JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN   Open Access
A GLOBAL JOURNAL OF EMERGENCY MEDICINE

WILEY

ORIGINAL RESEARCH

Health Policy

Association of health insurance coverage and probability of dying in an emergency department or hospital from a motor vehicle traffic injury

Jim P. Stimpson PhD[1] 🟢 | **Alec W. Becker MAS**[2] | **Lindsay Shea DrPH**[1,2] |
Fernando A. Wilson PhD[3]

[1] Drexel University, Dornsife School of Public Health, Philadelphia, Pennsylvania, USA

[2] Drexel University, A.J. Drexel Autism Institute, Philadelphia, Pennsylvania, USA

[3] University of Utah, Matheson Center for Health Care Studies, Salt Lake City, Utah, USA

Correspondence
Jim P. Stimpson, PhD, Drexel University, Dornsife School of Public Health, 3215 Market Street, Philadelphia, PA 19104, USA.
Email: james.p.stimpson@drexel.edu

Twitter handle: @jpstimpson

Abstract

Objective: Describe the association of health insurance coverage with the odds of mortality in an emergency department (ED) or hospital for adult victims of a motor vehicle crash.

Methods: This cross-sectional study pooled and averaged 6 years of data, 2009–2014, from the Nationwide Emergency Department Sample (NEDS). Our analysis was restricted to patients 20–85 years old that were treated in an ED for an injury sustained from a motor vehicle traffic crash (N = 2,203,407 average annual hospital discharges). The outcome variables were whether the motor vehicle crash victim died in the ED or hospital. The predictor variable was health insurance status that was measured as uninsured, Medicare, Medicaid, private insurance, and other health insurance.

Results: Most patients that died had some form of health insurance with less than a quarter classified as uninsured (23%). Nearly half of the patients that died had private insurance (48%) followed by Medicare (13%), Medicaid (9%), and other insurance (8%). Compared to the uninsured, the multivariate adjusted odds ratios (ORs) for death were significantly ($P < 0.001$) lower for Medicare (OR = 0.83, 95% confidence interval [CI] = 0.76–0.92), Medicaid (OR = 0.76, 95% CI = 0.69–0.84), private insurance (OR = 0.63, 95% CI = 0.58–0.68), and other insurance (OR = O.61, 95% CI = 0.54–0.70).

Conclusion: After accounting for hospital and patient characteristics, lack of health insurance was associated with a higher likelihood of death for patients admitted to an ED or hospital for injuries sustained from a motor vehicle crash.

KEYWORDS
emergency care, emergency medicine, health insurance, mortality, motor vehicle, uninsured

---

- -

1 | INTRODUCTION

1.1 | Background

Motor vehicle crashes are widely acknowledged to be a leading cause of death and global burden of disease.[1–3] The United States has comparatively higher mortality compared to other countries.[4,5] Emergency departments (EDs) care for millions of motor vehicle crash victims every year.[6] The focus on reducing motor vehicle traffic injuries and mortality has focused on traffic policies and the built environment with limited attention to the role of EDs and physicians.[7–12]

The Donabedian model is a conceptual framework that can be applied to the study of motor vehicle crash outcomes, especially because it has been validated for use in trauma systems.[13,14] In this framework, patient outcomes are determined by the structure and process of healthcare.[13] However, this model has been extended to include antecedents of care that precede the structure and process of care such as patient characteristics.[15] One of those antecedent factors, health insurance, is a well-established contributing factor to mortality, including in trauma care settings.[16–19]

1.2 | Importance

The mechanism for persons lacking health insurance to have higher mortality has been linked to the structure and processes of care such as access to quality of care, including car crash victims.[20,21] Past studies have also identified that uninsured ED patients may be more likely to be transferred to another ED compared to insured patients, which then impacts the structure and process of care.[22,23]

Studies of trauma care outcomes have found that health insurance is a predictor of survival after accounting for other factors including severity of injury.[24–30] Further underscoring the importance of insurance is that the odds of dying for trauma patients in level 1 trauma centers has been associated with type of health insurance coverage.[31] There is evidence that the availability of trauma surgeons can reduce mortality for patients admitted to a hospital.[32,33]

1.3 | Goals of this investigation

The broader role of health care access of ED patients as a risk factor for mortality in the ED has received limited attention, especially for motor vehicle crash victims.[21,34–35] Moreover, although the Donabedian model has been validated for use with trauma systems, there are few studies that have applied this framework to car crash outcomes in EDs.[13,14] Therefore, the objective of this paper is to describe the association of health insurance coverage, an antecedent factor in the Donabedian model, with the odds of mortality in an ED or hospital for adult victims of a motor vehicle crash.

The Bottom Line

In this analysis of 2.2 M emergency department (ED) motor vehicle collision visits in the National Emergency Department Sample, lack of health insurance was associated with higher odds of death. Although potentially limited by confounders, this study highlights the importance of insurance status as a determinant of health outcomes.

2 | METHODS

2.1 | Study design and data source

This cross-sectional study pooled 6 years of data (2009–2014) from the Nationwide Emergency Department Sample (NEDS) to generate average annual weighted counts, adjusted for sampling design. The NEDS is an all-payer database of hospital-owned ED visits in the United States as part of the Healthcare Cost and Utilization Project (HCUP) administered by the Agency for Healthcare Research and Quality. The unit of analysis in NEDS is the hospital discharge rather than a patient. The database enables national estimates of ED use by combining over 30 million annual ED visits from the State Inpatient Databases and State Emergency Department Databases. The data do not include patient identifiers. The de-identified data contain several data elements from discharge records including diagnosis and procedure codes, mortality status at discharge, patient demographics, payment source, ED charges, and hospital characteristics. A detailed description of HCUP and more information on the design of the NEDS has been published elsewhere.[36–38] This study used de-identified, publicly available data and was determined exempt by the Drexel University Institutional Review Board (protocol number 2106008623). We followed the STROBE reporting guidelines for observational, cross-sectional studies.

2.2 | Selection of participants

We restricted our analysis to patients 20–85 years old that were treated in an ED for an injury sustained from a motor vehicle traffic crash. We excluded persons 16–19 years old to reduce the variability in education status and health insurance status. We included patient discharges in the ED for an injury sustained from a motor vehicle crash as defined by code 2607 in the clinical classification software, which corresponds to ICD-9-CM codes E810.00 to E819.99, E968.5, and E988.5.[39] Records were included if any diagnosis that the met the criteria was present on the discharge record. The final sample size from the pooled records meeting the inclusion criteria was 2,203,407 hospital discharges, representing an annual average during 2009–2014. A flowchart showing the study sample selection is provided in Figure 1. A substantial number of persons 20–85 years old with
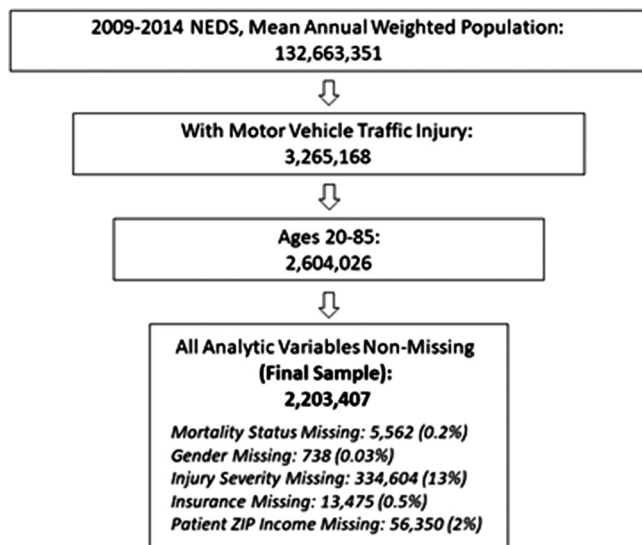
FIGURE 1 Sample identification flowchart

a motor vehicle traffic injury did not have an injury severity score ranging from 1–75 (n = 334,604; 13%) and were excluded, as were records missing any of the variables used in the multivariate analyses. HCUP NEDS documentation reports that some records with an injury are missing an injury severity score because the list of diagnoses accepted by the injury severity score algorithm is more restrictive than the list of diagnoses used by HCUP to identify injuries.

2.3 | Measurements

The primary outcome variable was whether the motor vehicle crash victim died in the ED or hospital. We also disaggregated deaths to investigate ED deaths and hospital deaths as outcomes separately. The predictor variable was health insurance status as indicated in the NEDS expected primary payer variable and was measured as uninsured (combination of self-pay and no charge), Medicare, Medicaid, private insurance, and other health insurance (worker's compensation, TRICARE/CHAMPUS, CHAMPVA, Title V, and other government programs). Patient demographic characteristics included sex (male or female), age (20–44 years, 45–64 years, and 65–85 years), and median income of patient's zip code divided into quartiles. HCUP generates an injury severity score by using a publicly available Stata program that implements the Baker & O'Neill Injury Severity Score (ISS) algorithm to classify injuries on a scale from 1 to 75 with the highest score indicating the most severe injury.[40–42] We categorized the injury scores as mild to moderate (1 to 15) and severe or profound (16 or greater).[41,42] Hospital characteristics included hospital region (Northeast, Midwest, South, West), hospital location and teaching status as determined from the American Hospital Association Annual Survey of Hospitals (nonmetropolitan, metropolitan teaching, metropolitan non-teaching), and hospital trauma level (nontrauma, level III, level II, and level I). Because of changes in the hospital trauma level variable throughout NEDS

years, some records were originally classified in collapsed categories including "nontrauma or level III," "level I or II," and "level I, II, or III." We recoded each of these levels to their corresponding lowest trauma level so that "nontrauma or level III" became nontrauma, "LEVEL I or II" became level II, and "level I, II, or III" became level III. We compared this approach with excluding records in the collapsed levels listwise from the analysis, but results were substantively unchanged.

2.4 | Statistical analysis

All analyses accounted for the NEDS complex sampling design including hospitals as the primary sampling unit, stratified sampling according to the NEDS hospital sampling strata, and weighting of all estimates to the universe of discharges using the NEDS discharge weight variable. All estimates reflected annual averages for the 6 included years by dividing the discharge weight variable by 6 in the combined 2009–2014 dataset prior to analysis. One- and 2-way tabulations were conducted in SAS version 9.4 using PROC SURVEYFREQ. The NEDS complex sampling design was accounted for with the STRATA, CLUSTER, and WEIGHT statements in PROC SURVEYFREQ, and subdomain analysis for the study sample was achieved via multiway tables for each level of a dichotomous study sample membership indicator. All logistic regressions were derived via maximum likelihood estimation and were conducted in Stata version 16.1 on the Picotte high-performance computing cluster in Drexel's University Research Computing Facility. The Stata svyset command was first used to define the complex sampling design. All logistic regressions were run using the Stata svy: logistic command with the subpop option to specify the analytic subpopulation. For all analyses, 2-sided $P < 0.05$ indicated statistical significance.

We first calculated annual average weighted proportions of ED discharges related to a motor vehicle traffic injury. Then, we calculated annual average weighted proportions of dying in the ED or hospital from a motor vehicle traffic injury. These proportions were tested for differences with the annual average weight proportions of those not dying using second-order Rao-Scott χ^2 tests. Second-order Rao-Scott χ^2 tests adjust for design effects and reduce the likelihood of type I errors in comparison with first-order design corrections.[43] Finally, we calculated odds ratios (ORs) and 95% confidence intervals (CIs) from multivariate-adjusted logistic regression models that predicted whether patient mortality, including all deaths combined and ED and hospital deaths separately, from injuries sustained from a motor vehicle crash was associated with health insurance status after accounting for patient and hospital characteristics. Control variables were selected based on availability in the NEDS database, relevance as indicated by existing literature, and unadjusted associations with dying in the ED or hospital. Variable interactions were not considered as the primary association of interest was the main effect of insurance status. Unadjusted ORs and 95% CIs were also calculated for insurance status from a simple logistic regression model of all deaths combined.

To investigate model fit and multicollinearity, the Stata user-written command svylogitgof and a variance inflation check was run after

4 of 10 | **WILEY** JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE Open Access

STIMPSON ET AL.

TABLE 1 Weighted proportion (annual average) of emergency department discharges related to a motor vehicle traffic injury among patients 20–85 years old, Nationwide Emergency Department Sample, 2009–2014

	Full sample (n = 2,203,407),	
	No.	%
Primary payer (expected)		
Uninsured	497,507	23
Medicare	106,181	5
Medicaid	202,552	9
Private including HMO	1,183,110	54
Other	214,057	10
Hospital teaching status		
Non-metropolitan	319,403	14
Metropolitan non-teaching	878,579	40
Metropolitan teaching	1,005,426	46
Hospital region		
Northeast	400,433	18
Midwest	391,544	18
South	1,059,813	48
West	351,618	16
Hospital trauma level		
Nontrauma	1,275,431	58
Level III	247,615	11
Level II	347,075	16
Level I	333,286	15
Year		
2009	359,639	16
2010	380,212	17
2011	362,687	16
2012	369,940	17
2013	358,359	16
2014	372,570	17
Patient age, y		
20-44	1,396,701	63
45-64	621,530	28
65-85	185,176	8
Patient gender		
Female	1,154,644	52
Male	1,048,763	48
Patient injury severity score		
Mild or moderate (1–15)	2,150,832	98
Severe or profound (16+)	52,576	2
Patient zip code median income		
Quartile 1 (low)	698,543	32
Quartile 2	592,403	27
Quartile 3	512,488	23
Quartile 4 (high)	399,974	18

(Continues)

TABLE 1 (Continued)

	Full sample (n = 2,203,407),	
	No.	%
Patient died		
No	2,194,355	99.6
Yes	9053	0.4
Died in ED	4263	0.2
Died in hospital	4790	0.2

Abbreviations: ED, emergency department; HMO, health maintenance organization.

estimation of the main model of all deaths combined via the Stata command estat vif.[44] The initial model also included patient residence urbanicity as a covariate. The mean variance inflation factor (VIF) of the initial model was 1.95 and only hospital teaching status and patient residence urbanicity had VIFs >5. Although guidance on acceptable VIFs ranges slightly in the literature, 1 published standard is that multicollinearity is said to be present if the VIF is higher than 5 to 10.[45] To reduce multicollinearity, patient residence urbanicity was then dropped from the final model—the mean VIF reduced to 1.52 and no variables had VIFs >3. Patient residence urbanicity was dropped rather than hospital teaching status because it was non-significant in the initial model. The svylogitgof command, which implements an F-adjusted mean residual test, indicated lack of fit both in the initial model (F-adjusted test statistic = 15.4; $P < 0.001$) and the final model (F-adjusted test statistic = 15.7; $P < 0.001$). This indicated that additional variables would be needed for improved fit. With large samples, goodness-of-fit tests increase in power and often indicate significant lack of fit even with low levels of systematic error.[46] Because we felt our model was conceptually sound, we accepted the lack of fit as a limitation and impetus for future research to consider additional variables.

3 | RESULTS

3.1 | Characteristics of study subjects

Table 1 presents the descriptive statistics for the sample of discharges that meet the eligibility criteria. There was a weighted annual average of 9053 patients 20–85 years old that died in the ED or hospital during the study period representing <1% of the discharge outcomes. Approximately half of these deaths occurred in the ED (47%), and the remaining deaths occurred in the hospital (53%). The majority of all sample discharges had private health insurance (54%) followed by uninsured (23%), other (10%), Medicaid (9%), and the least common health insurance status was Medicare (5%). Most discharges related to motor vehicle crash injuries occurred at metropolitan hospitals (86%), nontrauma hospitals (58%), and hospitals located in the South (48%). Most patients were 20–44 years old (63%), female (52%), resided in a low (32%), or second quartile (27%) median income area and were classified as mild on the injury severity score (98%).

TABLE 2 Weighted probability (annual average) of dying in the ED or hospital and not dying from a motor vehicle traffic injury among patients 20–85 years old, Nationwide Emergency Department Sample, 2009–2014

	Did not die (n = 2,194,355), %	Died in ED or hospital (n = 9053), %	P-value
Primary payer (expected)			<0.001
Uninsured	23	22	
Medicare	5	13	
Medicaid	9	9	
Private including HMO	54	48	
Other	10	8	
Hospital teaching status			<0.001
Non-metropolitan	15	10	
Metropolitan non-teaching	40	24	
Metropolitan teaching	46	66	
Hospital region			0.06
Northeast	18	15	
Midwest	18	18	
South	48	49	
West	16	18	
Hospital trauma level			<0.001
Nontrauma	58	20%	
Level III	11	10%	
Level II	16	28%	
Level I	15	42%	
Year			0.30
2009	16	18	
2010	17	19	
2011	16	16	
2012	17	15	
2013	16	16	
2014	17	16	
Patient age, y			<0.001
20–44	63	41	
45–64	28	34	
65–85	8	25	
Patient gender			<0.001
Female	52	30	
Male	48	70	
Patient injury severity score			<0.001
Mild or moderate (1–15)	98	49	
Severe or profound (16+)	2	51	
Patient zip code median income			0.17
Quartile 1 (low)	32	32	
Quartile 2	27	28	
Quartile 3	23	23	
Quartile 4 (high)	18	17	

Abbreviations: ED, emergency department; HMO, health maintenance organization.

Table 2 presents column percentages for persons that died in the ED or hospital and for persons that did not die by the study variables. Most patients that died had some form of health insurance with less than a quarter classified as uninsured (22%). Nearly half of the patients that died had private insurance (48%) followed by Medicare (13%), Medicaid (9%), and other insurance (8%). Most patients died in a metropolitan teaching hospital (66%), a hospital in the South (49%), and a level I or II trauma hospital (70%). A notable patient characteristic was that the majority of patients that died were male (70%) even though the proportion of males reported in Table 1 was less than half (48%).

3.2 | Main results

Table 3 presents the odds of dying in the ED or hospital of injuries after being admitted to a hospital for injuries sustained in a motor vehicle crash. Results are presented both unadjusted and fully adjusted for all variables. Unadjusted, discharged visits in which Medicare was the expected primary payer had 2.78 times greater odds of resulting in death (95% CI, 2.53–3.05) while the other insurance payers were not significantly different from uninsured. After accounting for hospital and patient characteristics, patient discharges with some form of health insurance as the expected primary payer had a lower likelihood of death. Compared to uninsured patient discharges, the ORs for mortality were significantly (P < 0.001) lower for Medicare (OR, 0.83; 95% CI, 0.76–0.92), Medicaid (OR, 0.76; 95% CI, 0.69–0.84), private insurance (OR, 0.63; 95% CI, 0.58–0.68), and other insurance (OR, 0.61; 95% CI, 0.54–0.70). Statistically significant findings from the hospital characteristics were that odds of mortality were lower for metropolitan hospitals compared to non-metropolitan hospitals, higher for hospitals located in the South or West compared to the Northeast, and lower for nontrauma hospitals compared to level I, II, or III hospitals. Statistically significant findings from the patient characteristics were that odds of mortality were higher for patients 45–85 years old compared to patients 20–44 years old, male sex patients compared to female patients, and severe/profound injury severity compared to mild/moderate injury severity.

Table 4 presents the odds of dying in the ED and in the hospital separately. Results were adjusted for the same patient and hospital characteristics as those reported in Table 3. Associations with dying in the ED were substantively similar to associations with all deaths, but we observed an attenuation of health insurance associations with dying in the hospital. There was no significant difference in odds of dying in the hospital for those with Medicare or Medicaid as the as the expected primary payer compared to uninsured patient discharges. The ORs for private insurance and other insurance, although still significant (P < 0.001), decreased in magnitude to 0.83 (95% CI, 0.75–0.93) and 0.80 (95% CI, 0.67–0.95), respectively. As well, the associations of increased injury severity, although large in magnitude and significant for both types of deaths (P < 0.001), attenuated for deaths in ED and strengthened for deaths in the hospital.

TABLE 3 Unadjusted and multivariate adjusted odds of dying in the ED or hospital (combined) from a motor vehicle traffic injury among patients 20–85 years old, Nationwide Emergency Department Sample, 2009–2014

| | Died in ED or hospital | | | |
| | Unadjusted | | Fully adjusted | |
	OR	95% CI	OR	95% CI
Primary payer (expected)				
Uninsured (ref)	–	–	–	–
Medicare	2.78***	2.53–3.05	0.83***	0.76–0.92
Medicaid	0.98	0.89–1.09	0.76***	0.69–0.84
Private including HMO	0.92	0.84–1.02	0.63***	0.58–0.68
Other	0.86	0.71–1.05	0.61***	0.54–0.70
Hospital trauma level				
Nontrauma (ref)			–	–
Level III	2.56***	2.05–3.21	1.82***	1.56–2.13
Level II	5.01***	4.43–5.66	3.19***	2.85–3.58
Level I	7.89***	6.86–9.07	3.75***	3.26–4.32
Hospital teaching status				
Non-metropolitan (ref)			–	–
Metropolitan non-teaching	2.15***	1.85–2.49	0.62***	0.54–0.72
Metropolitan teaching	0.87*	0.77–0.99	0.62***	0.55–0.71
Hospital region				
Northeast (ref)			–	–
Midwest	1.21*	1.00–1.46	0.95	0.85–1.05
South	1.22*	1.00–1.50	1.11*	1.00–1.23
West	1.36***	1.15–1.62	1.18**	1.05–1.32
Year				
2009 (ref)			–	–
2010	1.02	0.84–1.24	1.04	0.94–1.15
2011	0.91	0.74–1.11	0.86**	0.78–0.95
2012	0.83	0.69–1.01	0.77***	0.69–0.86
2013	0.90	0.72–1.12	0.83***	0.75–0.91
2014	0.90	0.76–1.06	0.76***	0.69–0.84
Age, y				
20–44 (ref)			–	–
45–64	1.86***	1.77–1.95	1.58***	1.51–1.66
65–85	4.73***	4.44–5.04	3.41***	3.17–3.66
Gender				
Female (ref)			–	–
Male	2.58***	2.46–2.71	1.79***	1.70–1.89
Injury severity score				
Mild or moderate (1–15) (ref)	–	–	–	–
Severe or profound (16+)	47.45***	44.20–50.94	24.27***	22.11–26.65
Zip code median income (patient)				
Quartile 1 (ref)			–	–
Quartile 2	1.05	0.97–1.15	1.05	0.99–1.10
Quartile 3	0.97	0.88–1.08	1.01	0.95–1.08
Quartile 4	0.94	0.83–1.07	0.96	0.90–1.03

Abbreviations: CI, confidence interval; ED, emergency department; HMO, health maintenance organization; OR, odds ratio.

*P < 0.05, **P < 0.01, ***P < 0.001.

TABLE 4 Multivariate adjusted odds of dying in the ED or hospital (disaggregated) from a motor vehicle traffic injury among patients 20–85 years old, Nationwide Emergency Department Sample, 2009–2014

	Died in ED		Died in hospital	
	OR	95% CI	OR	95% CI
Primary payer (expected)				
Uninsured (ref)	–	–	–	–
Medicare	0.68***	0.59–0.78	1.08	0.94–1.24
Medicaid	0.56***	0.48–0.65	1.06	0.93–1.21
Private including HMO	0.51***	0.46–0.55	0.83**	0.75–0.93
Other	0.51***	0.42–0.61	0.80**	0.67–0.95
Hospital trauma level				
Nontrauma (ref)	–	–	–	–
Level III	1.48***	1.23–1.79	3.96***	3.02–5.20
Level II	2.27***	1.95–2.64	7.40***	5.93–9.22
Level I	2.71***	2.17–3.39	7.99***	6.29–10.15
Hospital teaching status				
Non-metropolitan (ref)	–	–	–	–
Metropolitan non-teaching	0.40***	0.34–0.48	2.08***	1.51–2.87
Metropolitan teaching	0.50***	0.43–0.57	1.67**	1.22–2.29
Hospital region				
Northeast (ref)	–	–	–	–
Midwest	0.94	0.82–1.09	0.98	0.86–1.12
South	1.05	0.90–1.23	1.12	1.00–1.26
West	1.13	0.95–1.34	1.21*	1.05–1.41
Year				
2009 (ref)	–	–	–	–
2010	1.04	0.90–1.20	1.02	0.91–1.14
2011	0.86*	0.74–1.00	0.85**	0.75–0.96
2012	0.80**	0.69–0.92	0.74***	0.65–0.85
2013	0.93	0.80–1.07	0.75***	0.67–0.84
2014	0.77***	0.67–0.89	0.74***	0.66–0.83
Age, y				
20–44 (ref)	–	–	–	–
45–64	1.68***	1.57–1.80	1.49***	1.39–1.59
65–85	3.18***	2.88–3.51	3.51***	3.18–3.88
Gender				
Female (ref)	–	–	–	–
Male	2.07***	1.93–2.22	1.53***	1.43–1.64
Injury severity score				
Mild or moderate (1–15) (ref)	–	–	–	–
Severe or profound (16+)	9.34***	8.03–10.86	52.59***	45.80–60.39
Zip code median income (patient)				
Quartile 1 (ref)	–	–	–	–
Quartile 2	1.06	0.98–1.15	1.03	0.96–1.11
Quartile 3	1.03	0.94–1.13	0.98	0.91–1.07
Quartile 4	1.00	0.90–1.10	0.92	0.84–1.02

Abbreviations: CI, confidence interval; ED, emergency department; HMO, health maintenance organization; OR, odds ratio.

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

8 of 10 | WILEY—JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE

STIMPSON ET AL.

4 | LIMITATIONS

The study findings should be interpreted within the limitations of the data. The data have limited patient demographic characteristics that might be associated with health insurance status such as education, race/ethnicity, and employment. It is possible that the association between mortality and health insurance status could be reduced if these other patient characteristics could have been included. For example, less risk adverse individuals may be less likely to purchase insurance and more likely to drive recklessly, and individuals unable to afford health insurance may be more likely to drive older cars with possibly inferior safety technologies or poorly maintained cars, leading to higher injury severity. Another limitation is that the data we accessed did not have contextual identifiers to allow linking the file with other neighborhood characteristics. Other studies of trauma outcomes have found that the supply of surgeons in an area has been reduced mortality for patients admitted to a hospital.[32,33] Another limitation is that the data do not have a measure for car insurance, which pays some medical bills for persons that have liability coverage or have extended medical care coverage through the car insurance provider. Finally, the data reported are hospital discharges and do not include follow-up data on patients after discharge. It is possible that health insurance and access to care could be associated with survival after discharge especially for patients treated at nontrauma hospitals and with limited access to care near their residence.[34]

5 | DISCUSSION

We found that lack of health insurance was associated with a higher likelihood of death for patients admitted to an ED or hospital for injuries sustained from a motor vehicle crash even after accounting for hospital and patient characteristics. Health insurance is a well-documented risk factor for poor outcomes from trauma across hospitals, but the evidence regarding death in an ED or hospital for motor vehicle injuries was limited.[21-26] Our results support a prior study that found health insurance was a mortality risk factor for trauma patients even in level 1 trauma centers.[31] Further investigation is warranted to better understand how health insurance could influence the survivability of injuries from a motor vehicle crash, even in level I or II trauma center hospitals.[29-31]

It also bears noting that patients are not randomly assigned to hospitals and more detailed data on patient characteristics would help to illuminate the antecedent factors identified in the conceptual model that could affect the odds of mortality. Moreover, patient and hospital factors are not randomly distributed in the population of car crash victims.[1-4] As supporting evidence, we found a substantial change in the findings for the association of health insurance with mortality between the unadjusted and adjusted models. Therefore, further investigation is warranted to measure other patient and hospital characteristics suggested by the conceptual model.[12-15] There is also a need for future studies that can consider the improvements in health insurance coverage and other policy changes brought by the Affordable Care Act.

The focus on government interventions to prevent car crashes from occurring and improve the survivability of car crashes has been on public policies and improvements to the built environment or car safety.[7-11] The trends in car crash injuries and deaths over time indicate that hospitals can expect to treat millions more vehicle crash victims each year.[6] If after further research, health insurance continues to be shown to be a risk factor for death in the ED or hospital, independent of the quality of the care team and hospital resources, then policy interventions that improve the health insurance coverage of patients are needed.[12] Improving health insurance coverage could have a positive effect on hospital discharge outcomes for motor vehicle injuries and, by extension, potentially reduce the global burden of deaths from motor vehicle crashes.[11,15,21]

ACKNOWLEDGMENT

AUTHOR CONTRIBUTIONS

JPS conceived the study and created the research design. AWB provided statistical advice on study design, analyzed the data, and drafted the methods and results. LS obtained the data, coordinated the analysis, and reviewed the draft. FAW provided advice on the research design. JPS drafted the manuscript, and all authors contributed substantially to its revision. JPS takes responsibility for the paper as a whole.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ORCID

Jim P. Stimpson PhD https://orcid.org/0000-0002-1266-9436

REFERENCES

1. Rockett IR, Regier MD, Kapusta ND, Coben JH, Miller TR, Hanzlick RL, Todd KH, Sattin RW, Kennedy LW, Kleinig J, Smith GS. Leading causes of unintentional and intentional injury mortality: United States, 2000–2009. *Am J Public Health*. 2012;102(11):e84-92. https://doi.org/10.2105/AJPH.2012.300960.

2. Bergen G, Peterson C, Ederer D, Florence C, Haileyesus T, Kresnow MJ, Xu L; Centers for Disease Control and Prevention (CDC). Vital signs: health burden and medical costs of nonfatal injuries to motor vehicle occupants–United States, 2012. *MMWR Morb Mortal Wkly Rep*. 2014;63(40):894-900.

3. Douglas MJ, Watkins SJ, Gorman DR, Higgins M. Are cars the new tobacco? *J Public Health (Oxf)*. 2011;33(2):160-9. https://doi.org/10.1093/pubmed/fdr032. Erratum in: J Public Health (Oxf). 2011 Sep;33(3):472.

4. James SL, Lucchesi LR, Bisignano C, et al. Morbidity and mortality from road injuries: results from the Global Burden of Disease Study 2017. *Inj Prev*. 2020;26(Supp 1):i46-i56. https://doi.org/10.1136/injuryprev-2019-043302.

5. Evans L. Traffic fatality reductions: United States compared with 25 other countries. *Am J Public Health*. 2014;104(8):1501-7. https://doi.org/10.2105/AJPH. 2014.301922.

6. Zhao, L. (Social & Scientific Systems, Inc.), Lucado, J. (Social & Scientific Systems, Inc.), and Stocks, C. (AHRQ). *Emergency Department Visits Associated with Motor Vehicle Accidents, 2006. HCUP Statistical Brief #84*. 2010. Agency for Healthcare Research and Quality, Rockville, MD. http://www.hcup-us.ahrq.gov/reports/statbriefs/sb84.pdf

7. Ahangari H, Atkinson-Palombo C, Garrick NW. Progress towards zero, an international comparison: Improvements in traffic fatality from 1990 to 2010 for different age groups in the USA and 15 of its peers. *J Safety Res*. 2016;57:61-70. https://doi.org/10.1016/j.jsr. 2016.03.006.

8. Peden M. Saving lives through vehicle safety. *Lancet Glob Health*. 2020;8(6):e746-e747. https://doi.org/10.1016/S2214-109X(20)30189-3.

9. Araz OM, Wilson FA, Stimpson JP. Complex systems modeling for evaluating potential impact of traffic safety policies: a case on drug-involved fatal crashes. *Ann Oper Res*. 2020;291:37-58. https://doi.org/10.1007/s10479-018-2961-5

10. Stimpson JP, Wilson FA, Araz OM, Pagan JA. Share of mass transit miles traveled and reduced motor vehicle fatalities in major cities of the United States. *J Urban Health*. 2014;91(6):1136-43. https://doi.org/10.1007/s11524-014-9880-9.

11. Chekijian S, Paul M, Kohl VP, Walker DM, Tomassoni AJ, Cone DC, Vaca FE. The global burden of road injury: its relevance to the emergency physician. *Emerg Med Int*. 2014;2014:139219. https://doi.org/10.1155/2014/139219.

12. Hughes BP, Anund A, Falkmer T. A comprehensive conceptual framework for road safety strategies. *Accid Anal Prev*. 2016;90:13-28.

13. Donabedian A. The quality of care. How can it be assessed?. *JAMA*. 1988;260(12):1743–1748. http://doi.org/10.1001/jama.260.12.1743

14. Moore L, Lavoie A, Bourgeois G, Lapointe J. Donabedian's structure-process-outcome quality of care model: validation in an integrated trauma system. *J Trauma Acute Care Surg*. 2015;78(6):1168-75. https://doi.org/10.1097/TA.0000000000000663. PMID: 26151519.

15. Coyle YM, Battles JB. Using antecedents of medical care to develop valid quality of care measures. *Int J Qual Health C*. 1999;11(1):5–12.

16. Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, Himmelstein DU. Health insurance and mortality in US adults. *Am J Public Health*. 2009;99(12):2289-95.

17. Woolhandler S, Himmelstein DU. The relationship of health insurance and mortality: is lack of insurance deadly?. *Ann Intern Med*. 2017;167(6):424-31.

18. Sorlie PD, Johnson NJ, Backlund E, Bradham DD. Mortality in the uninsured compared with that in persons with public and private health insurance. *Arch Intern Medicine*. 1994;154(21):2409-16.

19. Osler T, Glance LG, Li W, Buzas JS, Wetzel ML, Hosmer DW. Trauma care doesn't discriminate: the association of race and health insurance with mortality following traumatic injury. *J Trauma Acute Care Surge*. 2015;78(5):1026.

20. Michael McWilliams J. Health consequences of uninsurance among adults in the United States: Recent evidence and implications. *Milbank Quarterly*. 2009;87(2):443–494. http://doi.org/10.1111/j.1468-0009.2009.00564.x

21. Doyle JJ Jr. Health insurance, treatment and outcomes: using auto accidents as health shocks. *Rev Econ Statis*. 2005;87(2):256-70.

22. Delgado MK, Yokell MA, Staudenmayer KL, Spain DA, Hernandez-Boussard T, Wang NE. Factors associated with the disposition of severely injured patients initially seen at non–trauma center emergency departments: disparities by insurance status. *JAMA Surg*. 2014;149(5):422-30. https://doi.org/10.1001/jamasurg.2013.4398.

23. Wright MK, Gong W, Hart K, Self WH, Ward MJ. Association of insurance status with potentially avoidable transfers to an academic emergency department: a retrospective observational study. *J Am Coll Emerg Physicians Open*. 2021;2(2):e12385. https://doi.org/10.1002/emp2.12385. PMID: 33733247; PMCID: PMC7936794.

24. Alban RF, Berry C, Ley E, Mirocha J, Margulies DR, Tillou A, Salim A. Does health care insurance affect outcomes after traumatic brain injury? Analysis of the National Trauma Databank. *Am Surg*. 2010;76(10):1108-11.

25. Rosen H, Saleh F, Lipsitz SR, Meara JG, Rogers SO Jr. Lack of insurance negatively affects trauma mortality in US children. *J Pediatr Surg*. 2009;44(10):1952-7. https://doi.org/10.1016/j.jpedsurg.2008.12.026.

26. Sonderman KA, Wolf LL, Madenci AL, Beres AL. Insurance status and pediatric mortality in nonaccidental trauma. *J Surg Res*. 2018;231:126-132. https://doi.org/10.1016/j.jss.2018.05.033.

27. Haider AH, Chang DC, Efron DT, Haut ER, Crandall M, Cornwell EE 3rd. Race and insurance status as risk factors for trauma mortality. *Arch Surg*. 2008;143(10):945-9. https://doi.org/10.1001/archsurg.143.10.945.

28. Mikhail JN, Nemeth LS, Mueller M, Pope C, NeSmith EG, Wilson KL, McCann M, Fakhry SM. The association of race, socioeconomic status, and insurance on trauma mortality. *J Trauma Nurs*. 2016;23(6):347-356. https://doi.org/10.1097/JTN.0000000000000246.

29. Haider AH, Weygandt PL, Bentley JM, Monn MF, Rehman KA, Zarzaur BL, Crandall ML, Cornwell EE, Cooper LA. Disparities in trauma care and outcomes in the United States: a systematic review and meta-analysis. *J Trauma Acute Care Surg*. 2013;74(5):1195-205. https://doi.org/10.1097/TA.0b013e31828c331d.

30. Jarman MP, Pollack Porter K, Curriero FC, Castillo RC. Factors mediating demographic determinants of injury mortality. *Ann Epidemiol*. 2019;34:58-64.e2. https://doi.org/10.1016/j.annepidem.2019.03.013.

31. Salim A, Ottochian M, DuBose J, Inaba K, Teixeira P, Chan LS, Margulies DR. Does insurance status matter at a public, level I trauma center? *J Trauma*. 2010;68(1):211-6. https://doi.org/10.1097/TA.0b013e3181a0e659.

32. Desai A, Bekelis K, Zhao W, Ball PA. Increased population density of neurosurgeons associated with decreased risk of death from motor vehicle accidents in the United States. *J Neurosurg*. 2012;117(3):599-603. https://doi.org/10.3171/2012.6.JNS111281.

33. Chang DC, Eastman B, Talamini MA, Osen HB, Tran Cao HS, Coimbra R. Density of surgeons is significantly associated with reduced risk of deaths from motor vehicle crashes in US counties. *J Am Coll Surg*. 2011;212(5):862-6. https://doi.org/10.1016/j.jamcollsurg.2011.01.057.

34. Sacks GD, Hill C, Rogers SO Jr. Insurance status and hospital discharge disposition after trauma: inequities in access to postacute care. *J Trauma*. 2011;71(4):1011-5. https://doi.org/10.1097/TA.0b013e3182092c27.

35. Mannix R, Chiang V, Stack AM. Insurance status and the care of children in the emergency department. *J Pediatr*. 2012;161(3):536-541.e3. https://doi.org/10.1016/j.jpeds.2012.03.013.

36. Steiner, C., Elixhauser, A., Schnaier, J. The healthcare cost and utilization project: an overview. *Effect Clin Pract* 2002;5(3):143–51.

37. U.S. Agency for Healthcare Research and Quality. Introduction to the HCUP Nationwide Emergency Department Sample (NEDS), 2006. Online. 2009. http://www.hcup-us.ahrq.gov/db/nation/neds/NEDS_2006_Introductionv4.pdf

38. Owens PL, Barrett ML, Gibson TB, Andrews RM, Weinick RM, Mutter RL. Emergency department care in the United States: a profile of national data sources. *Ann Emerg Med*. 2010;56(2):150-65. https://doi.org/10.1016/j.annemergmed.2009.11.022.

39. Agency for Healthcare Research and Quality. Clinical Classification Software-DIAGNOSES. Accessed April 20, 2021. https://www.hcup-us.ahrq.gov/toolssoftware/ccs/AppendixASingleDX.txt

10 of 10 | **WILEY** JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE

STIMPSON ET AL.

40. Clark DE, Osler TM, Hahn DR. ICDPIC: Stata module to provide methods for translating International Classification of Diseases (Ninth Revision) diagnosis codes into standard injury categories and/or scores. *Statistical Software Components S457028, Boston College Department of Economics*. 2010. https://ideas.repec.org/c/boc/bocode/s457028.html

41. Baker SP, O'Neill B. The injury severity score: an update. *J Trauma*. 1976;16(11):882-5. https://doi.org/10.1097/00005373-197611000-00006. PMID: 994270.

42. Stevenson M, Segui-Gomez M, Lescohier I, Di Scala C, McDonald-Smith G. An overview of the injury severity score and the new injury severity score. *Inj Prev*. 2001;7(1):10-3. https://doi.org/10.1136/ip.7.1.10.

43. SAS Documentation. Rao-Scott Chi-Square Test. The SURVEYFREQ Procedure. Accessed April 26, 2021. https://documentation.sas.com/doc/en/pgmsascdc/9.4_3.4/statug/statug_surveyfreq_details64.htm

44. Archer KJ, Lemeshow S. Goodness-of-fit Test for a logistic regression model fitted using survey sample data. *Stata J*. 2006;6(1):97-105. https://doi.org/10.1177/1536867X0600600106

45. Kim JH. Multicollinearity and misleading statistical results. *Korean J Anesthesiol*. 2019;72(6):558-569. https://doi.org/10.4097/kja.19087

46. Nattino G, Pennell ML, Lemeshow S. Assessing the goodness of fit of logistic regression models in large samples: a modification of the Hosmer-Lemeshow test. *Biometrics*. 2020;76(2):549-560. https://doi.org/10.1111/biom.13249. Epub 2020 Apr 6. PMID: 32134502.

AUTHOR BIOGRAPHY

Jim Stimpson, PhD, is a Professor of Health Management and Policy at Drexel University in Philadelphia, Pennsylvania.