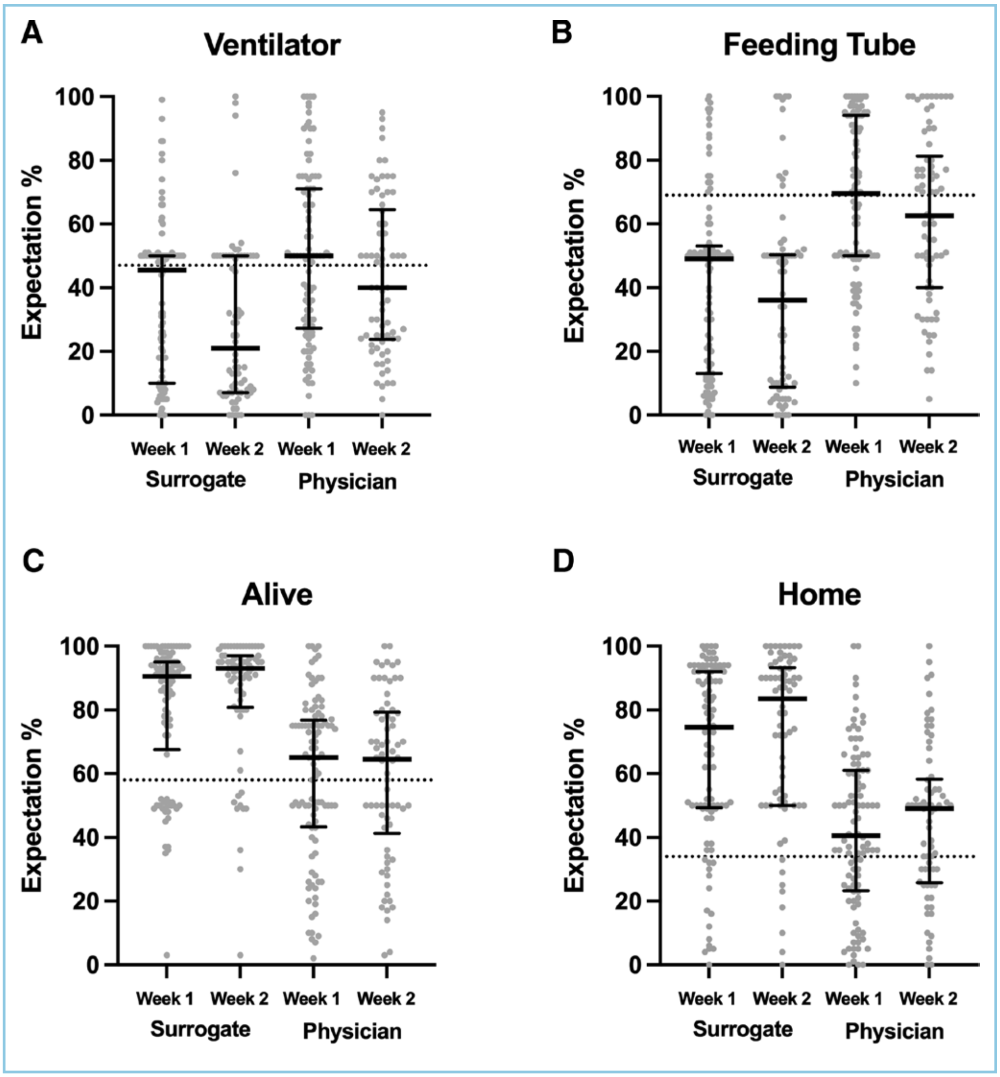


Figure 3. Participant expectations for patient outcomes. **A**, Patient will require mechanical ventilation in 1 mo. **B**, Patient will require artificial nutrition in 1 mo. **C**, Patient will be alive in 3 mo. **D**, Patient will be at home in 3 mo. Median expectations with interquartile ranges as error bars are represented. Actual patient outcomes are represented by dotted lines (mechanical ventilation and artificial nutrition outcomes were composite with death).

DISCUSSION

In this study of adults mechanically ventilated for at least 1 week, respective surrogates and physicians

TABLE 3.
Accuracy of Surrogates and Physician Predications for Four Patient Outcomes

Patient Outcome	Wk 1 AUROC	Wk 1 95% CI	Wk 2 AUROC	Wk 2 95% CI	*p*
Surrogate expectation					
Mechanical ventilation at 1 mo[a]	0.61	0.50–0.72	0.53	0.39–0.68	0.54
Artificial nutrition at 1 mo[a]	0.67	0.56–0.78	0.54	0.39–0.69	0.12
Alive at 3 mo	0.66	0.55–0.77	0.67	0.53–0.81	0.78
Home at 3 mo	0.61	0.50–0.73	0.57	0.43–0.71	0.25
Physician expectation					
Mechanical ventilation at 1 mo[a]	0.6	0.49–0.71	0.68	0.55–0.81	0.11
Artificial nutrition at 1 mo[a]	0.72	0.61–0.83	0.66	0.52–0.80	0.64
Alive at 3 mo	0.69	0.59–0.80	0.73	0.60–0.85	0.32
Home at 3 mo	0.76	0.66–0.85	0.78	0.66–0.90	0.86

AUROC = area under the receiver operating characteristic curve.

[a]Composite outcome with death.Wk 1 AUROCs were generated from the full dataset ($n = 100$). p values were determined by comparing wk 1–2 AUROCs among participants who completed surveys at two time points ($n = 70$).

were asked to make predictions about whether patients would be free from mechanical ventilation, free from artificial nutrition, alive, and living at home in the months after ICU admission. We found that initial predictions at the end of the first week of mechanical ventilation tended to be better than would be expected by chance, as has been previously described (8, 13, 14). Our important, surprising finding was that the adjustments surrogates and physicians made to their expectations 1 week later did not improve predictive accuracy for any of the measured outcomes. These findings suggest that we require a better understanding of how a patient's ICU clinical course impacts long-term outcomes and that clinicians and surrogates require tools to help them incorporate this knowledge into their prognostic approach (35).

When faced with uncertainty regarding prognosis, a common outcome of the shared decision-making process is to monitor a patient's progress over time before making a definitive decision, referred to as a time-limited trial (20, 36). The fact that average initial expectations for patient outcomes among physicians were closer to 50% than 0 or 100% likely indicates this uncertainty. Over time, physicians tended to adjust their expectations to similar degrees positively and negatively away from their initial predictions; as a result, their expectations remained highly stable over time on average. Furthermore, these adjustments in expectations over time were not associated with patient outcomes, a finding that runs counter to conventional wisdom (21). Our findings likely reveal that there is still a large amount of uncertainty with prognostication even after a patient has received 2 weeks of mechanical ventilation. In some cases, clinicians may rely overly on an expectation formed early during the ICU stay, also known as anchoring bias (37). Further study is needed to understand the extent to which biases may affect accuracy of clinician prognoses.

Given that physicians have expertise in caring for critically ill patients and witnessing the challenges that come with recovery, it is not surprising that physician prognoses were more closely calibrated to the actual frequency of patient outcomes than surrogate prognoses. Discordance between surrogates and physicians with respect to patient prognosis is common and persists even when steps are taken to ensure that the medical team communicates a quantitative prognosis to surrogates (6, 38). We found that from week 1–2 of mechanical ventilation, surrogates maintained a very optimistic outlook for patient survival relative to physicians, despite additional time witnessing the patient's care and interacting with the medical team. These findings reveal that it is often very difficult to overcome the optimism bias on the part of the surrogate. Many surrogates may need to maintain a belief that the patient will survive an ICU stay as a coping mechanism for an incredibly stressful experience (18, 19, 25, 27). Nevertheless, although surrogates were typically more optimistic than physicians, some surrogates were less optimistic than other surrogates. As a result, surrogates appeared to be able to distinguish 3-month survivors from nonsurvivors to similar degrees as physicians.

One conclusion from our study may be surrogates and clinicians require more than 1 week of witnessing a patient's course to arrive at more accurate predictions. However, there are challenges with attempting to determine whether this is actually the case. First, as time passes, the question of prognosis becomes relevant to fewer and fewer patients. Some patients will improve to the point that they will be discharged whereas others will succumb to critical illness and pass away; in our study, either of these types of events occurred in over 20% of the cohort in just 1 week. Second, ICU physician well-being may be improved by working in shorter block schedules (i.e., 1 wk vs. 2 wk) (39). A potential negative consequence of shorter block schedules is discontinuity in care. In practice, prognostic estimates that are spaced weeks apart will be performed by different physicians who have different levels of familiarity with the patient and different approaches to prognostication. Using an algorithm or scoring system to help physicians prognosticate over time may overcome this issue of frequent physician turnover (40). Further study is needed to determine whether use of artificial intelligence will lead to prediction models that are superior to clinical judgment and how use of these models may impact clinical practice.

Our findings should be viewed in the context of the study's limitations. First, this was a small, single-center study that may have been underpowered to detect small improvements in the accuracy of predictions from week 1–2. Second, nearly half of eligible surrogates chose not to participate and our results may not generalize to specific populations, such as those that do not speak English. Third, our findings apply only to patients intubated for at least 1 week, which is a minority of intubated patients at our institution. Fourth, to determine whether the predictive accuracy of physicians changed over time, the same physician was asked to complete a survey for each patient. Physicians may have not been providing direct care to the patient when they completed the second survey, which may have affected predictive accuracy. Fifth, we did not ask participants to explain why they adjusted their expectations over time. Thus, we do not know the extent to which predictions were influenced by specific patient characteristics, such as degree of organ dysfunction or physician level of experience. We also do not know how these predictions related to actual conversations and decisions that occurred in the ICU, nor the extent to which physicians and surrogates influenced one another over time. Sixth, we were able to determine whether predictive accuracy changed over time only in the subgroup of participants who completed surveys at two time points. Seventh, participant interpretation of survey questions may have affected how they responded. Correlations between participant responses suggest when participants thought patients were most likely to pass away, they also thought these patients were most likely to require mechanical ventilation, artificial nutrition, and not be at home. Finally, there are outcomes other than survival that are important to ICU decision-makers, such as the long-term need for mechanical ventilation and artificial nutrition (28). In cases where patients die during follow-up (either because of clinical deterioration or a transition to comfort-focused care), it may be impossible to know if they would have required mechanical ventilation and artificial nutrition had they survived. Thus, accuracy of predictions for these outcomes and other quality-of-life measures may be affected by the percentage of patients who die during follow-up and whether patient deaths are censored. In this study, we considered composite outcomes of mechanical ventilation and artificial nutrition with death.

In conclusion, our findings suggest that clinicians and surrogates take different approaches at predicting outcomes for mechanically ventilated patients. Predictions of both clinicians and surrogates tended to be associated with patient outcomes, confirming that these expectations could be used to inform clinical decisions. However, the information surrogates and physicians gained between week 1 and 2 of mechanical ventilation patients did not result in more accurate predictions of post-ICU outcomes. Our findings reinforce the notion that a decision to use a time-limited trial should be based on the patient's individual circumstances and should be sufficiently long enough to answer a specific question. Additional studies are needed to help understand how changes in patient conditions over time relate to prognoses and how this information can be used to facilitate the shared decision-making process. Clinicians may need specialized training to understand the role of biases in forming prognoses and to communicate prognoses effectively.

1 Rush Medical College, Chicago, IL.

2 Department of Internal Medicine, Rush University Medical Center, Chicago, IL.

3 Department of Psychology, Central Michigan University, Mt. Pleasant, MI.

4 Division of Pulmonary and Critical Care Medicine, Northwestern Medicine Palos Hospital, Palos Heights, IL.

5 Department of Family and Preventive Medicine, Rush University Medical Center, Chicago, IL.

6 Bioinformatics and Biostatistics Core, Rush University Medical Center, Chicago, IL.

7 Department of Psychology, Ohio University, Athens, OH.

8 Division of Pulmonary and Critical Care, Department of Internal Medicine, Rush University Medical Center, Chicago, IL.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (http://journals.lww.com/ccejournal).

Mr. Dufour and Drs. Shah, Gerhart, and Greenberg were involved in the conception and design of the study. Drs. Quinn and Greenberg were involved in data collection. Mr. Dufour, Dr. Duehren, Ms. England, Dr. Keuper, Ms. Diep, and Drs. Gerhart and Greenberg were involved in data analysis. Mr. Dufour and Drs. Duehren and Greenberg were involved in drafting of article. All authors were involved in critical revision, reading, and approval of the article. Dr. Greenberg is the guarantor of the article, taking responsibility for the integrity of the work as a whole, from inception to published article.

The authors have disclosed that they do not have any potential conflicts of interest.

Mr. Dufour and Dr. Duehren are co-first authors, contributing equally to the work.

For information regarding this article, E-mail: jared_greenberg@rush.edu

REFERENCES

1. Wunsch H, Wagner J, Herlim M, et al: ICU occupancy and mechanical ventilator use in the United States. *Crit Care Med* 2013; 41:2712–2719
2. Beduneau G, Pham T, Schortgen F, et al; WIND (Weaning according to a New Definition) Study Group and the REVA (Réseau Européen de Recherche en Ventilation Artificielle) Network ‡: Epidemiology of weaning outcome according to a new definition. The WIND study. *Am J Respir Crit Care Med* 2017; 195:772–783
3. Su Y, Yuki M, Hirayama K: The experiences and perspectives of family surrogate decision-makers: A systematic review of qualitative studies. *Patient Educ Couns* 2020; 103:1070–1081
4. Torke AM, Sachs GA, Helft PR, et al: Scope and outcomes of surrogate decision making among hospitalized older adults. *JAMA Intern Med* 2014; 174:370–377
5. Kon AA, Davidson JE, Morrison W, et al; American College of Critical Care Medicine: Shared decision making in ICUs: An American College of Critical Care Medicine and American Thoracic Society Policy Statement. *Crit Care Med* 2016; 44:188–201
6. Cox CE, White DB, Hough CL, et al: Effects of a personalized web-based decision aid for surrogate decision makers of patients with prolonged mechanical ventilation: A randomized clinical trial. *Ann Intern Med* 2019; 170:285–297
7. Comer AR, Hickman SE, Slaven JE, et al: Assessment of discordance between surrogate care goals and medical treatment provided to older adults with serious illness. *JAMA Netw Open* 2020; 3:e205179
8. Detsky ME, Harhay MO, Bayard DF, et al: Discriminative accuracy of physician and nurse predictions for survival and functional outcomes 6 months after an ICU admission. *JAMA* 2017; 317:2187–2195
9. Beil M, Moreno R, Fronczek J, et al: Prognosticating the outcome of intensive care in older patients: A narrative review. *Ann Intensive Care* 2024; 14:97
10. Nelson JE, Cox CE, Hope AA, et al: Chronic critical illness. *Am J Respir Crit Care Med* 2010; 182:446–454
11. Ohbe H, Satoh K, Totoki T, et al; J-STAD (JAPAN Sepsis Treatment and Diagnosis) Study Group: Definitions, epidemiology, and outcomes of persistent/chronic critical illness: A scoping review for translation to clinical practice. *Crit Care* 2024; 28:435
12. Buehler AE, Ciuffetelli IV, Delman AM, et al: Contributors to intensive care unit clinicians' predictions of patient outcomes: A qualitative analysis. *Am J Crit Care* 2018; 27:445–453
13. White DB, Ernecoff N, Buddadhumaruk P, et al: Prevalence of and factors related to discordance about prognosis between physicians and surrogate decision makers of critically ill patients. *JAMA* 2016; 315:2086–2094
14. Cox EGM, Onrust M, Vos ME, et al; SICS Study Group & SOCCS Student Team: The simple observational critical care studies: Estimations by students, nurses, and physicians of in-hospital and 6-month mortality. *Crit Care* 2021; 25:393
15. White DB, Engelberg RA, Wenrich MD, et al: Prognostication during physician-family discussions about limiting life support in intensive care units. *Crit Care Med* 2007; 35:442–448
16. Turnbull AE, Davis WE, Needham DM, et al: Intensivist-reported facilitators and barriers to discussing post-discharge outcomes with intensive care unit surrogates. A qualitative study. *Ann Am Thorac Soc* 2016; 13:1546–1552
17. Lee Char SJ, Evans LR, Malvar GL, et al: A randomized trial of two methods to disclose prognosis to surrogate decision makers in intensive care units. *Am J Respir Crit Care Med* 2010; 182:905–909
18. Zier LS, Sottile PD, Hong SY, et al: Surrogate decision makers' interpretation of prognostic information: A mixed-methods study. *Ann Intern Med* 2012; 156:360–366
19. Tannenbaum AM, Halpern SD: Knowing is (only) half the battle. *Ann Intern Med* 2019; 170:338–339
20. Kruser JM, Ashana DC, Courtright KR, et al: Defining the time-limited trial for patients with critical illness: An official American thoracic society workshop report. *Ann Am Thorac Soc* 2024; 21:187–199

21. Kruser JM, Nadig NR, Viglianti EM, et al: Time-limited trials for patients with critical illness: A review of the literature. *Chest* 2024; 165:881–891
22. Cox CE, Martinu T, Sathy SJ, et al: Expectations and outcomes of prolonged mechanical ventilation. *Crit Care Med* 2009; 37:2888–2894
23. Meadow W, Pohlman A, Frain L, et al: Power and limitations of daily prognostications of death in the medical intensive care unit. *Crit Care Med* 2011; 39:474–479
24. Meadow W, Pohlman A, Reynolds D, et al: Power and limitations of daily prognostications of death in the medical ICU for outcomes in the following 6 months. *Crit Care Med* 2014; 42:2387–2392
25. Keuper K, Eaton England A, Shah RC, et al: Surrogate and physician decision making for mechanically ventilated patients according to expected patient outcome. *J Palliat Med* 2022; 25:907–914
26. Greenberg JA, Quinn TV, Gerhart J, et al: Surrogates and physician preferences regarding the continuation of mechanical ventilation among critically ill adults. *Ann Am Thorac Soc* 2020; 17:1448–1454
27. Nelson JE, Hanson LC, Keller KL, et al: The voice of surrogate decision-makers. Family responses to prognostic information in chronic critical illness. *Am J Respir Crit Care Med* 2017; 196:864–872
28. Nelson JE, Mercado AF, Camhi SL, et al: Communication about chronic critical illness. *Arch Intern Med* 2007; 167:2509–2515
29. Harris PA, Taylor R, Minor BL, et al; REDCap Consortium: The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform* 2019; 95:103208
30. Harris PA, Taylor R, Thielke R, et al: Research electronic data capture (REDCap)--A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009; 42:377–381
31. Hosokawa K, Nishimura M, Egi M, et al: Timing of tracheotomy in ICU patients: A systematic review of randomized controlled trials. *Crit Care* 2015; 19:424
32. Bice T, Nelson JE, Carson SS: To trach or not to trach: Uncertainty in the care of the chronically critically ill. *Semin Respir Crit Care Med* 2015; 36:851–858
33. Hosmer DW, Lemeshow S: *Applied logistic regression*. 2nd Edition. New York, Wiley, 2000
34. DeLong ER, DeLong DM, Clarke-Pearson DL: Comparing the areas under two or more correlated receiver operating characteristic curves: A nonparametric approach. *Biometrics* 1988; 44:837–845
35. Ehlenbach WJ, Cooke CR: Making ICU prognostication patient centered: Is there a role for dynamic information? *Crit Care Med* 2013; 41:1136–1138
36. Chang DW, Neville TH, Parrish J, et al: Evaluation of time-limited trials among critically ill patients with advanced medical illnesses and reduction of nonbeneficial ICU treatments. *JAMA Intern Med* 2021; 181:786–794
37. Ly DP, Shekelle PG, Song Z: Evidence for anchoring bias during physician decision-making. *JAMA Intern Med* 2023; 183:818–823
38. A controlled trial to improve care for seriously ill hospitalized patients: The study to understand prognoses and preferences for outcomes and risks of treatments (SUPPORT). The SUPPORT principal investigators. *JAMA* 1995; 274:1591–1598
39. Mikkelsen ME, Anderson BJ, Bellini L, et al: Burnout, and fulfillment, in the profession of critical care medicine. *Am J Respir Crit Care Med* 2019; 200:931–933
40. Kunitomo Y, Thomas A, Chouairi F, et al: Electronic health record risk score provides earlier prognostication of clinical outcomes in patients admitted to the cardiac intensive care unit. *Am Heart J* 2021; 238:85–88