Disability among Elderly Survivors of Mechanical Ventilation

Amber E. Barnato[1,2,3], Steven M. Albert[4], Derek C. Angus[1,2,3], Judith R. Lave[1,3], and Howard B. Degenholtz[1,3]

[1]Center for Research on Health Care, [2]The Clinical Research, Investigation, and Systems Modeling of Acute Illness Laboratory, Department of Critical Care Medicine, [3]School of Medicine, Department of Health Policy and Management, Graduate School of Public Health, and [4]Department of Behavioral and Community Health Sciences, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, Pennsylvania

***Rationale*: Studies of long-term functional outcomes of elderly survivors of mechanical ventilation (MV) are limited to local samples and biased retrospective, proxy-reported preadmission functional status.**
***Objectives*: To assess the impact on disability of hospitalization with MV, compared with hospitalization without MV, accounting for prospectively assessed prior functional status.**
***Methods*: Retrospective population-based longitudinal cohort study of Medicare beneficiaries age 65 and older enrolled in the Medicare Current Beneficiary Survey, 1996–2003.**
***Measurements and Main Results*: Premeasures and postmeasures of disability included mobility difficulty and weighted activities of daily living disability scores ranging from 0 (not disabled) to 100 (completely disabled) based on self-reported health and functional status collected 1 year apart. Among 54,771 person-years (PY) of observation over 7 calendar years of data, 42,890 PY involved no hospitalization, 11,347 PY involved a hospitalization without MV, and 534 PY included a hospitalization with MV. Mortality at 1 year was 8.9%, 23.9%, and 72.5%, respectively. The level of disability at the post-assessment was substantially higher for a prototypical patient who survived after hospitalization with MV (adjusted activities of daily living disability score [95% confidence interval] 14.9 [12.2–17.7]; adjusted mobility difficulty score [95% confidence interval] 25.4 [22.4–28.4]) compared with an otherwise identical patient who survived hospitalization without MV (11.5 [11.1–11.9] and 22.3 [21.8–22.9]) or who was not hospitalized (8.0 [7.9–8.1] and 13.4 [13.3–13.6]).**
***Conclusions*: The greater marginal increase in disability among survivors of MV compared with survivors of hospitalization without MV is larger than would be predicted from prior functional status.**

Keywords: Medicare; intensive care; mechanical ventilation; quality of life; functional status

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

A recent literature review found conflicting evidence regarding long-term outcomes of elderly survivors of intensive care; five studies demonstrated that functional status after discharge was unchanged from baseline, whereas three found a significant decline. A major weakness of all of these studies was retrospective ascertainment of preadmission functional status, typically by proxy. Proxy respondents typically overestimate dependence, biasing comparisons between preadmission and postadmission functional status toward the null.

What This Study Adds to the Field

Using a nationally representative population-based sample with preadmission functional status measures and a hospitalized control group, survivors of mechanical ventilation experience a much greater increase in disability than survivors of hospitalization without mechanical ventilation.

The use of intensive care and, in particular, mechanical ventilation (MV) among aged Medicare beneficiaries has increased markedly in the last decade (1). Data on long-term mortality associated with use of MV in the elderly are available from both local and national samples (2–6), but reports of physical function and quality of life are fewer and are limited to local samples (7–11). For example, in a study by Chelluri and coworkers (11) of 817 adults who were mechanically ventilated for more than 48 hours in a tertiary referral medical center, 57% of survivors needed caregiver assistance at 1 year. Rates of dependency were much higher for those over age 65. The mean number of activities of daily living (ADL) and instrumental ADL deficiencies were 1.35 and 3.38, respectively, and mean SF-36 physical function score was 45.5.

In addition to the limitation inherent in a local tertiary care sample, it is impossible to assess the impact of the acute care experience without a measure of prehospital physical function. A review of the literature on outcomes of elderly survivors of intensive care found that all studies used retrospective reports of prehospitalization physical function, often by proxy (12). However, serious doubts have been raised about the accuracy of both proxy and retrospective assessments of physical function (13). It is recognized that proxies generally overestimate dependence (14, 15). Yet if findings from these studies are to be used as the basis for clinical decision making, better informed consent, or health policy, a high level of confidence in the accuracy is required.

The purpose of the current study was, therefore, to estimate the level of disability among elderly survivors of MV, conditional on prehospitalization functional status, in a national probability sample of Medicare beneficiaries. Some of the results of this study have been previously reported in the form of an abstract (16).

METHODS

Overview

We conducted a retrospective longitudinal cohort study of Medicare beneficiaries 65 and older using 7 years (1996–2003) of data from the

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Correspondence and requests for reprints should be addressed to Amber E. Barnato, M.D., M.P.H., M.S., Center for Research on Health Care, 200 Meyran Avenue, Suite 200, Pittsburgh, PA 15213. E-mail: aeb2@pitt.edu

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Medicare Current Beneficiary Survey (MCBS). MCBS conducts in-person interviews with each beneficiary four times per year for 4 years. We linked each beneficiary's annual report of health and functioning during the autumn "access to care" survey ("pre") with their report 1 year later ("post"), conditional on whether they were hospitalized without MV or with MV during the 12 months between assessments (Figure 1). If a beneficiary had more than one hospitalization in the year, at least one of which involved MV, we categorized that beneficiary's exposure as "hospitalized with MV." We focused on survivors of MV, rather than intensive care unit (ICU), because there is heterogeneity of ICU admission thresholds across hospitals and regions (17) and because the driving force underlying differences in post-ICU outcome is receipt of MV (18).

Data

The MCBS is a continuous survey of a nationally representative sample of aged, disabled, and institutionalized Medicare beneficiaries sponsored by Centers for Medicare and Medicaid Services (CMS), with oversampling of the oldest old and minorities. MCBS conducts in-person interviews with each sampled beneficiary four times per year for 4 years, after which they rotate off the panel; the sample is refreshed annually. Proxy informants (about 9.7% overall) are used for beneficiaries who are unable to participate in the interview because of illness or difficulty communicating. Questions related to health and functional status are asked once a year during the autumn "access to care" round. Conditional response rates for the second, third, and fourth year are 88.9%, 94.7%, and 96.8%, respectively, yielding progressively declining attrition rates of 11.1%, 5.3%, and 3.2%. Empiric analysis of MCBS finds that conditional response rates are not different for those in poor health versus those in better health (19). Moreover, existing non-response weighting procedures address the impact of attrition on estimates for most measures. We drew hospitalization records from linked Medicare inpatient claims files provided by CMS.

Sample

We restricted the analyses to beneficiaries aged 65 and older who were community-dwelling in the "pre" period and not enrolled in a group health plan (group health plans do not submit claims data to Medicare, limiting their usefulness for this study). Each beneficiary could contribute up to 3 person-years (PY) of observation over their 4 years of participation in the MCBS.

Functional Outcomes

We used data elements from the health status and functioning questionnaire to develop two indices of disability: a mobility difficulty score and a weighted ADL disability score (*see* the online supplement for detail).

We used the validated Rosow-Breslau Functional Health Scale (20) to calculate the mobility difficulty score from three items (difficulty walking two to three blocks, lifting 10 lb, and stooping or kneeling). We calculated the mobility difficulty score by assigning scores to each degree of difficulty (0 = none; 1 = a little; 2 = some; 3 = a lot; and 4 = cannot

Panels of survey respondents, by year and assessment

	1996				1997				1998				1999				2000				2001				2002				2003			
	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S
A	(x				(x)				x)																							
B	(x				(x)				(x)				x)																			
C					(x				(x)				(x)				x)															
D									(x				(x)				(x)				x)											
E													(x				(x)				(x)				x)							
F																	(x				(x)				(x)				x)			
G																					(x				(x)				x)			
H																									(x				x)			

F=fall, W=winter, Sp=Spring, S=Summer
x = health and functional status questions administered in the "access to care" survey
( ) ( ) = distinct pre- and post- measurement windows; a "post" for one period becomes the "pre" for the next period.

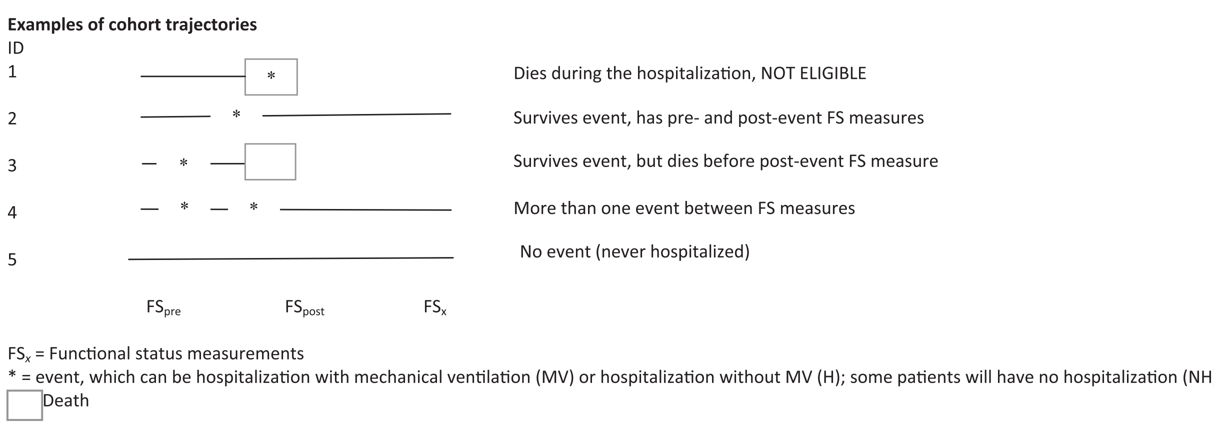

Figure 1. Schematic of the Medicare Current Beneficiary Survey (MCBS) study cohort. The rows represent the MCBS cohort (each cohort participates for 4 yrs) and the columns represent the calendar years, broken down by season. The annual "access to care" survey is administered in the fall of each year. The completion date of this survey became the arbitrary start (and, 1 year later, end) of each beneficiary's person-year (PY) of data. Beneficiaries could contribute up to 3 "pre-post" PY of comparison data over their 4 years of participation in the MCBS. We categorized each PY of data according to the patient's Medicare claims for the year. If the person was hospitalized with mechanical ventilation (MV) one or more times in the year, we categorized them as "hospitalized with MV." If they were hospitalized one or more times in the year without MV (and never had a hospitalization with MV) we categorized them as "hospitalized without MV." If they were never hospitalized, we categorized them as "not hospitalized." If they died during the hospitalization, they were not eligible for this study because they were not "survivors" of MV or hospitalization without MV. If they died before the next autumn, they were censored (missing because of death). If they were alive the next autumn, but did not respond to the survey, they were censored (missing because of nonresponse). As expected, this survivor and nonresponse and survivor bias were greater for the MV group. Assuming these decedents and nonresponders were systematically more disabled, our results underestimate the degree of disability among survivors of MV.

do) and summing across difficulty domains. These mobility difficulty items capture functional limitation likely to precede ADL disability.

We used the validated modified Katz Activities of Daily Living Scale (21) to calculate ADL disability score (level of difficulty and receipt of assistance with bathing, dressing, getting in or out of bed or chairs, eating, walking, and toileting). We further weighted ADL disability score using the validated weighting scheme developed by Finch and coworkers (22) using magnitude estimation to convert functional status to a continuous scale. This approach assigns greater weight to loss of ADLs associated with greater disability (e.g., loss of toileting is weighted heavier than loss of ability to dress).

Finally, we normalized both the mobility difficulty score and the weighted ADL disability score to a 100-point scale for ease of interpretation: a score of 0 is not disabled and of 100 is completely disabled. Thus, every value between 0 and 100 can be interpreted as a percentage of complete mobility or ADL disability.

Independent Variables

The primary independent variable was MV, identified from inpatient claims files using the International Classification of Diseases 9th edition procedure codes for MV (96.X) in any of the six procedure fields or a diagnosis-related group code indicating MV (475 or 483). Additional model covariables included age; sex; race; marital status; income; baseline cognitive score (a four-point score [0–3] created by summing three dichotomous survey questions: memory loss, problems making decisions, and trouble concentrating); baseline normalized weighted ADL disability score or normalized mobility score (depending on outcome modeled); comorbidity (count of Charlson comorbidities classified using administrative data [(23]); cerebrovascular accident (CVA) as the reason for hospitalization; number of hospitalizations in the 1-year period; and days since the last hospitalization before the "post" survey date. We used mean value imputation for missing data on income.

Statistical Analysis

We report mean "pre" functional status among beneficiaries not hospitalized between a preobservation and postobservation period, among those hospitalized at least once but without MV, and among those hospitalized at least once with MV. To assess the marginal impact on disability of hospitalization with MV, compared with hospitalization without MV, we fitted separate generalized linear models for each outcome (weighted ADL disability score and mobility difficulty score) using the γ distribution to address the skewness of outcome data and accounted for repeated measures among beneficiaries using an autoregressive correlation. We estimated separate regressions for hospitalized (including a dummy for MV vs. no MV) and nonhospitalized beneficiaries. Variables for the number of comorbidities, hospitalization, and cognitive score were entered as continuous variables. We standardized age and days since the last hospitalization to adjust for nonlinearity and for ease of interpretation. Finally, for ease of presentation, we calculated adjusted scores for a "prototypical" person with average age and cognitive score, baseline disability or difficulty score equal to 10, no CVA, and Charlson count equal to 1. We performed data management and statistical analyses using SAS Version 9.2 (SAS, Cary, NC).

We conducted the study under a data use agreement with the CMS and received approval from the University of Pittsburgh Institutional Review Board.

RESULTS

Sample

Among 134,991 PY of observation over 7 years, we excluded 26,638 for age less than 65, 26,424 for enrollment in group health, 27,032 for rotation off the panel, and 1,230 for missing "post" data. This left 54,771 PY of observation among 26,072 unique beneficiaries. A total of 42,890 PY involved no hospitalization, 11,347 PY involved a hospitalization without MV, and 534 PY included a hospitalization with MV (Figure 1). The respective rates of missing "post" data for these three groups was 1.9%, 2.8%, and 8.1% and the respective 1-year mortality rate was 8.9%, 23.9%, and 72.5%. The interval between discharge and "post" assessment for those hospitalized with or without MV averaged 127.9 (SD 95.9) and 161.6 (SD 101.5) days, respectively.

Compared with those hospitalized without MV, those who received MV in the year were similar ages, but more likely to be males, be black, have worse baseline mobility and ADL disability scores, and be cognitively impaired (*see* table in Appendix 1 in the online supplement). Reflecting the survivor

TABLE 1. DEMOGRAPHIC AND CLINICAL CHARACTERISTICS OF THE SAMPLE INCLUDED IN PRE-POST ANALYSES,* MEDICARE CURRENT BENEFICIARY SURVEY 1996–2003

	Not Hospitalized (*n* = 39,107 PY)		Hospitalized, Without MV (*n* = 8,771 PY)		Hospitalized, With MV (*n* = 152 PY)		
	Mean or %	SD	Mean or %	SD	Mean or %	SD	*P* Value†
"Pre" (baseline) measures							
Age, yr	75.6	6.9	77.6	7.3	75.9	6.7	0.005
Female, %	58.3		59.1		58.6		0.895
Black, %	8.3		9		9.9		0.713
Other non-white race, %	3.2		2.2		2.6		0.697
Married, %	55.2		48.2		43.4		0.243
Income >$25,000, %	38.6		33.1		27.4		0.127
Pre-ADL disability score	5.3	13.8	10.9	19.5	9.8	19.3	0.470
Premobility difficulty score	21.0	22.6	32.4	26.5	33.9	25.7	0.482
Cognitive score‡	0.23	0.67	0.39	0.86	0.32	0.76	0.343
Clinical measures between "pre" and "post" assessments							
Charlson comorbidity count	—		1.0	1.0	1.8	1.1	<0.001
CVA during the year, %	—		3.9		5.9		0.213
No. of hospitalizations	—		1.6	1.1	2.8	2.5	<0.001
Days since last hospitalization, d	—		161.6	101.6	127.9	95.8	<0.001
Nursing home resident at "post," %	0.8		7.2		12.5		0.013

Definition of abbreviations: ADL = activities of daily living; MV = mechanical ventilation; PY = person years of observation.

* Beneficiaries who survived from fall interview to fall interview; the exception is 194 nursing home residents who died before the fall interview, but whose health and functional status were abstracted from the last available nursing home record before death.

† Comparison between hospitalized without MV versus hospitalized with MV; *t* test or chi-square for discrete variables.

‡ The cognitive score is a four-point score (0–3) created by summing three dichotomous survey questions (memory loss, problems making decisions, and trouble concentrating).

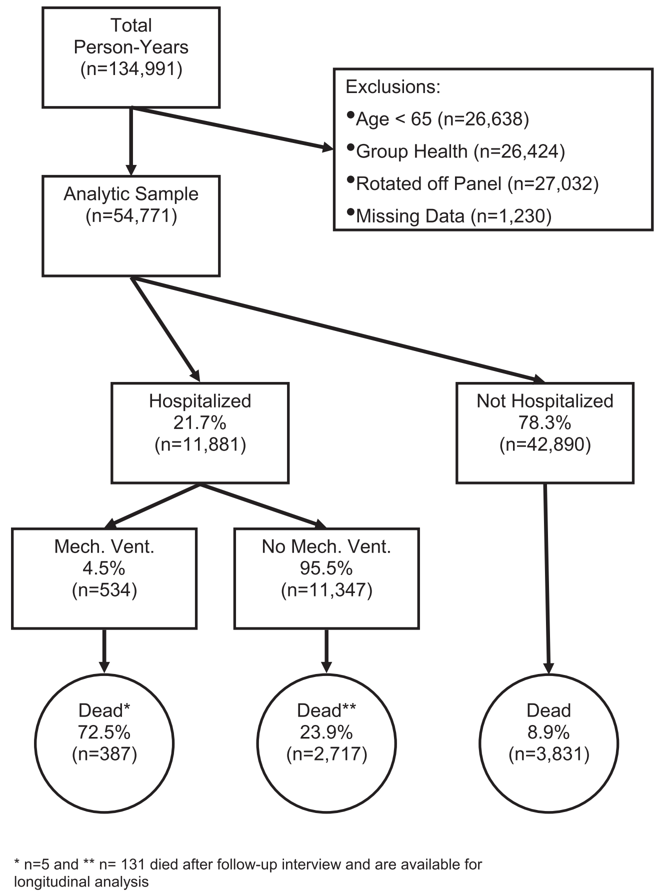

Figure 2. Person-years of observation. We used 8 years of Medicare Current Beneficiary Survey data, with each participating beneficiary contributing to up to four annual measures of health and physical functioning and inpatient claims before rotating off the panel.

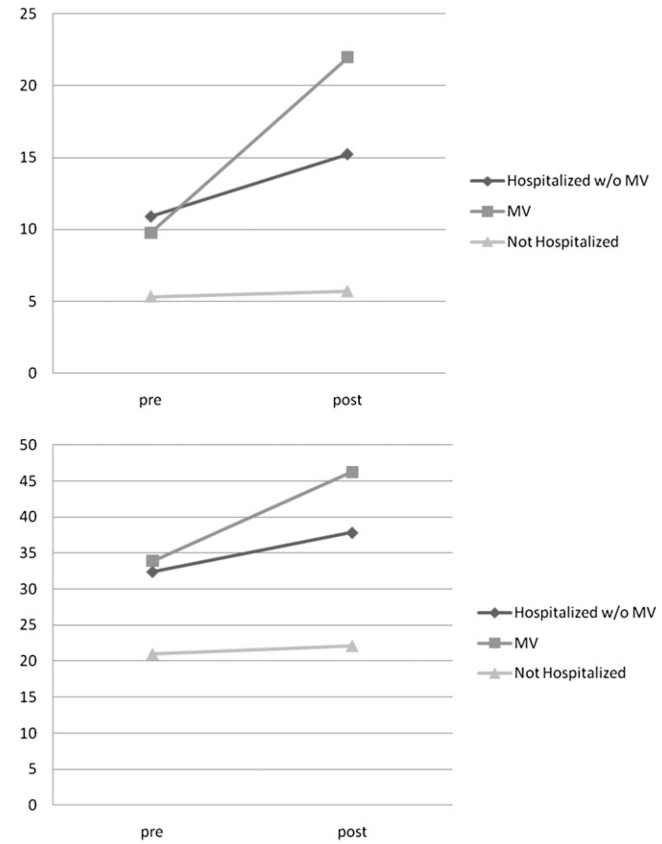

Figure 3. Unadjusted 1-year change in activities of daily living (ADL) disability (*top panel*) and mobility difficulty (*bottom panel*) scores. Nonhospitalized beneficiaries show small increases in disability over the year. Among those who are hospitalized, survivors of mechanical ventilation (MV) experience steeper increases in disability than those who did not receive MV (differences in the unadjusted "post" scores between hospital survivors without MV and with MV for ADL disability [P = 0.0008] and mobility [P = 0.0002]).

bias, baseline mobility, ADL disability, and cognitive scores were similar between those hospitalized with and without MV in the analytic sample (Table 1). Those surviving MV had a higher Charlson comorbidity count, more hospitalizations, and were more likely to be recently discharged and residing in a nursing home than those surviving hospitalization without MV (Table 1).

Functional Outcomes

The ADL disability and mobility difficulty scores range from 0 (not disabled) to 100 (completely disabled) and can be interpreted as a percentage of complete disability on the measure. Among survivors, "post" period ADL disability and mobility difficulty were substantially greater among those who received MV (crude ADL disability score [95% confidence interval] 22.5 [18.8–26.2]; crude mobility difficulty score [95% confidence interval] 46.2 [42.7–49.6]) compared with those who were hospitalized without MV (15.3 [14.2–16.4] and 37.9 [36.8–39]) and those who were not hospitalized (5.7 [5.4–6] and 22 [21.7–22.4]). Not only is the absolute "post" score worse, but the increase (worsening) of the score from the "pre" period to the "post" period was also much greater among survivors of MV compared with survivors of hospitalization without MV and with nonhospitalized controls (Figure 2). This is particularly easy to appreciate for the survivors of hospitalization, because those with and without MV had the same mean "pre" period ADL disability and mobility difficulty scores (Figure 3). To adjust for potential confounders in Table 1, we present the adjusted ADL disability and mobility difficulty scores for a prototypical patient (with average age and cognitive score, baseline disability or difficulty score of 10, no CVA, and a Charlson comorbidity count of 1) who was not hospitalized, hospitalized without MV, or hospitalized with MV during the year in Table 2. Compared with surviving a hospitalization without MV, the prototypical patient surviving a hospitalization with MV experiences 30% greater ADL disability (11.5 vs. 14.9) and 14% greater mobility difficulty (22.3 vs. 25.4) in the "post" period.

DISCUSSION

Our findings offer the first nationally representative estimates of functional status outcomes for aged MV survivors using a prospective population-based sample. We document a larger marginal increase in disability among survivors of MV compared with survivors of hospitalization without MV. Although numerically small, this increase is greater than would be predicted from prior functional status and has clinical implications.

In a recent review of long-term outcomes of elderly survivors of intensive care, Hennessy and coworkers (12) identified 16 studies with functional status or health-related quality of life; 14 were single site and 2 were multicenter; 9 were prospective; and most used consecutive sampling. Inclusion criteria and instruments for outcome ascertainment varied widely, with most including any ICU survivor, not just those with MV. Among

TABLE 2. ADJUSTED 1-YEAR DISABILITY SCORES FOR A PROTOTYPICAL ELDERLY MV SURVIVOR COMPARED WITH A SURVIVOR HOSPITALIZED WITHOUT MV AND A SURVIVOR NOT HOSPITALIZED, MEDICARE CURRENT BENEFICIARY SURVEY 1996–2003

Disability Score	Not Hospitalized Adjusted Mean (*95% CI*)	Hospitalized, no MV Adjusted Mean (*95% CI*)	Hospitalized, With MV Adjusted Mean (*95% CI*)
ADL disability	8.0 (7.9–8.1)	11.5 (11.1–11.9)	14.9 (12.2–17.7)
Mobility difficulty	13.4 (13.3–13.6)	22.3 (21.8–22.9)	25.4 (22.4–28.4)

Definition of abbreviations: ADL = activities of daily living; CI = confidence interval; MV = mechanical ventilation.

Adjusted for prior functional status and cognitive score, demographics, Charlson comorbidity count, stroke in the year, number of hospitalizations, and days since last hospitalization. Scores are the average level of disability, ranging from 0 = not disabled to 100 = completely disabled. Scores under each scenario are calculated for the same prototypical person with average age and cognitive score, baseline ADL disability or mobility difficulty score = 10, no cerebrovascular accident, and Charlson count = 1.

those focusing on ADLs and physical functioning, five demonstrated no change between functional status pre-ICU admission and post-ICU discharge (7, 24–27), whereas three found a significant decline (10, 28, 29). Health-related quality of life was generally unchanged. A major weakness of all of these studies was retrospective ascertainment of preadmission functional status, typically by proxy. Proxy respondents typically overestimate dependence, biasing pre–post comparisons toward the null (14, 15). Our study overcomes this weakness by using prospectively collected interview data on functional status.

We believe that our findings swing the balance in this controversy toward the conclusion that survivors of MV experience substantial declines in functional status. Those hardy enough to survive into the postdischarge period actually had better baseline functional status than survivors of hospitalization without MV. Hence, the relatively larger decrement in ADL disability and mobility difficulty scores is likely attributable to more than just the restricted mobility of acute illness (30) and probably includes a cognitive component (31). The reasons for the late morbidity after MV are many, and include the stress and nature of critical illness and the therapies and environment of intensive care. In recent years, there have been efforts to optimize care in the ICU to reduce some of these sequelae. However, many problems that develop in the ICU are difficult to eradicate and some ICU interventions and management strategies necessary to prevent immediate death are associated with unavoidable complications. In the care of other diseases and conditions, such as stroke and traumatic brain injury, the need for dedicated, prolonged care beyond the initial critical episode has long been recognized. This has led to the organization of dedicated services, such as multidisciplinary rehabilitation services, and wide recognition among primary care providers and other physicians of the benefits of early referral to such services. Frail geriatric populations requiring hospitalization have also benefited from a programmatic approach to inpatient care (32) and rehabilitation postdischarge. In contrast, there is no systematic approach to care following MV even though some hypothesize that a course of MV may induce many of the anatomic and physiologic characteristics of frailty. Given that patients with frailty (33), hospital-acquired ADL deficiencies (34), declines in mobility (35), and recent MV (18) have poor longer-term survival, interventions focused on improving function and mobility in this population could impact mortality and functional status.

Our study is subject to several limitations. With the exception of CVA, which directly impacts physical functioning, we did not seek to differentiate between the episodes of critical illness that precipitated the need for MV from the MV itself, such as respiratory arrest and resuscitation. We did not seek to differentiate between shorter and longer episodes of MV or to disentagle relationships between post-MV cognitive function from physical function due to the relatively small numbers of beneficiaries with any MV event. We did not have clinical data about presence and duration of delirium. The study period reflects the epidemiology of posthospitalization survival and disability 7–14 years ago. Although there has been secular decrease in hospital mortality from MV in recent years, 90-day survival has not improved, with deaths shifting into the postacute setting (18, 36, 37). Therefore, our estimates may underestimate the magnitude of disability in 2010. Finally, our analyses suffer from survivor bias and nonresponse bias, which also underestimates the magnitude of disability. Specifically, those who survived to hospital discharge, but who died before the next autumn survey and those who were alive but did not respond were likely more disabled.

Significant disability among survivors of MV has implications for patients' treatment goals; many elders might not elect to receive a high burden intervention if they knew it would result in substantial disability (38). Outcomes for prolonged MV patients are significantly worse than expected by patients' surrogates and physicians (39). Clinicians should consider accurate predictions of disability risk and mortality risk when making decisions about the use of MV with elderly patients. Future research should explore the predictors of better long-term outcomes of MV.

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