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Use of intensive care services and associated hospital mortality after Massachusetts healthcare reform

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Abstract

Objective—To use the natural experiment of health insurance reform in Massachusetts to study the impact of increased insurance coverage on ICU utilization and mortality

Design—Population based cohort study

Setting—Massachusetts and 4 states (New York, Washington, Nebraska, and North Carolina) that did not enact reform

Participants—All non-pregnant, non-elderly adults (age 18–64), admitted to non-federal, acute-care hospitals in one of the five states of interest were eligible, excluding patients who were not residents of a respective state at the time of admission.

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Disclosure

Dr. Carr spends a portion of his time as a Senior Policy Analyst in the Office of the Assistant Secretary for Preparedness and Response. The Findings and conclusions in this report are those of the author and do not necessarily represent the views of the Department of Health and Human Services or its components.

Measurements—We used a difference-in-differences approach to compare trends in ICU admissions and outcomes of in-hospital mortality and discharge destination for ICU patients.

Main Result—Healthcare reform in Massachusetts was associated with a decrease in ICU patients without insurance from 9.3% to 5.1%. There were no significant changes in adjusted ICU admission rates, mortality, or discharge destination. In a sensitivity analysis excluding a state that enacted Medicaid reform prior to the study period, our difference-in differences analysis demonstrated a significant increase in mortality of 0.38% per year (95% CI 0.12 – 0.64%) in Massachusetts, attributable to a greater per-year decrease in mortality post-reform in comparison states (–0.37%, 95% CI –0.52 – –0.21%) compared to Massachusetts (0.01%, 95% CI –0.20% – 0.11%).

Conclusion—Massachusetts healthcare reform increased the number of ICU patients with insurance but was not associated with significant changes in ICU use or discharge destination among ICU patients. Reform was also not associated with changed in-hospital mortality for ICU patients; however, this association was dependent upon the comparison states chosen in the analysis.

Keywords

healthcare reform; health insurance; critical care; health policy

Introduction

Lack of health insurance is associated with preventable morbidity and mortality in acute care, particularly among patients with critical illness.^{1–6} While expanding health insurance coverage may improve overall health,^{7,8} it may also lead to increases in healthcare use and costs and further exacerbate existing inefficiencies in the health care system^{7,9,10} ICU utilization and costs in the United States are already high relative to other nations, and while ICU care is not the sole driver of rising health care costs, curbing ICU costs through more efficient use is considered a key component of reducing overall health care spending.^{11–13} The degree to which efforts to broaden access to health insurance increase ICU use and improve outcomes for those that experience critical illness remains unknown.

Information on the impact of changes in health insurance status is particularly important given the passage of the Patient Protection and Affordable Care Act (ACA), which expands access to health insurance through several provisions modeled after the health insurance reform enacted by Massachusetts in July 2006. Massachusetts health insurance reform required all adults to purchase health insurance by July 1, 2007. Within three years over 430,000 Massachusetts residents were enrolled in health insurance programs, reducing the percentage of uninsured residents in Massachusetts from approximately 10.9% to less than 6.3%.¹⁴

We sought to use the Massachusetts experience to anticipate the impact of the ACA on critical care use and outcomes in the United States. Prior studies of insurance expansion demonstrate increased outpatient and inpatient access to health services^{7,9,10,15} and decreased mortality.⁸ Greater access not only increases an individual's opportunity to seek

elective procedures that require ICU care, but also allows for better preventative care, which may reduce the burden of comorbid illness, and ultimately an individual's risk of death in the ICU. Individuals with insurance are also more likely to present earlier in the course of their illness when their acute illness severity is lower. These are only a few of the ways that gaining insurance may impact ICU use and reduce mortality. As such, we hypothesized that insurance reform would be associated with increased ICU use and reduced mortality among the critically ill. Additionally, because insurance status is associated with differences in hospital discharge practice among the critically ill,¹⁶ we also examined the impact of insurance reform on hospital discharge location among ICU survivors in Massachusetts. Some of these results have been previously reported in the form of abstracts.^{17,18}

Methods

Study Design

We conducted a retrospective cohort study using hospital discharge records from Massachusetts and four comparison states: New York, North Carolina, Nebraska, and Washington, for patients admitted from January 2003 to November 2009. Massachusetts differs from other states in several respects. It is densely populated with several urban areas, as well as rural areas. Compared to the national average, its population is highly educated, with a higher median household income and it has fewer racial and ethnic minorities (supplementary digital content, Tables S1 and S2). With this in mind, we selected comparison states, which overlap Massachusetts in population demographics, while also being broadly representative of the United States as a whole. These states also provide discharge records necessary to identify ICU admissions through the State Inpatient Databases (SID), a data clearinghouse maintained as part of the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project. The SID are uniformly reported hospital discharge data that include demographics, diagnosis, procedure, and revenue codes, among other variables, for virtually all hospital discharges from participating states.¹⁹ We linked SID datasets to population estimates for each 3-digit ZIP code, the smallest geographic level available in the Massachusetts SID, based upon U.S. Census data (Geolytics, Inc). We also linked discharges to hospital characteristics from the American Hospital Association Annual Survey and the Healthcare Cost Information System,²⁰ including provider type (e.g government vs. private), service type (e.g. acute vs. long-term care), total hospital beds, and total critical care beds.

Patient selection

To capture patient populations potentially eligible under the insurance reform policy in Massachusetts, we limited the analysis to non-pregnant, non-elderly adults (age 18–64), admitted to non-federal, acute-care hospitals in one of the five states of interest. We excluded people who were not residents of a respective state at the time of admission.

Variable definitions

The initial health insurance reform legislation in Massachusetts went into effect in July 2006; however, residents were not mandated to purchase health insurance until July 1, 2007. Therefore, we considered the time period before July 2007 (January 2003 - June 2007) as

the pre-reform period, and defined post-reform as July 2007 through November 2009.^{10,14,21} Our study period therefore includes 54 months before and 29 months after the Massachusetts individual mandate.

The primary outcomes of interest were population- and hospital-based ICU use. We calculated the monthly population-based hospital and ICU admission rates, defined as the number of respective admissions per 10,000-population for each 3-digit ZIP code by month. We defined the hospital-based ICU admission rate as the proportion of hospitalizations admitted to the ICU. ICU admission was defined using billing claims as previously described.²⁰ Secondary outcomes were inhospital mortality for all ICU patients. For survivors, we categorized discharge location as home with or without home health, skilled nursing or intermediate care, rehabilitation, hospice, or other.

Statistical Analysis

We aimed to isolate the effect of Massachusetts's health insurance reform on each of our outcomes. In our analysis of population and patient demographic and clinical characteristics, we used chi-squared tests for proportions, t-tests for means, and analyses of variance for continuous variables. To examine unadjusted and adjusted results for our primary and secondary outcomes over time comparing Massachusetts and control states, we fit a series of regression models using a difference-in-differences analysis.^{22,23} These models attempt to adjust for secular trends that can bias estimated effects (Table S3). All models employed generalized estimating equations (GEE) with robust variance estimates to account for clustering by 3-digit ZIP code for our population-based outcomes, and by hospital for the outcomes of hospital-based ICU admission, hospital mortality, and discharge disposition among survivors.²⁴

In models examining population-based admission rates we adjusted for demographic characteristics at the 3-digit ZIP code level, including race, gender, age, median income and home ownership. In models examining hospital-based ICU admission rate, in-hospital mortality and discharge disposition, we adjusted for multiple patient-level demographic and clinical covariates that might serve as potential confounders. We used these models to calculate the adjusted predictions for each year in a separate model that included year interacted with state as categorical variables and plotted them over time.

Sensitivity analyses

We performed several sensitivity analyses to determine the robustness of our findings to different cohort and model specifications. To examine whether hospital closures over the study period may have accounted for our results, we repeated our analyses limiting the cohort only to hospitals open during the entire study period. We hypothesized that safety-net hospitals were likely to experience the greatest increase in patients gaining health insurance after reform and repeated our analyses after limiting the cohort to hospitals in the top quartile of Medicaid admissions before reform. In 2001 New York state expanded eligibility for Medicaid to childless adults with incomes up to 100% of the federal poverty level and parents with incomes up to 150% of the federal poverty level in 2001.²⁵ Given the recent evidence of decreased population level mortality rates following Medicaid expansion in New

York,⁸ we excluded New York from our comparison states, hypothesizing that Medicaid expansion in this state, although occurring prior to Massachusetts insurance reform, may attenuate differences in our outcomes of interest. We varied the modeling approach for in-hospital mortality by refitting models using a random effects (RE) linear probability model, and logistic regression where we separately accounted for clustering within hospital using either GEE or random effects.

Statistical analyses were performed with SAS 9.2 (SAS Institute Inc., Cary, North Carolina) and Stata 12.0 (StataCorp, College Station, TX). All tests were two tailed, and $p < 0.05$ was considered significant. This project used de-identified data and was exempted from human subjects review by the Institutional Review Boards for University of Pennsylvania and University of Michigan.

Results

Characteristics of the patients who were admitted to ICU

There were 2.1 million hospitalizations in Massachusetts and 11.5 million in comparison states from January 1, 2003 through November 30, 2009 eligible for analysis. A total of 259,240 (14.2%) and 1,562,869 (13.6%) of hospital discharges included an ICU stay in Massachusetts and comparison states, respectively. The proportion of uninsured ICU patients in Massachusetts in the post-reform period declined compared to pre-reform (9.1% vs. 5%, $p < 0.001$), but increased in control states (9.3% vs. 10.2%). ICU patients in MA appeared to have greater severity of illness as evidenced by the higher proportion of individuals who were mechanically ventilated. ICU patients in the pre-reform compared to post-reform period were otherwise similar in both Massachusetts and the comparison states with regard to general characteristic (Table 1) and primary diagnoses (Table S4). There were no significant differences in the growth of ICU beds between MA and comparison states over the study period (Table S6).

Population level hospital and ICU admission rates

In the adjusted population-based analyses, the per capita hospital and ICU admission rates in Massachusetts remained similar across the reform period (Figures 1a and 1b). In our difference-in-differences analysis there was no significant difference in per capita ICU admission rates when comparing these changes in Massachusetts to those in comparison states (0.01 per year per 10,000 95% CI -0.19 to 0.21) (Table 2).

ICU admission rates among hospitalized patients

In the patient-level analysis we found a non-significant net annual increase in ICU admission among hospitalized patients in Massachusetts of 0.25% (95% CI -0.17 to 0.67) in the post-versus pre-reform period (Figure 1c). In our difference-in-differences analysis there was no significant change in hospital-based ICU admission rates associated with Massachusetts health insurance reform (Table 2).

Mortality and discharge destination for ICU patients

Risk adjusted in-hospital mortality for ICU patients decreased similarly in both Massachusetts and comparison states across the insurance reform period (Figure 2). In the difference-in-differences analysis, Massachusetts reform was not associated with a change in mortality among critically ill patients (annual change 0.22%, 95% CI -0.02 to 0.46%, Table 3). For all discharge destinations among survivors, there were no significant differences in the trends seen in Massachusetts (Figure S1) and no difference that could be attributable to insurance reform in our difference-in-differences analysis (Table 3).

Sensitivity analyses

There were no significant changes to our primary results upon limiting the analysis to hospitals open during the entire period nor to those in the top quartile of percent Medicaid (Table S5), nor when we varied the regression modeling technique (Tables S7). When we excluded New York State from our comparator group, we found a significant difference-in-difference in in-hospital mortality for ICU patients. In this analysis mortality remained essentially unchanged in Massachusetts but decreased significantly in comparison states, for a difference-in-difference of 0.38% per year (95% CI 0.12% to 0.64%).

Discussion

Our study demonstrated that Massachusetts health insurance reform resulted in a significant reduction in the number of critically ill patients without health insurance. Despite the reduction in uninsured patients, we found no increase in ICU utilization as measured by ICU admissions per capita or ICU admissions per hospitalization, and no changes in mortality or use of post-acute care facilities among patients admitted to the ICU. In a sensitivity analysis excluding a comparison state because it had undergone Medicaid expansion prior to the study period, Massachusetts had increased in-hospital mortality among ICU patients following insurance reform accounting for changes in the control group in a difference-in-differences analysis.

These results contrast with those in related studies examining the impact of health insurance reform on health care utilization and outcomes. In a recent study examining Medicaid expansion through a randomized lottery in Oregon, hospital admissions increased by 30% in one year for those who gained insurance, an effect size that approximates the results of the RAND health insurance experiment from the 1970s^{7,9}. In Massachusetts, prior studies examining primary care and emergency department use found that Massachusetts health insurance reform was associated with an increase in primary care utilization,¹⁵ a decrease in emergency department visits for low-severity conditions²¹ and non-urgent conditions²⁶ and a concomitant decrease in overall hospitalizations for preventable conditions.^{15,27} Another study of Massachusetts health insurance reform found an increase in outpatient surgical referrals among lower income racial/ethnic minorities in the post-reform period.¹⁰

Although we saw no overall difference in ICU utilization in our population, small changes in admission rates may be masked by changes within the larger context of critically ill patients. For example, decreases in potentially preventable critical illness such as asthma or diabetic

ketoacidosis may be offset by increases in discretionary critical care for elective surgical procedures. Furthermore, in ICUs that operate close to capacity, increased demand for critical care services may be difficult to measure. In such circumstances, greater demand may be reflected by spillover effects such as the moving patients out of the ICU to make room for sicker patients, delays in admission from the emergency department or the general wards, rather than increased overall utilization. Our study was not designed to examine such effects.

There are several possible explanations for the absence of changes in critical care related mortality after Massachusetts health insurance reform we observed in our study. Although previous studies demonstrated that lack of health insurance is associated with increased mortality in critical illness, it could be that lack of health insurance may be a marker for other socioeconomic factors, such as un- or under-employment and poverty, and that acquiring health insurance does not counteract the negative impact of the non-measured socioeconomic factors for which it is proxy. In a recent study of Medicaid expansion, the reduction in adjusted all-cause mortality was not apparent until five years after the policy change.²⁸ In our study, it is possible that reform has not had sufficient time to alter rates of preventable ICU mortality through improved access to primary and preventable medical services, and that longer follow up may be necessary to see a change in these rates. Lastly, our post-reform period coincided with the financial recession beginning in 2008. Population changes in healthcare utilization in response to economic hardship may have mitigated potential benefit to gaining health insurance in the critically ill population.

The findings excluding New York state data suggest that estimates of change may be affected by the choice of comparison groups. Given prior findings that overall population-level mortality in New York state had decreased with expansion of Medicaid coverage,⁸ we anticipated that removal of New York state might increase the relative mortality of comparison states. However, we found the opposite – namely that overall mortality for critically ill patients in our other comparison states decreased further when excluding New York. This finding provides preliminary evidence that the Medicaid expansion in New York and Massachusetts health reform may have negatively affected in-hospital mortality for ICU patients to the same degree. Possible explanations for increased mortality may be due to higher procedural utilization with concomitant iatrogenic complications, or shifting ICU populations with more high-risk patients and fewer low risk patients. This might occur if more high-risk patients who now have insurance were admitted to the ICU, and because of increased census fewer low risk patients were admitted in response. Although we adjusted for comorbidities in our study, we were unable to fully adjust for illness severity on admission, leaving open this possibility.

Our findings have important implications for anticipating the effects of the Affordable Care Act. The care of patients with critical illness currently accounts for between 16.9% and 38.4% of total hospital costs.²⁹ As the number of ICU beds in the US continues to increase and the population ages, critical care costs will also grow.³⁰ Balancing patients' need for critical care with the available resources is a policy challenge. Although we were unable to determine the impact of reform on ICU bed allocation, our study provides evidence that expanding access to health insurance alone may not significantly alter utilization through

greater demand, nor create additional need for post-hospital discharge resources. Instead of building more ICU beds in anticipation of rising demand, our results suggest that policymakers and health systems leaders should continue to focus on improving the efficiency of use of existing resources.³¹

The results of our study should be placed in the context of several limitations. First, we examined health insurance reform in Massachusetts, a state in which only 9% of individuals were uninsured prior to reform compared to the current national average of 17%.¹⁴ Greater increases in insurance due to the ACA may magnify the results we observed in Massachusetts. In addition, the population in Massachusetts has a higher baseline socioeconomic status and less racial diversity than the national average, and the previously uninsured population in Massachusetts may not resemble the broader uninsured population in the US, suggesting that the Massachusetts insurance reform experience may not be generalizable. Second, when examining ICU mortality we were limited to in-hospital mortality, which fails to account for deaths that occur shortly after discharge.^{32,33} Third, our use of administrative data limited our ability to adjust for differences in severity of illness over time. Nevertheless, we employed a difference-in-differences analysis to account for trends in severity of illness and in our outcomes over time in Massachusetts and comparison states. This approach should mitigate the impact of possible unmeasured confounding. Our analysis contrasted Massachusetts to several comparison states. Although this approach strengthens inference about the effect of Massachusetts reform on the studied outcomes, it assumed that no concomitant changes to insurance reform occurred in the comparison states over the period of the study.

In conclusion, while the number of critically ill patients without health insurance decreased significantly after Massachusetts healthcare reform, our primary results show no significant changes in ICU utilization or change in utilization of discharge services for ICU survivors. We additionally found that health insurance reform had no significant impact on mortality for critically ill patients. Our results suggest therefore that health insurance expansion may not further exacerbate the projected shortage of critical care beds and providers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1a. Per capita population adjusted hospital admission rate **Figure 1b. Per capita population adjusted ICU admission rate** **Figure 1c. Risk adjusted ICU admission rate per hospitalization** **Figure 1.**

ICU utilization in Massachusetts (MA) and control states pre- and post-insurance reform

Figure 1a. Per capita population adjusted hospital admission rate

Figure 1b. Per capita population adjusted ICU admission rate

Figure 1c. Risk adjusted ICU admission rate per hospitalization

Figure 2.
Risk-adjusted hospital mortality for ICU patients in Massachusetts (MA) and control states in pre- and post-insurance reform periods

Table 1

Characteristics of ICU discharges in Massachusetts and comparison states by insurance reform period

Characteristics	Massachusetts		Comparison states	
	Pre-reform n=165,057	Post-reform n=94,027	Pre-reform n=1,008,741	Post-reform n=554,182
Age, mean (SD)	49 (12)	49 (12)	49 (12)	49 (12)
Female %	41	41	42	42
Race %				
White	82	80	62	62
Black	8	9	21	19
Hispanic	6	8	7	9
Asian/Pacific Islander	2	2	2	3
Other	3	2	7	7
Primary insurance %				
Private	52	48	48	44
Medicare	19	21	18	19
Medicaid	18	20	21	23
Other	2.1	5.4	3.7	3.5
Uninsured	9.1	5	9.3	10.2
Urban-Rural %	99	99	78	79
Metropolitan > 1 million	72	73	47	47
Metropolitan < 1 million	28	27	32	33
Micropolitan or neither	0.5	0.5	21	20
Median household income by ZIP, \$US, mean	66,000	65,000	56,800	56,800
Urgency of admission %				
Emergent	63	64	64	66
Urgent	20	19	18	16
Elective	17	17	18	17
Other	0	0	0.1	0.9
Admission source %				
Emergency department	58	57	62	64
Another hospital	9	10	7	8
Another health care facility	3	2	1.2	1.5
Other	30	30	30	26
Number of comorbidities (median, IQR)	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)
Number of organ failures %				
0	68	62	73	66
1	23	26	19	23
2+	9	12	7	11
Mechanical ventilation %	19	20	14	17
Discharge disposition %				
Dead	6	6	6	6

Characteristics	Massachusetts		Comparison states	
	Pre-reform n=165,057	Post-reform n=94,027	Pre-reform n=1,008,741	Post-reform n=554,182
Home with or without home health	65	65	74	73
Short-term hospital	7	5	6	5
Skilled nursing or intermediate care	6	7	5	6
Rehabilitation	6	9	2	3
Hospice	0.3	0.5	0.4	0.7
Other	9	9	6	6

Difference-in-differences estimates of the change in ICU utilization rates in Massachusetts (MA) and comparison states in the pre- versus post- insurance reform period

Table 2

Utilization	Adjusted yearly rate of change in outcome						
	Massachusetts			Comparison States			MA minus Comparison
	Pre- reform	Post- reform	Post - Pre (95% CI)	Pre- reform	Post- reform	Post-Pre (95% CI)	
No. of hospitalizations per 10,000 pop.	0.36	0.33	0.03 (-0.53 to 0.48)	0.27	-0.32	-0.60 (-1.10 to 0.10)	0.58 (-0.11 to 1.26)
No. of ICU admissions per 10,000 pop.	-0.04	0.05	0.09 (-0.07 to 0.24)	-0.14	-0.06	0.08 (-0.05 to 0.21)	0.01 (-0.19 to 0.21)
ICU admission rate per hospitalization (%)	-0.21	0.04	0.25 (-0.17 to 0.67)	-0.41	-0.2	0.21 (-0.13 to 0.56)	0.03 (-0.51 to 0.58)

Difference-in-differences estimates of the change in discharge disposition rates in Massachusetts (MA) and Comparison states in the pre- versus post-insurance reform period

Table 3

Discharge Status	Adjusted yearly rate of change in outcome (%)									
	Massachusetts			Comparison States			MA minus Comparison			
	Pre- reform	Post- reform	Post - Pre (95% CI)	Pre- reform	Post- reform	Post-Pre (95% CI)	Difference-in-differences (95% CI)			
Dead	-0.32	-0.32	-0.01 (-0.22 to 0.21)	-0.21	-0.44	-0.23 (-0.34 to -0.11)	0.22 (-0.02 to 0.46)			
Home with or without home health	-0.02	0.52	0.54 (-0.52 to 1.6)	-0.08	0.65	0.73 (0.37 to 1.01)	-0.19 (-1.31 to 0.92)			
Short term hospital	-0.28	-0.50	-0.21 (-0.55 to 0.13)	-0.21	-0.31	-0.10 (-0.29 to 0.09)	-0.19 (-1.31 to 0.92)			
Skilled nursing or intermediate care	0.02	0.05	0.02 (-0.32 to 0.37)	0.13	-0.16	-0.29 (-0.46 to -0.12)	-0.11 (-0.50 to 0.27)			
Rehabilitation	0.10	0.00	-0.10 (-0.69 to 0.49)	0.42	-0.08	-0.50 (-0.72 to -0.29)	0.40 (-0.23 to 1.03)			
Hospice	0.09	0.02	-0.02 (-0.12 to -0.02)	0.12	0.03	-0.08 (-0.12 to -0.04)	0.06 (-0.05 to 0.08)			
Other	-0.08	-0.10	-0.18 (-1.22 to 0.86)	-0.37	-0.13	0.24 (-0.02 to 0.51)	-0.43 (-1.50 to 0.64)			