The Effect of Insurance Status on Mortality and Procedural Use in Critically Ill Patients

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Rationale: Lack of health insurance may be an independent risk factor for mortality and differential treatment in critical illness.

Objectives: To determine whether uninsured critically ill patients had differences in 30-day mortality and critical care service use compared with those with private insurance and to determine if outcome variability could be attributed to patient-level or hospital-level effects.

Methods: Retrospective cohort study using Pennsylvania hospital discharge data with detailed clinical risk adjustment, from fiscal years 2005 and 2006, consisting of 167 general acute care hospitals, with 138,720 critically ill adult patients 64 years of age or younger.

Measurements and Main Results: Measurements were 30-day mortality and receipt of five critical care procedures. Uninsured patients had an absolute 30-day mortality of 5.7%, compared with 4.6% for those with private insurance and 6.4% for those with Medicaid. Increased 30-day mortality among uninsured patients persisted after adjustment for patient characteristics (odds ratio [OR], 1.25 for uninsured vs. insured; 95% confidence interval [CI], 1.04–1.50) and hospital-level effects (OR, 1.26; 95% CI, 1.05–1.51). Compared with insured patients, uninsured patients had decreased risk-adjusted odds of receiving a central venous catheter (OR, 0.84; 95% CI, 0.72–0.97), acute hemodialysis (OR, 0.59; 95% CI, 0.39–0.91), and tracheostomy (OR, 0.43; 95% CI, 0.29–0.64).

Conclusions: Lack of health insurance is associated with increased 30-day mortality and decreased use of common procedures for the critically ill in Pennsylvania. Differences were not attributable to hospital-level effects, suggesting that the uninsured have a higher mortality and receive fewer procedures when compared with privately insured patients treated at the same hospitals.

Keywords: insurance; intensive care unit; critical care; mortality

There is known variation in mortality and intensity of care among patients with critical illness across hospitals in the United States (1). One determinant of that variation may be whether the patient has health insurance (2). With approximately 50.9

AT A GLANCE COMMENTARY

Scientific Knowledge on the Subject

There is known variation in mortality and intensity of care among patients with critical illness across hospitals in the United States. One determinant of that variation may be whether the patient has health insurance. Previous studies generally show that lack of health insurance is associated with an increased risk of death in the intensive care unit (ICU) but inconsistently adjust for severity of illness and typically use a single-center design. Previous work has yet to distinguish whether poorly insured patients have worse outcomes because of their own insurance status—which would be influenced by health care reform—or by receiving their care at poorer quality hospitals—which would not.

What This Study Adds to the Field

This study found a significant increase in 30-day mortality and decreased use of common procedures for critically ill patients without health insurance. Our use of a large multicenter database with adjustment for severity of illness markers constitutes a significant contribution to our understanding of health outcomes for the uninsured. Furthermore, this study is the first to our knowledge to identify that this effect is present at the patient level, meaning that uninsured patients have significantly increased mortality compared with those with health insurance within the same hospital. Identifying this effect at the patient level would suggest that improving access to health insurance through national insurance reform may help mitigate disparities in outcomes and use in the ICU.

(Received in original form January 16, 2011; accepted in final form June 2, 2011)

Supported by National Institutes of Health grant T32 HL007891 (S.M.L.).

No funding source had any role in the study's design, conduct, or reporting.

Contributions: S.M.L. – Conception, design, hypotheses delineation, analysis, interpretation of data, drafting and revisions, and final approval. N.M.B. – Analysis and interpretation of data, revisions, and final approval. C.R.C. – Hypotheses delineation, substantial revisions, and final approval. T.J.I. – Hypotheses delineation, substantial revisions, and final approval. S.J.R. – Design, analysis, revisions, and final approval. J.M.K. – Conception, design, hypotheses delineation, acquisition of data analysis, interpretation of data, substantial revisions, and final approval.

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Am J Respir Crit Care Med Vol 184, pp 809–815, 2011

Originally Published in Press as DOI: 10.1164/rccm.201101-0089OC on June 23, 2011

Internet address: www.atsjournals.org

million Americans uninsured in 2009 (3), understanding how insurance status impacts health care outcomes and use is crucial to improving disparities in critical illness. Previous studies generally show that lack of health insurance is associated with an increased risk of death in the intensive care unit (ICU), but inconsistently adjust for severity of illness and typically use a single-center design (4–9). Determining whether uninsured patients experience poor outcomes because they tend to receive care in low performance hospitals, or because they receive differential care within hospitals, will help focus efforts to improve health care delivery to this patient population. With the implementation of the health care reform, we anticipate the transition of millions of Americans from no insurance to Medicaid and private insurance. Previous work has yet to distinguish whether poorly insured patients have worse outcomes because

of their own insurance status—which would be influenced by health care reform—or by receiving their care at poorer quality hospitals—which would not. Therefore, we sought to analyze the distinction between private insurance, no insurance, and Medicaid insurance in anticipation of this policy change.

The purpose of this study was to examine the effect of health insurance on 30-day mortality and procedural use in patients with critical illness. We did so in a statewide data set that incorporates a wide range of hospitals and includes unusually detailed clinical risk adjustment. We further sought to distinguish whether disparities in ICU care and outcomes by insurance status were a result of differential care within hospitals or differences between hospitals where patients sought care. Some of the results of these studies have been previously reported in the form of an abstract (10).

METHODS

Study Design and Patients

We performed a retrospective cohort study using data from the Pennsylvania Health Care Cost Containment Council (PHC4) for fiscal years 2005 and 2006. PHC4 is a nonprofit government agency that collects discharge records of all patients admitted to Pennsylvania hospitals for benchmarking and research purposes. We initially included all adult patients admitted to an ICU, defined using ICU-specific revenue codes. Using the expected primary payer field, we classified insurance into three mutually exclusive categories: private, Medicaid, and uninsured. We excluded all patients age 65 years and older, as well as those with Medicare, military, or Veterans Affairs insurance, and those with unknown insurance status. To avoid interdependence of observations we examined only the first ICU admission. We excluded hospitals with fewer than 10 eligible patients over the study period. This study was exempted from human subjects review by the University of Pennsylvania Institutional Review Board.

Variables

Our primary exposure variable was insurance status, as described above. The primary outcome was mortality within 30 days of hospital admission, obtained by linking the PHC4 database to the Pennsylvania Department of Health vital status file. Our secondary outcomes, selected as potential markers of the intensity of ICU services, were five common ICU procedures: central venous catheterization (CVC), pulmonary artery catheterization (PAC), acute hemodialysis, tracheostomy, and bronchoscopy. We selected these procedures based on a literature search to identify common ICU procedures (4, 11–13) and a series of consensus-building discussions with practicing ICU physicians. Procedures were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) procedure codes, as previously defined (12). For analysis of acute hemodialysis we excluded patients with chronic renal failure defined using the Elixhauser and colleagues' comorbidity definition (14, 15). When analyzing tracheostomy we limited our analysis to those receiving mechanical ventilation.

As potential confounders, we considered several *a priori* defined patient variables, including: age, sex, race (16), socioeconomic status (median income level of 5-digit ZIP code, obtained from U.S. census estimates) (17), admission source, admission type, primary diagnosis, mechanical ventilation, comorbidities, and severity of illness on presentation. Admission type and mechanical ventilation were defined based on the presence of ICD-9-CM diagnosis and procedure codes as previously validated (12, 14, 18–21). Primary diagnosis was categorized into groups using the Agency for Health Care Research and Quality Clinical Classification Software. Comorbid conditions were defined using the Deyo modification of the Charlson Comorbidity Index (22–25). Severity of illness was defined using the MediQual Atlas probability of in-hospital death, a validated risk-adjustment tool for hospitalized patients (26–28). The MediQual Atlas score is automatically calculated by PHC4 using key clinical and demographic characteristics on admission but may be absent due to missing clinical data.

Analysis

Using private insurance as our reference group, we sought to understand whether differences in 30-day mortality and procedure use existed for uninsured and Medicaid patients. We graphically examined variation in the proportion of uninsured and Medicaid patients cared for in Pennsylvania hospitals using a histogram. We then compared demographic and clinical characteristics across groups using analysis of variance for continuous variables and a chi-square test for categorical variables.

We used logistic regression to determine the effect of insurance status on each of our outcomes using a series of regression models. First, we created a base model that included only insurance status as an independent variable, with private insurance as the comparator group. Next, we fit multivariable regression models, including insurance status and the patient-level variables defined above. Finally, we fit hierarchical fixed-effects models similar to the multivariable models but including hospital as a fixed effect. These regression coefficients can be interpreted as controlling for any hospital variable that affects the treatment of all patients within a hospital center so that it reflects the difference in outcome between private and uninsured or Medicaid patients within an individual hospital (29). Comparing these models provides information about whether the observed effects of insurance status are due to patient- or hospital-level effects. Analyses were performed using STATA 11.0 (College Station, TX). All tests were two-tailed, and a *P* value of 0.05 or less was considered significant.

RESULTS

Our initial database contained 471,112 adult intensive care admissions to 169 Pennsylvania hospitals from fiscal years 2005 to 2006. After exclusions, 138,720 patients were included in the final analysis: 95,995 (69.2%) were privately insured, 36,911 (26.6%) were insured by Medicaid, and 5,814 (4.2%) were uninsured (Figure 1). Severity of illness, measured as the MediQual Atlas probability of death, was available for 74,353 (77.5%) privately insured patients, 25,533 (69.2%) Medicaid patients, and 3,829 (73.9%) uninsured patients.

Patient demographic and clinical characteristics by insurance status are shown in Table 1. Uninsured patients were younger, with a mean age of 42 versus 50 years, were more likely to be men (71.3 vs. 59.7%), with a higher percentage of minorities (black 15.8 vs. 7.9%). The uninsured were more likely to be admitted to the hospital through the emergency department, with a higher percentage of trauma and nonsurgical admissions. Uninsured patients in our cohort also had fewer comorbidities and tended to have a lower MediQual probability of death. For those with Medicaid, the mean age, race, and median income fell between that of the uninsured and private insurance groups. Women made up a higher percentage of Medicaid patients, and Medicaid patients were more likely to have a higher MediQual death probability. For our primary outcome, uninsured patients had an absolute 30-day mortality of 5.7%, compared with 4.6% for those with private insurance and 6.4% for Medicaid.

We found substantial variation in the percent of uninsured patients cared for in the 167 hospitals included in our study (Figure 2A), ranging from 0 to nearly 20%, with uninsured patients accounting for less than 10% of the critically ill in the majority of Pennsylvania hospitals. In contrast, the proportion of Medicaid patients accounted for 0 to 80% of critically ill patients in individual hospitals (Figure 2B). With significant variation between the 167 hospitals included in our studies, Medicaid patients were found to constitute 10 to 50% of the critically ill in the majority of PA hospitals. When compared with patients with private insurance, uninsured patients were more likely to be admitted to small community hospitals, whereas Medicaid patients were more likely to be admitted to larger academic hospitals.

Patients without insurance had an unadjusted 30-day mortality odds ratio (OR) of 1.26 (95% confidence interval [CI], 1.12–

Figure 1. Exclusions. FFS = fee for service; HMO = health management organization.

1.41; $P < 0.001$) when compared with those with private insurance (Table 2). The increased odds of death persisted after adjustment for patient variables (OR, 1.25; 95% CI, 1.04–1.51; $P = 0.020$). Furthermore, the increased odds of 30-day mortality persisted in our fixed-effects model that controlled for hospital site, with uninsured patients having a 25% higher odds of death within 30 days compared with privately insured patients (OR, 1.25; 95% CI, 1.04–1.50; $P = 0.016$). In unadjusted analysis, patients with Medicaid also had increased odds of 30-day mortality compared with those with private insurance, (OR, 1.42; 95% CI, 1.35–1.50; $P < 0.001$), but adjustment for patient characteristics eliminated this effect (OR, 1.06; 95% CI, 0.98–1.15; $P = 0.164$). Further adjustment for hospital center fixed effects again showed no difference in 30-day mortality for Medicaid patients when compared with the privately insured. Given the absence of center effects we used a marginal model to estimate the standardized absolute risk difference for 30-day mortality. We found an absolute risk difference of 0.01 ($P = 0.011$) when comparing patients alternatively as if they were all privately insured versus all uninsured, meaning for

every 1,000 patients treated there would be 10 more deaths if everyone in our sample was uninsured.

In our analysis of five critical care procedures used as a proxy for ICU service use, the uninsured were significantly less likely to receive CVC, tracheostomy, and acute hemodialysis in our unadjusted analyses (Table 2). This effect, although attenuated, persisted after adjustment for patient characteristics and did not change when we additionally adjusted for hospital-level effects in our fixed-effects model: uninsured patients had decreased odds of CVC placement (OR, 0.84; 95% CI, 0.72–0.97; $P = 0.018$), acute hemodialysis (OR, 0.59; 95% CI, 0.39–0.58; $P = 0.016$), and tracheostomy (OR, 0.43; 95% CI, 0.29–0.64; $P < 0.001$). Although uninsured critically ill patients were also less likely to receive bronchoscopy or PAC in all models, results for these procedures did not reach statistical significance.

Medicaid patients were more likely to receive CVC, tracheostomy, and acute hemodialysis than the privately insured patients in unadjusted analyses. Although the effect size seen was attenuated by adjustment for patient characteristics and hospital-level fixed effects, Medicaid patients had increased odds

TABLE 1. DEMOGRAPHIC AND CLINICAL CHARACTERISTICS

Variable	Private Insurance (n = 95,995)	Medicaid (n = 36,917)	Uninsured (n = 5,814)	P Value
Demographics				
Mean age	50 (12)	44 (13)	42 (13)	<0.001
Male sex	57,335 (59.7)	19,743 (53.5)	4,146 (71.3)	<0.001
Female sex	38,656 (40.3)	17,167 (46.5)	16687(28.7)	<0.001
Race				<0.001
White	81,381 (84.8)	22,557 (61.1)	4,222 (72.6)	
Black	7,629 (7.9)	9,866 (26.7)	920 (15.8)	
Other	6,985 (7.3)	4,488 (12.2)	672 (11.6)	
Median income, \$	42,856 (13,840)	34,380 (11,538)	37,562 (11,464)	<0.001
Clinical characteristics, n (%)				
Admission source				<0.001
Emergency department	50,563 (52.7)	26,493 (71.8)	4,458 (76.7)	
Direct admit	37,200 (38.8)	7,669 (20.8)	874 (15.0)	
Transfer	8,215 (8.6)	2,736 (7.4)	477 (8.2)	
Unknown	17 (0.02)	13 (0.04)	5 (0.09)	
Admission type				<0.001
Nonsurgical	45,998 (47.9)	23,439 (63.5)	3,737 (64.3)	
Surgical nontrauma	39,262 (40.9)	8,713 (23.6)	867 (14.9)	
Trauma	10,735 (11.2)	4,759 (12.9)	1,210 (20.8)	
Mechanical ventilation	10,880 (11.3)	7,372 (20.0)	950 (16.3)	<0.001
Charlson Comorbidity Index				<0.001
0	37,679 (39.3)	14,313 (38.8)	3,229 (55.6)	
1–2	51,527 (53.7)	18,917 (51.3)	2,332 (40.1)	
3+	6,798 (7.1)	3,681 (10.0)	253 (4.4)	
Comorbidities, type				
Cancer	5,957 (6.2)	1,447 (3.9)	106 (1.8)	<0.001
Diabetes	15,640 (16.3)	6,665 (18.1)	777 (13.4)	<0.001
CHF	9,053 (9.4)	4,804 (13.0)	380 (6.6)	<0.001
AMI	15,966 (16.6)	4,444 (12.0)	698 (12.0)	<0.001
COPD	15,458(16.1)	8,501 (23.0)	720 (12.4)	<0.001
MediQual death probability*				<0.001
≤0.05	63,841 (85.9)	19,906 (78.0)	3,168 (82.7)	
0.050 < x ≤ 0.10	4,050 (5.5)	2,049 (8.0)	226 (5.9)	
0.10 < x ≤ 0.25	3,290 (4.4)	1,898 (7.4)	169 (4.4)	
0.25 < x ≤ 1.00	3,172 (4.3)	1,680 (6.6)	266 (7.0)	
Discharge to post-hospital care facility†	7,923 (8.3)	3,706 (10.0)	209 (3.6)	<0.001
Outcomes				
30-d Mortality, n (%)	4,373 (4.6)	2,348 (6.4)	330 (5.7)	<0.001
5 Common procedures, n (%)				
Central venous catheter	11,079 (9.8)	6,891 (14.5)	466 (7.3)	< 0.001
Tracheostomy‡	2,441 (22.4)	1,388 (18.8)	82 (8.6)	< 0.001
Acute hemodialysis§	1,018 (1.1)	762 (2.1)	43 (0.7)	< 0.001
Pulmonary artery catheter	1,076 (1.1)	308 (0.8)	31 (0.5)	< 0.001
Bronchoscopy	1,637 (1.7)	615 (1.7)	58 (1.0)	< 0.001

Definition of abbreviations: AMI = acute myocardial infarction; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease.

Values are presented as mean (SD), median (SD), or n (%).

* MediQual Probability total patients included in analysis: private insurance, n = 74,353 (77.5%); Medicaid, n = 25,533 (69.2%); uninsured, n = 3,829 (73.9%).

† Post-hospital care facility = skilled nursing facility, rehabilitation, hospice, or long-term acute care hospital.

‡ Analysis was limited to patients receiving mechanical ventilation: private insurance, n = 10,880; Medicaid, n = 7,372; uninsured, n = 950.

§ Patients with chronic renal failure were excluded from the hemodialysis calculations. Total patients included in analysis for acute hemodialysis: private insurance, n = 94,714; Medicaid, n = 36,292; uninsured n = 5,780.

of CVC (OR, 1.21; 95% CI, 1.14–1.28; $P < 0.001$), acute hemodialysis (OR, 1.21; 95% CI, 1.06–1.39; $P = 0.006$), and tracheostomy (OR, 1.16; 95% CI, 1.03–1.31; $P < 0.019$) in our final adjusted model. No difference was seen in our adjusted models for bronchoscopy or PAC for Medicaid patients when compared with those with private insurance.

DISCUSSION

In a large statewide database with detailed risk adjustment we found that risk of death at 30 days was significantly higher for uninsured patients with critical illness when compared with that of patients with private insurance. The increased risk of death for the uninsured persisted after adjustment for both patient clinical and demographic factors as well as hospital-level effects. Based

on this analysis it appears that the increased mortality among the uninsured in Pennsylvania cannot be attributed to uninsured patients receiving care at poorer overall performing hospitals but rather reflects an increased mortality when compared with privately insured patients within individual hospitals. Critically ill Medicaid patients were also found to have a higher unadjusted 30-day mortality. However, in contrast to our findings in the uninsured, patient characteristics as well as hospital-level effects could explain the increased mortality among Medicaid patients.

These findings, both for uninsured and Medicaid patients, are consistent with the American Thoracic Society's recently published systematic review, which highlighted several studies identifying an association between the lack of insurance and mortality as well as an attenuated mortality risk for Medicaid critically ill patients that was no longer significant after adjustment

Figure 2. Histogram of the proportion of critically ill (A) uninsured and (B) Medicaid patients at 167 Pennsylvania hospitals 2004 to 2006.

for confounding variables (2). Our results would suggest that providing a safety net of state-operated insurance such as Medicaid to patients who currently lack insurance may improve their critical care outcomes to a point comparable to patients with private insurance. This is important given the growing number of Americans who rely on Medicaid programs and the proposed expansion of these programs under the Affordable Care Act, as well as recent efforts by many states to enact disenrollment of segments of the Medicaid population (30–32).

Our results complement most (4, 7, 9, 33–37) but not all previous studies (38) examining the impact of insurance status on use of critical care services. Danis and colleagues showed that uninsured patients had an increased mortality and were less likely to receive ICU services on a population level (36). An important limitation of this study is a lack of adjustment for severity of illness. In addition, previous studies did not examine the relative roles of patient- versus hospital-level effects,

a crucial piece of information for identifying targets for quality improvement. By showing that insurance-associated differences in ICU outcomes are not attributable to simply differential care at a subset of hospitals, our study suggests that efforts to improve outcomes for the uninsured should be directed across all hospitals rather than target specific centers.

Although our study shows an increased 30-day mortality and decreased ICU use for uninsured patients when compared with those with private insurance, the mechanism of this effect is unclear. Most concerning is the possibility that physicians or health systems approach the care of the uninsured differently. The presence of a potential systematic bias in clinical practice is difficult for clinicians to accept. However even if not actively sought out, insurance status is easily suggested by patient past medical and social history and is often brought to the forefront in discussions of discharge planning, which are typically initiated early in a patient's hospital stay. It is important to note, however, that lack of health insurance may, in principle, be a marker for

TABLE 2. ADJUSTED 30-DAY MORTALITY AND PROCEDURAL USE BY INSURANCE STATUS

Variable	Private Insurance, OR (n = 95,995)	Medicaid (n = 36,911)		Uninsured (n = 5,814)	
		OR (95% CI)	P Value	OR (95% CI)	P Value
30-d Mortality					
Unadjusted	1.0	1.42 (1.35–1.50)	<0.001	1.26 (1.12–1.41)	<0.001
Adjusted for patient characteristics	1.0	1.06 (0.98–1.15)	0.164	1.25 (1.04–1.51)	0.020
Adjusted plus hospital fixed effects	1.0	1.05 (0.97–1.14)	0.204	1.25 (1.04–1.50)	0.016
Central venous catheter					
Unadjusted	1.0	1.57 (1.51–1.63)	<0.001	0.81 (0.74–0.90)	<0.001
Adjusted for patient characteristics	1.0	1.19 (1.12–1.26)	<0.001	0.81 (0.71–0.94)	0.005
Adjusted plus hospital fixed effects	1.0	1.21 (1.14–1.28)	<0.001	0.84 (0.72–0.97)	0.018
Tracheostomy*					
Unadjusted	1.0	0.99 (0.90–1.09)	0.882	0.38 (0.28–0.62)	<0.001
Adjusted for patient characteristics	1.0	1.24 (1.01–1.28)	0.003	0.42 (0.28–0.62)	<0.001
Adjusted plus hospital fixed effects	1.0	1.16 (1.03–1.31)	0.019	0.43 (0.29–0.64)	<0.001
Acute hemodialysis†					
Unadjusted	1.0	1.97 (1.80–2.17)	<0.001	0.69 (0.51–0.94)	0.018
Adjusted for patient characteristics	1.0	1.22 (1.07–1.40)	0.003	0.55 (0.36–0.84)	0.005
Adjusted plus hospital fixed effects	1.0	1.21 (1.06–1.39)	0.006	0.59 (0.39–0.91)	0.016
Pulmonary artery catheterization					
Unadjusted	1.0	0.74 (0.65–0.84)	<0.001	0.47 (0.33–0.68)	<0.001
Adjusted for patient characteristics	1.0	0.94 (0.80–1.11)	0.455	0.78 (0.51–1.20)	0.258
Adjusted plus hospital fixed effects	1.0	0.95 (0.80–1.12)	0.525	0.92 (0.59–1.43)	0.701
Bronchoscopy					
Unadjusted	1.0	0.98 (0.89–1.07)	0.621	0.58 (0.45–0.76)	<0.001
Adjusted for patient characteristics	1.0	1.00 (0.88–1.15)	0.964	0.78 (0.54–1.12)	0.176
Adjusted plus hospital fixed effects	1.0	1.10 (0.97–1.25)	0.146	0.88 (1.05–1.51)	0.483

Definition of abbreviations: CI = confidence interval; OR = odds ratio.

* Analysis limited to patients receiving mechanical ventilation. Total patients included in analysis for tracheostomy: private insurance, n = 10,880; Medicaid, n = 7,372; uninsured, n = 950.

† Patients with chronic renal failure were excluded from the hemodialysis calculations. Total patients included in analysis for acute hemodialysis: private insurance, n = 94,714; Medicaid, n = 36,292; uninsured, n = 5,780.

different beliefs and perspectives on intensity of care in the ICU, including: lack of trust or belief in the health care system, limitations to care over concerns from surrogate decision makers over hospital costs, or potentially a marker for the absence of a primary surrogate decision maker. Certainly patient autonomy or surrogate decision-maker autonomy may also influence care decisions. We observed that the uninsured were less likely to receive acute hemodialysis or a tracheostomy, two procedures that often require long-term care after ICU discharge. Because long-term care is costly, a patient without insurance, or their surrogate, may forego these procedures due to financial hardship.

In our analysis of common ICU procedures as a marker of intensity of critical care service use, we found that uninsured critically ill patients were less likely to receive CVC, acute hemodialysis, and tracheostomy. Again this difference persisted after adjustment for patient demographic and clinical characteristics and was not diminished by adjustment for hospital effects, suggesting that within individual hospitals critically ill uninsured patients are treated less aggressively. Although the uninsured were also less likely to receive bronchoscopy and PAC, these results did not reach statistical significance. In contrast, we found that Medicaid patients were more likely to receive certain common ICU procedures. We did not test whether differences in use mediate 30-day mortality and do not suggest that the mortality difference seen in our study population is related to decreased procedural use. Indeed, there is little evidence overall that higher-intensity care is associated with improved survival among hospitalized patients (39).

Our study has potential important health policy implications. It is currently estimated that one-third of Americans under age 65 years are uninsured, with the number of uninsured increasing by nearly 4.4 million from 2008 to 2009 (3). September 2010 saw the roll out of the many of the initial reforms of the Patient Protection and Affordable Care Act. Overall this legislation expands access to health insurance in a stepwise fashion with the goal of a national insurance exchange in 2014. The Affordable Care Act may impact many different health care settings, improving access to primary care and ensuring continued access to care in the face of chronic medical conditions. Access to preventive care may be an important modifier of the effect of insurance status on critical care outcomes. Although future research should address the intersection between health insurance reform, preventative care, and acute care use, our study suggests that expanding access to health insurance could help reduce disparities in outcomes and critical care service use.

There are several issues to consider when interpreting the results of our study. Although we controlled for several potential confounders, the possibility of residual uncontrolled confounding is a concern given our study design. This includes misclassification due to coding errors in administrative databases (40), use of median income for 5-digit ZIP code as a proxy for socioeconomic status (41), and inability to track 30-day mortality in a small number of patients who may have died outside of Pennsylvania after discharge. Use of 30-day mortality rather than in-hospital mortality, by linking our hospital discharge database to the Pennsylvania Department of Health vital status file, adds strength to our results as the use of in-hospital mortality neglects to account for mortality related to an episode of critical illness that occurs at home or at a post-hospital care facility. Although it is possible that physician coding practices differ for insured patients (42), our study uses hospital administrative data in which procedural upcoding is less likely to influence reimbursement. The incentive for upcoding among hospitals is small and unlikely to significantly impact our results.

Although we adjusted our model for both patient demographic and clinical characteristics, the MediQual Atlas probability of

death was not reported for approximately 25% of patients in our database; however, we have no reason to suspect that missing data for this variable influenced our results. Previous studies using these data demonstrate that imputation of the MediQual probability of death does not substantially change results (43). MediQual uses a proprietary algorithm that predicts in-hospital death within 67 disease groups based on 260 key clinical findings, including laboratory, radiographic, pathologic, diagnostic tests, and physical examination findings (27). We are able to report only the final score as provided to PHC4 by the hospitals, not the degree to which different variables contribute to that score. Although imperfect risk adjustment could affect our results, previous validation studies show that discrimination as measured by the area under the receiver operating characteristic curve is comparable for MediQual and Acute Physiology and Chronic Health Evaluation (APACHE), which is considered the gold standard for risk adjustment in the ICU (26). Furthermore, we have no reason to suspect that the physiological variables in MediQual would systematically underestimate risk in the uninsured population as would be required to introduce bias in our study.

Finally our database only contains adult patients in Pennsylvania; the increased mortality among the uninsured and decreased use of critical care procedures may not be generalizable to areas of the country where Medicaid, private insurance policies, and systems for indigent patient care may differ.

In summary, lack of health insurance in Pennsylvania is associated with an increased 30-day mortality for the critically ill and a decreased use of common procedures. These differences were not explained by patient characteristics but rather reflected differences for uninsured critically ill patients within hospitals. This suggests that uninsured patients have a worse mortality and receive fewer procedures when compared with the privately insured within individual hospitals. Identifying this effect at the patient level would suggest that improving access to health insurance through national insurance reform may help mitigate disparities in outcomes and use in the ICU. We acknowledge that insurance status may be a marker for an exposure not captured by our patient and clinical characteristics variables. The mechanism behind the effect of insurance status on disparities in critical illness outcomes for the uninsured remains the missing link and is an important area of further research.

Author Disclosure: None of the authors has a financial relationship with a commercial entity that has an interest in the subject of this manuscript.

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