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Financial burden of traumatic injury amongst the privately insured

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Abstract

Objective: We sought to evaluate the overall financial burden associated with traumatic injury amongst patients with private insurance and assess the effect of high deductible plans on out-of-pocket costs.

Summary background data: Traumatic injury can be a source of unexpected financial burden for households. However, the effect of increasing participation in higher cost-sharing private health insurance plans remains unknown.

Methods: We conducted a retrospective cohort observational study, using the Clinformatics® Data Mart Database, a nationwide single-payer administrative claims database to identify US adults who required emergency department services or hospital

admission for single traumatic injury from 2008 to 2018. A two-part model using a logistic regression and a generalized linear model with gamma distribution and log link was used to evaluate 12-month out-of-pocket costs after traumatic injury. Multivariable logistic regression was used to evaluate the likelihood of catastrophic health expenditure after injury.

Results: Of 426,945 included patients, 53% were male, 71% were white, and median age was 42 years. Patients faced monthly OOPC of $660 at the time of their injury. High deductible plan enrollment was associated with an increase of $1,703 in 12-month OOPC after trauma, compared to those covered by traditional health plans. In addition to HDHP enrollment, worsening injury severity and longer hospital stays were also associated with increased 12-month OOPC after trauma. Non-white minorities paid less 12-month OOPC after trauma compared to non-Hispanic white patients, but also used fewer services. Overall, the incidence of CHE was 5%; however high-deductible health plan enrollees faced a 13% chance of CHE.

Conclusions: Privately insured trauma patients face substantial out-of-pocket costs at the time of their injuries. High-deductible health plans are associated with increased financial vulnerability after trauma.

Mini-abstract

Traumatic injury can be a source of unexpected financial burden for households. We examined differences in annual out of-pocket costs and the likelihood of catastrophic health expenditures after traumatic injury among privately insured adult patients.

Introduction

Traumatic injury is the leading cause of death and disability in young adults and children in the United States with an estimated $671 billion in medical bills and lost work productivity.[1–3] Approximately $4 billion of this total are annual out-of-pocket costs (OOPC) paid directly by patients, who self-report an average individual increase of $186 in annual OOPC after trauma.[4,5] Trauma patients also disproportionately suffer from poor outcomes[6,7] and are often ill-equipped to assume additional financial burden.[8–13]

Health insurance serves to protect against catastrophic health expenditures (CHE) and reduce overall OOPC for patients. The Patient Protection and Affordable Care Act (ACA) of 2010 increased the number of covered persons[14,15] and subsequently out-of-pocket expenditures decreased, particularly for low-income groups.[16] However, higher premiums and increased prevalence of cost-sharing plans during this period have contributed to the financial detriment of those already insured.[17–20]

The financial burden of traumatic injury among the privately insured is poorly understood. Further, there remains a lack of research on the effect of high-deductible health plans on out-of-pocket health expenditures after traumatic injury. We examined the impact of traumatic injury on OOPC in adults with private insurance and characterized the effect of high-deductible plans on financial burden after trauma. We hypothesized that, even among privately insured patients, trauma would be associated with an overall increase in OOPC, and this increase would be more dramatic in patients with high-deductible plans.

Methods

Study Design

We performed a retrospective cohort study using the Clinformatics® Data Mart Database (OptumInsight™, Eden Prairie, MN, USA). The Clinformatics® Data Mart (CDM) is a statistically de-identified database of administrative health claims for members of a large national managed care company. The dataset comprises information from over 62 million beneficiaries with commercial or Medicare Advantage health plans from 2003-2020. This study was exempted from review by the Stanford Institutional Review Board because the data were de-identified.

Study participants

We included patients who met the following criteria: 1) emergency department (ED) or inpatient admission for trauma defined by International Classification of Diseases (ICD) version 9 and 10 codes corresponding to traumatic injury[21,22] (eTable 1 in Supplement, http://links.lww.com/SLA/D453); 2) trauma encounter occurring between 2008 and 2018; 3) age 18-63 years at the time of trauma encounter; and 4) 12 months of continuous enrollment before and after the trauma encounter. We selected ED presentation as an inclusion criterion, as ED visits are associated with high costs, even if they do not result in hospital admissions.[23] We excluded minor injuries such as sprains, contusions, and superficial lacerations, as well as injuries related to poisonings, toxic effects, and late effects of injury. We further excluded: 1) patients with multiple traumas of different anatomic regions by ICD code within 1 year of their index injury, to isolate the 12-month costs associated with a single trauma; 2) patients with severe or profound injuries (ISS >16) without an admission associated with their trauma, as these patients likely were transferred to out-of-network facilities or expired in the emergency department and miscoded; and 3) patients with inpatient costs greater than $5,000 in the month prior to their index injury encounter, due to concerns of miscoding of the index trauma encounter.

Patients with missing information for any of these covariates were also excluded from analysis: age, sex, race and ethnicity, high deductible health plan (HDHP) enrollment, and insurance product type. HDHP enrollment was based on the annual deductible threshold as defined by the United States Internal Revenue Service each year for individuals and families,[24] as well as patients with a Health Savings Account (HSA). We calculated injury

severity scores (ISS) for patients using the International Classifications of Diseases Programs for Injury Categorization (ICDPIC) program.[25] ISS was further categorized as mild (ISS <9), moderate (ISS 9-15), severe (ISS 16-24), and profound (ISS >25).[21] Other patient and injury-level variables included discharge location (ED versus hospital), length of stay (LOS) and Charlson Comorbidity Index (CCI) derived from ICD-9 and ICD-10 codes.[26]

Study Outcomes

Our primary outcome was per-patient 12-month out-of-pocket cost (OOPC) after trauma. 12-month OOPC was calculated by summing the deductible, copay, and coinsurance payments from medical and pharmacy claims for every patient. The Clinformatics® dataset includes negative costs, reflecting reimbursements paid back to patients from prior years' payments. For our analysis, we converted negative costs to zero to represent true costs attributable to trauma. All costs were adjusted for inflation to December 2019 US dollar amounts using the Consumer Price Index. Our secondary outcomes were utilization of healthcare services, classified as the following categories: inpatient, outpatient, emergency department (ED), surgery, administered medications, radiology, durable medical equipment (DME) and supplies, prescriptions, skilled nursing facility (SNF), clinic, diagnostic testing, laboratory and pathology, mental health, home health, and dental, vision and hearing.

In a sub-analysis, we evaluated catastrophic health expenditures (CHE), defined by the World Bank and previous literature as OOPC ≥10% of household income.[16,27–30] We analyzed CHE for patients with < $100,000 in household income. Within the Clinformatics® dataset, household income was categorized from < $40,000, $40,000 to 49,000, $$50,000 to 59,000, $$60,000 to 74,000, $$75,000 to $99,00, and > $100,000. We then applied the upper limit as the household income for each patient, ($40,000, $49,000, $59,000, $74,000, and $99,000), thereby excluding patients earning more than $100,000.

Statistical Analysis

Descriptive characteristics were summarized using median for continuous variables and frequency for categorical variables. For univariate analysis, we performed Wilcoxon-Mann-Whitney and Kruskal-Wallis tests for continuous variables given the non-normal distribution of variables, and chi-square tests for categorical variables. We used Wilcoxon matched-pairs signed-rank tests to compare out-of-pocket spending before and after the traumatic event.

Healthcare cost data are often characterized by a large proportion of zero value observations as well as skewed positive values. We constructed a two-part model to estimate the effect of explanatory variables on 12-month change in OOPC to accommodate these characteristics.[31] The first part of the model utilized a logistic regression to estimate the probability of a non-zero cost. The same explanatory variables were used in the second part of the model, which was a generalized linear model with gamma distribution and log link to estimate the OOPC of patients with non-zero costs. The models were compared against ordinary least squares regression and other generalized linear models with various distributions and link functions

using the Akaike information criterion (AIC) to measure goodness of fit amongst the various models.

In the regression, our primary independent variable was injury severity categories (mild, moderate, severe, and profound). Other covariates included age category, sex, Charlson comorbidity index, education, US Census division, high-deductible health plan enrollment, the 12-month OOP of the year preceding the trauma encounter, year of trauma encounter, and length of stay. Covariates were selected based on statistical criteria of non-missingness and clinical relevance. Effect estimates are reported as predicted incremental 12-month OOPC with 95% confidence intervals.

For our catastrophic health expenditures analysis, we performed logistic regression to estimate the associations of CHE with potential explanatory variables. Absolute risk probabilities and 95% confidence intervals are reported. Statistical significance was assessed at the level of $p<0.05$ (two tailed) for all tests. All analyses were performed using Stata V.16 (StataCorp, College Station, TX).

Results

Of the 533,793 patients with a single traumatic encounter from 2008-2018, a total of 426,945 were included for analysis. Most trauma patients were discharged from the ED (84%) and the remainder were admitted for inpatient care (16%). Patients were predominantly white (71%), male (53%), and attained some college or more (73%). Overall, trauma patients paid $197 more in 12-month OOPC post-trauma compared to pre-trauma (IQR $0-$1,003). Patients with high-deductible health plans paid significantly higher 12-month OOPC after trauma than patients with traditional plans ($905 vs $168, $p<0.001$), see Table 1.

Univariate analysis

Patients experienced significantly higher OOPC in the 12 months after injury, increasing from a baseline median of $169 the year before trauma to $853 in the year after injury (table 2). Copays and deductible costs increased in the 12 months after trauma (copays: $65 to $187, deductibles: $25 to $252, both $p<0.001$). Overall median OOPC for outpatient services increased from $65 to $444. On a per-patient level, the largest increases occurred in ED services ($0 to $107, $p<0.001$), radiology ($0 to $26, $p<0.001$), prescriptions ($65 to $88, $p<0.001$), and clinic visits ($59 to $90, $p<0.001$). These services were utilized by significantly more patients in the 12 months after trauma, which includes the index trauma encounter. For example, 94% of patients accessed the ED in the 12 months after trauma (not including their index trauma encounter), compared to 17% in the year prior.

Racial and ethnic groups differed significantly across nearly all demographic, clinical, and economic characteristics (eTable 2, http://links.lww.com/SLA/D454). White patients experienced the highest median difference in OOPC after trauma of $223, compared to Black ($173), Hispanic ($114), and Asian ($117) patients ($p<0.001$). Correspondingly, racial and

ethnic groups differed in health services utilization (eTable 3, http://links.lww.com/SLA/D455). White patients used services at higher rates than their racial minority counterparts across most categories, including surgery, skilled nursing facility and rehabilitation (SNF/rehab), durable medical equipment and supplies, clinic visits, and mental health services. Lower proportions of Black patients underwent surgery (57%) and used SNF/rehab services (16%), compared to white patients (surgery 68%, SNF/rehab 21%), Hispanic patients (surgery 59%, SNF/rehab 16%), and Asian patients (surgery 60%, SNF/rehab 20%, all $p<0.001$). Hispanic patients had the slightly lower rates of clinic visits in the post-trauma period at 84%, compared to other racial groups (white 88%, Black 85%, and Asian 86% ($p<0.001$).

We identified significant differences in OOPC by geographic division (Figure 1). Patients from the Mountain states experienced the highest increase in OOPC, equaling $1,073 (IQR $397-$2,473), while those in the Pacific division had the smallest increase of $363 (IQR $12-$1,504, $p<0.001$). The median injury severity scores (ISS) were equal amongst all divisions (median ISS 1, IQR 1-4), although the Mountain states had the highest mean average ISS of 2.8, compared to 2.4-2.6 for the other divisions. Patients from the Mountain division were admitted to the hospital at higher rates than other divisions (12% compared to 8-11% for the other divisions, $p<0.001$).

Most OOPC were accrued at the time of injury, declining to slightly elevated levels over baseline for 1 month after injury, and returning to baseline within 2 months (Figure 2). In the month of trauma, patients with high deductible health plans paid a median $2,173 in OOPC, significantly higher than the $464 for those with traditional plans. After adjusting for inflation, median 12-month OOPC after trauma increased yearly from $234 in 2008 to $718 in 2018 (Figure 3). This was accompanied by an increase in the percentage of trauma patients with high-deductible health plans, as defined by incurring deductible payments above the IRS-determined HDHP threshold or possessing a health savings account (HSA). HDHP participation increased steadily from 8% in 2008 to 33% in 2018.

Multivariable analysis

Compared to mild injuries, progressive injury severity was associated with predicted incremental 12-month OOPC increases after trauma of $351 for moderate injuries, $552 for severe, and $656 for profound injuries (table 3). High deductible health plan was associated with predicted incremental increase $1,703 in 12-month OOPC after injury, compared to traditional plan coverage. Other patient factors associated with higher predicted incremental 12-month OOPC after trauma include increasing age and higher baseline CCI (eTable 4, http://links.lww.com/SLA/D456). Increasing length of stay was associated with predicted increase of $1,244 in 12-month OOPC for those with hospital stay of 1 day and $1,471 with 2 or more days. Patient factors associated with decreases in predicted 12-month OOPC after trauma include minority race or ethnicity, male sex, and increasing education background (eTable 4, http://links.lww.com/SLA/D456).

In analysis stratified by discharge location, hospital admission was associated with higher OOPC at every covariate level, compared to ED discharged patients. Amongst the hospital admission (inpatient) cohort, moderate injury severity was associated with $638 in predicted incremental OOPC relative to mild injuries, compared to $299 for moderate injuries for ED patients (table 3). High-deductible health plans were associated with predicted incremental 12-month OOPC of $3,067 in the inpatient cohort and $1,455 in the ED cohort, relative to traditional plans. In the inpatient cohort, length of stay was associated with costs of $1,596 and $1,887 for admission lasting 1 day and 2 days or more, respectively.

Catastrophic health expenditures

Overall, the incidence of CHE after traumatic injury was uncommon. Of the 219,085 patients earning less than $100,000 12-monthly, 5% experienced CHE (eTable 5, http://links.lww.com/SLA/D457). Patients who suffered CHE skewed older (57% vs 46% older than age 45 years), more ill at baseline (20% vs $10% with CCI ≥2), with lower household incomes (65% vs 30% earning less than $40,000 per year), and were more likely to be enrolled in a HDHP (48% vs 14%). The CHE cohort paid a median of $4,470 more in 12-month OOPC after trauma, compared to $161 to patients who did not experience CHE.

In logistic regression, the factors associated with the highest likelihood of CHE was HDHP enrollment (12.7%) and length of stay greater than 2 days (12.4%) in table 4. Other factors associated with increased probability of CHE included Black race, Hispanic ethnicity, increasing injury severity, and higher baseline comorbidity (eTable 6, http://links.lww.com/SLA/D458). Factors associated with decreased odds of CHE included male sex and higher education. Increasing pre-trauma 12-month OOPC was associated with higher probability of CHE.

Discussion

Our analysis found that privately insured patients experienced an increase of $660 of monthly OOPC at time of traumatic injury. In adjusted multivariable analysis, HDHP enrollment was associated with $1,703 increase in 12-month OOPC after trauma compared to traditional plan beneficiaries. Our results align with patient self-reported outcomes, which suggest traumatic injury is associated an annual OOPC increase of $186.[5] The Federal Reserve has reported that 40% of US adults would not be able to cover an unexpected expense of $400 without selling possessions or borrowing money and 61% of households have less than $1,000 in savings.[32,33] In this context, our findings suggest even patients with private health insurance are subject to onerous financial burden after injury, and those with high-deductible health plans are particularly vulnerable.

In our study, 5% of patients with private insurance faced catastrophic health expenditures (CHE), as defined as health expenditures exceeding 10% of annual income. After the implementation of the Affordable Care Act, the odds of CHE after traumatic injury decreased by 31%.[28] Lower income groups and racial minorities experienced the largest decrease in

OOPC, indicating that gaining insurance lowers overall OOPC.[34] Yet despite protections such as private insurance, certain groups within our study still faced elevated risk of CHE, particularly HDHP enrollees, as well as women, older patients, and those with less education. Indeed, high-deductible health plans may erode the protective effects of insurance. For context, in 2021 the IRS defined a HDHP as one with a minimum deductible threshold of $1,400 for self coverage and $2,800 for family coverage. We report a trend of increasing annual OOPC difference after trauma over the decade spanning 2008 to 2018, corresponding with an increase in the proportion of patients in our cohort with HDHP. This mirrors patterns in employer-sponsored health coverage for adults aged 18-64 where HDHP enrollment has increased from 15% to 43%[35] from 2007 to 2017 while out-of-pocket costs have grown steadily since 1970.[36] Annual premiums grew by $2,329 and annual deductibles grew by $1,547 per household over the same period.[17] Additionally, our HDHP findings are conservative as we likely undercounted the true number of patients with HDHP, as there may have been patients with high-deductible health plans who simply did not incur enough costs to meet the deductible threshold for HDHP. Overall, this study supports concerning findings that underinsurance is growing among Americans.[20,37]

We found the largest increases in OOPC were in ED visits, prescriptions, radiology, and clinic visits. There was an 77% increase in ED visits, 36% increase in surgical intervention, and 38% increase in radiology services. Not surprisingly, increasing injury severity was associated with greater increases in 12-month OOPC after trauma, compared to mild injuries in adjusted analysis. In 2018, hospital costs represented 33% or $1,192 billion, the largest single component of national healthcare expenditures.[38] Severe and profound injuries often result in prolonged hospital admission and incur substantial hospital costs. We also found protective factors against higher OOPC, including higher education, reaffirming previous findings that the financial burden of traumatic injury is shouldered most by those with the least ability to afford health care.[39]

Racial and insurance disparities negatively affect outcomes after traumatic injury and other medical conditions.[40–48] Several studies suggest insurance can mitigate racial disparities in outcomes after trauma.[40,49,50] In our analysis of privately insured patients, racial and ethnic minority status was associated with lower OOPC after trauma compared to non-Hispanic White patients. We surmise this is driven by racial and ethnic inequalities in access to health care services after traumatic injury. Black, Hispanic, and Asian patients underwent surgery at lower rates and utilized SNF and mental health services less often than their non-Hispanic White counterparts. Our findings are consistent with previous research showing Black patients are less likely to receive post-discharge rehabilitation services after traumatic injury.[51–53] The causality of this discrepancy cannot be determined within this analysis; it is unclear whether minority patients are offered these services less often than their counterparts or if they decline these services more frequently. Given the nature of traumatic encounters, it can be argued that provider input carries more weight in certain health care decisions, such as undergoing surgery or discharge to a skilled nursing facility. In a study of acute care surgeons, unconscious racial and socioeconomic bias was demonstrated in theoretical clinical vignettes, including greater likelihood of assuming drug or alcohol abuse or sexually

transmitted diseases in Black patients compared to non-Hispanic White patients.[54] In other studies, patients' race and ethnicity appear to play a role in clinician assessment and treatment, particularly in pain management.[55,56] The healthcare community must be vigilant regarding systemic racism and implicit biases in daily health care decisions, especially in the context of the current coronavirus pandemic with disproportionate hospitalizations and mortality among racial and ethnic minority groups.[57,58]

As with other administrative claims analyses, this study has limitations. The Clinformatics® Data Mart Database provides valuable demographic characteristics and claims data, but it does not include patient symptoms, clinical course, or insights into their decisions to seek care, limiting the ability to draw conclusions on causality. Furthermore, the dataset does not include premium payments which may be a substantial component of out-of-pocket costs. Administrative claims data may also include coding errors, which may differ between ICD-9 and ICD-10, causing challenges for translating claims-based health services measures.[60] Administrative claims are subject to claims adjudication which may affect the timing of data availability. We eliminated potentially erroneous claims by excluding patients with ISS>16 who were not admitted to the hospital and patients with abnormally high inpatient costs prior to their traumatic incident. We further restricted to patients with continuous enrollment of at least two years. As private insurance is largely covered by employers in the United States, there may be selection biases in excluding patients who drop insurance within a year of their traumatic incident; for example, more severely injured patients may be more likely to lose employment. Nevertheless, continuous enrollment was necessary to establish baseline comorbidity and ensure validity of trauma codes. Regarding our analysis on catastrophic health expenditures, we were limited by the household income variable, which was categorical rather than continuous. Therefore, we estimated household incomes conservatively, based on the upper limit of the provided ranges, which underestimates the true incidence of CHE.

Conclusions

Trauma patients face monthly OOPC of $660 at the time of their injury. High-deductible health plan enrollment was associated with a $1,703 predicted increase in 12-month OOPC after trauma compared to those covered by traditional health plans in adjusted analysis. In addition to HDHP, other factors associated with increased OOPC included worsening injury severity and longer hospital stays. Racial or ethnic minorities paid lower 12-month OOP after trauma compared to non-Hispanic White patients, but also used fewer healthcare services. Catastrophic health expenditures were uncommon; however high-deductible health plan enrollees faced a 13% chance of CHE. Our results suggest there are opportunities within our healthcare coverage and providers systems to improve equality and equity for trauma patients.

References

1. Leading Causes of Death by Age Group United States 2018. Accessed July 15, 2020. https://webappa.cdc.gov/sasweb/ncipc/leadcause.html

2. Cost of Injury & Calculators | WISQARS | Injury Center | CDC. Published July 24, 2018. Accessed October 4, 2019. https://www.cdc.gov/injury/wisqars/cost/index.html

3. Peterson C, Xu L, Barnett SBL. Average lost work productivity due to non-fatal injuries by type in the USA. *Injury Prevention*. Published online March 30, 2020. doi:10.1136/injuryprev-2019-043607

4. Soni A. Statistical Brief #471: Top Five Most Costly Conditions among Adults Age 18 and Older, 2012: Estimates for the U.S. Civilian Noninstitutionalized Population. Published online 2012:6.

5. Alghnam S, Vanness DJ, Gaskin DJ, Thorpe RJ, Castillo R. Estimating annual medical and out-of-pocket expenditures associated with traumatic injuries in the United States. *J Trauma Acute Care Surg*. 2016;80(2):258-264. doi:10.1097/TA.0000000000000910

6. Haider AH, Weygandt PL, Bentley JM, et al. Disparities in trauma care and outcomes in the United States: a systematic review and meta-analysis. *J Trauma Acute Care Surg*. 2013;74(5):1195-1205. doi:10.1097/TA.0b013e31828c331d

7. Armenia SJ, Pentakota SR, Merchant AM. Socioeconomic factors and mortality in emergency general surgery: trends over a 20-year period. *J Surg Res*. 2017;212:178-186. doi:10.1016/j.jss.2017.01.015

8. Velopulos CG, Enwerem NY, Obirieze A, et al. National Cost of Trauma Care by Payer Status. *J Surg Res*. 2013;184(1):444-449. doi:10.1016/j.jss.2013.05.068

9. Knowlton LM, Minei J, Tennakoon L, et al. The economic footprint of acute care surgery in the United States: Implications for systems development. *J Trauma Acute Care Surg*. 2019;86(4):609-616. doi:10.1097/TA.0000000000002181

10. Rajasingh CM, Weiser TG, Knowlton LM, Tennakoon L, Spain DA, Staudenmayer KL. Trauma-induced insurance instability: Variation in insurance coverage for patients who experience readmission after injury. *Journal of Trauma and Acute Care Surgery*. 2018;84(6):876-884. doi:10.1097/TA.0000000000001832

11. Himmelstein DU, Warren E, Thorne D, Woolhandler S. Illness and injury as contributors to bankruptcy. *Health Aff (Millwood)*. 2005;Suppl Web Exclusives:W5-63-W5-73. doi:10.1377/hlthaff.w5.63

12. Morrison ER, Gupta A, Olson L, Cook L, Keenan H. *Health and Financial Fragility: Evidence from Car Crashes and Consumer Bankruptcy*. Social Science Research Network; 2013. Accessed October 4, 2019. https://papers.ssrn.com/abstract=2353328

13. Hollingworth W, Relyea-Chew A, Comstock BA, Overstreet JKA, Jarvik JG. The Risk of Bankruptcy Before and After Brain or Spinal Cord Injury: A Glimpse of the Iceberg's Tip. *Medical Care*. 2007;45(8):702-711. doi:10.1097/MLR.0b013e318041f765

14. Tolbert J, Orgera K, Singer N, Dec 13 ADP, 2019. Key Facts about the Uninsured Population. KFF. Published December 13, 2019. Accessed July 19, 2020. https://www.kff.org/uninsured/issue-brief/key-facts-about-the-uninsured-population/

15. Knowlton LM, Dehghan MS, Arnow K, et al. The impact of Medicaid expansion on trauma-related emergency department utilization: A national evaluation of policy implications. *J Trauma Acute Care Surg*. 2020;88(1):59-69. doi:10.1097/TA.0000000000002504

16. Goldman AL, Woolhandler S, Himmelstein DU, Bor DH, McCormick D. Out-of-Pocket Spending and Premium Contributions After Implementation of the Affordable Care Act. *JAMA Intern Med*. 2018;178(3):347-355. doi:10.1001/jamainternmed.2017.8060

17. Collins SR, Radley DC, Baumgartner JC. Trends in Employer Health Care Coverage, 2008–2018: Higher Costs for Workers and Their Families. The Commonwealth Fund. doi:https://doi.org/10.26099/btqx-ed95

18. Claxton G, Levitt L, Rae M, Sawyer B. Increases in cost-sharing payments continue to outpace wage growth. Kaiser Family Foundation. Accessed July 13, 2020. https://www.healthsystemtracker.org/brief/increases-in-cost-sharing-payments-have-far-outpaced-wage-growth/

19. Miller GE, Keenan P. Trends in Health Insurance at Private Employers, 2008–2019. AHRQ. Accessed July 15, 2020. https://meps.ahrq.gov/data_files/publications/st524/stat524.shtml

20. Health Insurance Coverage Eight Years After the ACA — 2018 Biennial | Commonwealth Fund. Accessed July 19, 2020. https://www.commonwealthfund.org/publications/issue-briefs/2019/feb/health-insurance-coverage-eight-years-after-aca

21. Bolorunduro OB, Villegas C, Oyetunji TA, et al. Validating the Injury Severity Score (ISS) in Different Populations: ISS Predicts Mortality Better Among Hispanics and Females. *Journal of Surgical Research*. 2011;166(1):40-44. doi:10.1016/j.jss.2010.04.012

22. Annest JL, Hedegaard H, Chen L-H, Warner M. Proposed Framework for Presenting Injury Data Using ICD-10-CM External Cause of Injury Codes. :32.

23. Bamezai A, Melnick G, Nawathe A. The Cost of an Emergency Department Visit and Its Relationship to Emergency Department Volume. *Annals of Emergency Medicine*. 2005;45(5):483-490. doi:https://doi.org/10.1016/j.annemergmed.2004.08.029

24. Publication 969 (2020), Health Savings Accounts and Other Tax-Favored Health Plans | Internal Revenue Service. Accessed February 25, 2021. https://www.irs.gov/publications/p969

25. icdpicr: ICDPICR in ablack3/icdpicr: ICDPIC In R. Accessed June 7, 2020. https://rdrr.io/github/ablack3/icdpicr/man/icdpicr.html

26. Quan H, Sundararajan V, Halfon P, et al. Coding Algorithms for Defining Comorbidities in ICD-9-CM and ICD-10 Administrative Data: *Medical Care*. 2005;43(11):1130-1139. doi:10.1097/01.mlr.0000182534.19832.83

27. O'Donnell O, van Doorslaer E, Wagstaff A, Lindelow M. *Analyzing Health Equity Using Household Survey Data: A Guide to Techniques and Their Implementation*. The World Bank; 2007. doi:10.1596/978-0-8213-6933-3

28. Liu C, Tsugawa Y, Weiser TG, Scott JW, Spain DA, Maggard-Gibbons M. Association of the US Affordable Care Act With Out-of-Pocket Spending and Catastrophic Health Expenditures Among Adult Patients With Traumatic Injury. *JAMA Netw Open*. 2020;3(2):e200157. doi:10.1001/jamanetworkopen.2020.0157

29. Wagstaff A, Doorslaer E van. Catastrophe and impoverishment in paying for health care: with applications to Vietnam 1993–1998. *Health Economics*. 2003;12(11):921-933. doi:10.1002/hec.776

30. Shrime MG, Dare AJ, Alkire BC, O'Neill K, Meara JG. Catastrophic Expenditure to Pay for Surgery: A Global Estimate. *Lancet Glob Health*. 2015;3(0 2):S38-S44. doi:10.1016/S2214-109X(15)70085-9

31. Smith VA, Preisser JS. A marginalized two-part model with heterogeneous variance for semicontinuous data. *Stat Methods Med Res*. 2019;28(5):1412-1426. doi:10.1177/0962280218758358

32. Report on the Economic Well-Being of U.S. Households in 2017, May 2018. Published online 2017:66.

33. Tepper T. Most Americans Don't Have Enough Savings To Cover A $1K Emergency | Bankrate.com. Bankrate. Accessed December 16, 2020. https://www.bankrate.com/banking/savings/financial-security-0118/

34. Liu C, Rahman AS, Chao TE. Catastrophic expenditures in California trauma patients after the Affordable Care Act: reduced financial risk and racial disparities. *The American Journal of Surgery*. Published online April 20, 2020. doi:10.1016/j.amjsurg.2020.04.012

35. Cohen RA. High-deductible Health Plan Enrollment Among Adults Aged 18–64 With Employment-based Insurance Coverage. *CDC National Center for Health Statistics*. 2018;(317):8.

36. Kamal R, McKermott D, Ramirez G, Cox C. How has U.S. spending on healthcare changed over time? Peterson-KFF Health System Tracker. Published December 23, 2020. Accessed April 6, 2021. https://www.healthsystemtracker.org/chart-collection/u-s-spending-healthcare-changed-time/

37. Institute of Medicine Committee on the Changing Market, Managed Care and the Future Viability of Safety Net Providers. *America's Health Care Safety Net: Intact but Endangered*.; 2000. doi:10.17226/9612

38. Hartman M, Martin AB, Benson J, Catlin A. National Health Care Spending In 2018: Growth Driven By Accelerations In Medicare And Private Insurance Spending. *Health Affairs*. 2019;39(1):8-17. doi:10.1377/hlthaff.2019.01451

39. Scott J, Raykar N, Rose J, et al. Cured into Destitution: Catastrophic Health Expenditure Risk Among Uninsured Trauma Patients in the United States. *Annals of Surgery*. 2018;267(6):1093-1099. doi:10.1097/SLA.0000000000002254

40. Haider AH, Chang DC, Efron DT, Haut ER, Crandall M, Cornwell EE. Race and Insurance Status as Risk Factors for Trauma Mortality. *Arch Surg*. 2008;143(10):945-949. doi:10.1001/archsurg.143.10.945

41. Schiraldi M, Patil CG, Mukherjee D, et al. Effect of insurance and racial disparities on outcomes in traumatic brain injury. *J Neurol Surg A Cent Eur Neurosurg*. 2015;76(3):224-232. doi:10.1055/s-0034-1543958

42. Glance LG, Osler TM, Mukamel DB, et al. Trends in Racial Disparities for Injured Patients Admitted to Trauma Centers. *Health Serv Res*. 2013;48(5):1684-1703. doi:10.1111/1475-6773.12064

43. Scott JW, Salim A, Sommers BD, Tsai TC, Scott KW, Song Z. Racial and Regional Disparities in the Effect of the Affordable Care Act's Dependent Coverage Provision on Young Adult Trauma Patients. *J Am Coll Surg*. 2015;221(2):495-501.e1. doi:10.1016/j.jamcollsurg.2015.03.032

44. Goldin J, Lurie I, McCubbin J. *Health Insurance and Mortality: Experimental Evidence from Taxpayer Outreach*. National Bureau of Economic Research; 2019:w26533. doi:10.3386/w26533

45. Rohlfing ML, Mays AC, Isom S, Waltonen JD. Insurance Status as a Predictor of Mortality in Patients Undergoing Head and Neck Cancer Surgery. *Laryngoscope*. 2017;127(12):2784-2789. doi:10.1002/lary.26713

46. Cole AP, Lu C, Krimphove MJ, et al. Comparing the Association Between Insurance and Mortality in Ovarian, Pancreatic, Lung, Colorectal, Prostate, and Breast Cancers. *Journal of the National Comprehensive Cancer Network*. 2019;17(9):1049-1058. doi:10.6004/jnccn.2019.7296

47. Wyrick JM, Kalosza BA, Coritsidis GN, Tse R, Agriantonis G. Trauma care in a multiethnic population: effects of being undocumented. *Journal of Surgical Research*. 2017;214:145-153. doi:10.1016/j.jss.2017.02.006

48. Englum BR, Hui X, Zogg CK, et al. Association Between Insurance Status and Hospital Length of Stay Following Trauma. *Am Surg*. 2016;82(3):281-288.

49. McQuistion K, Zens T, Sung HS, et al. Insurance status and race affect treatment and outcome of traumatic brain injury. *JSR*. 205:261-271.

50. Zogg CK, Payró Chew F, Scott JW, et al. Implications of the Patient Protection and Affordable Care Act on Insurance Coverage and Rehabilitation Use Among Young Adult Trauma Patients. *JAMA Surg*. 2016;151(12):e163609. doi:10.1001/jamasurg.2016.3609

51. Chun Fat S, Herrera-Escobar JP, Seshadri AJ, et al. Racial disparities in post-discharge healthcare utilization after trauma. *The American Journal of Surgery*. 2019;218(5):842-846. doi:10.1016/j.amjsurg.2019.03.024

52. Englum BR, Villegas C, Bolorunduro O, et al. Racial, Ethnic, and Insurance Status Disparities in Use of Posthospitalization Care after Trauma. *J Am Coll Surg*. 2011;213(6):699-708. doi:10.1016/j.jamcollsurg.2011.08.017

53. Sacks GD, Hill C, Rogers SO. Insurance status and hospital discharge disposition after trauma: inequities in access to postacute care. *J Trauma*. 2011;71(4):1011-1015. doi:10.1097/TA.0b013e3182092c27

54. Haider AH, Schneider EB, Sriram N, et al. Unconscious Race and Social Class Bias Among Acute Care Surgical Clinicians and Clinical Treatment Decisions. *JAMA Surg*. 2015;150(5):457. doi:10.1001/jamasurg.2014.4038

55. Burgess DJ, Van Ryn M, Crowley-Matoka M, Malat J. Understanding the Provider Contribution to Race/Ethnicity Disparities in Pain Treatment: Insights from Dual Process Models of Stereotyping. *Pain Med*. 2006;7(2):119-134. doi:10.1111/j.1526-4637.2006.00105.x

56. Hoffman KM, Trawalter S, Axt JR, Oliver MN. Racial bias in pain assessment and treatment recommendations, and false beliefs about biological differences between blacks and whites. *Proc Natl Acad Sci USA*. 2016;113(16):4296-4301. doi:10.1073/pnas.1516047113

57. CDC. Coronavirus Disease 2019 (COVID-19). Centers for Disease Control and Prevention. Published February 11, 2020. Accessed July 19, 2020. https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/racial-ethnic-minorities.html

58. Survey reveals extent of coronavirus-related job loss, outsized impact on blacks and Latinos > News > USC Dornsife. Accessed August 11, 2020. http://dornsifelive.usc.edu/news/stories/3198/coronavirus-covid-19-job-loss-and-anxiety-increases/

59. Kyanko KA, Curry LA, Busch SH. Out-of-Network Provider Use More Likely in Mental Health than General Health Care Among Privately Insured. *Medical Care*. 2013;51(8):699-705. doi:10.1097/MLR.0b013e31829a4f73

60. Mainor AJ, Morden NE, Smith J, Tomlin S, Skinner J. ICD-10 Coding Will Challenge Researchers: Caution and Collaboration may Reduce Measurement Error and Improve Comparability Over Time. *Medical Care*. 2019;57(7):e42. doi:10.1097/MLR.0000000000001010

Figure 1: Adjusted median 12-month OOPC difference after trauma by census division*

*Adjusted for patient age, sex, income level, injury severity, and Charlson comorbidity index

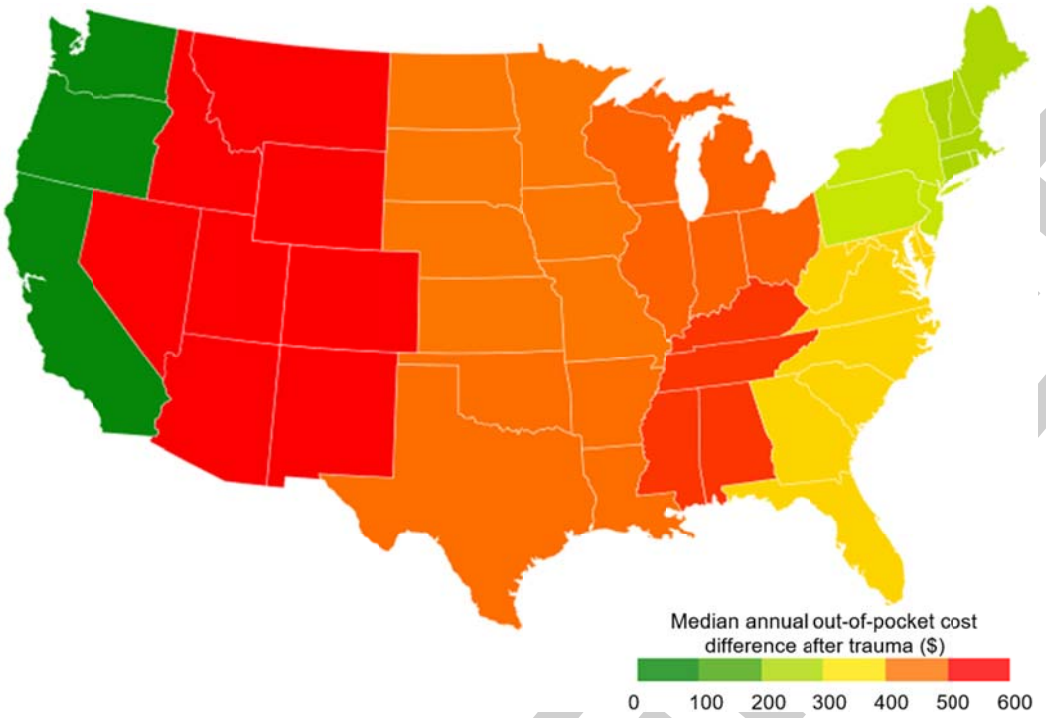

Figure 2: Monthly OOPC over time relative to injury

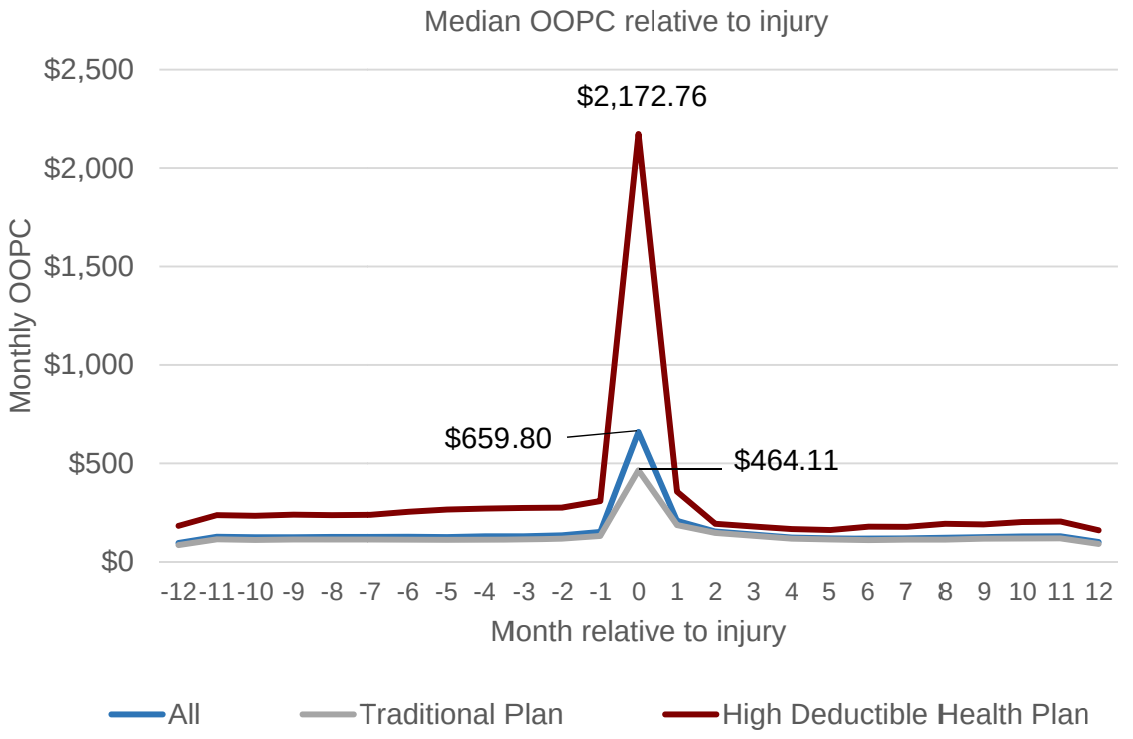

Figure 3: Trends in annual out-of-pocket cost difference after trauma and high-deductible plan enrollment from 2008 to 2018

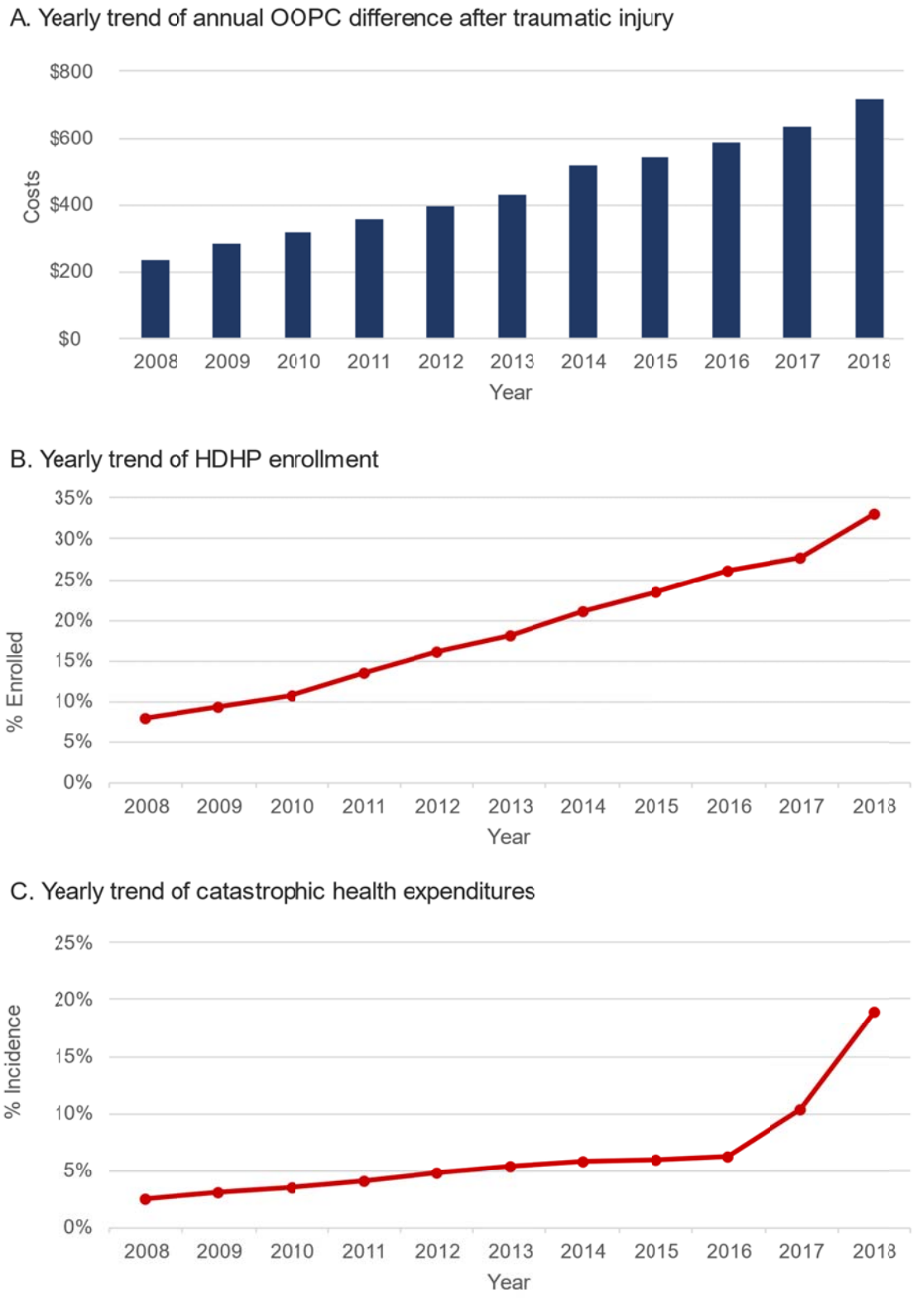

Table 1: Trauma patient characteristics by health plan type*

	Traditional plan **n=355,669**	**High deductible health plan** **n=71,276**
Age category, %		
18-29 years	24.3%	23.7%
30-44 years	32.0%	31.1%
45-54 years	23.6%	23.6%
55-63 years	20.1%	21.6%
Female, %	47.6%	46.8%
Charlson comorbidity index, %		
0	65.2%	66.9%
1	25.9%	24.4%
2+	8.9%	8.7%
Race, %		
Non-Hispanic White	69.8%	76.3%
Black	13.3%	9.9%
Hispanic	12.9%	10.2%
Asian	4.1%	3.6%
Education, %		
< 12th grade	0.5%	0.3%
High school diploma	27.1%	22.7%
< Bachelor's degree	52.2%	54.2%
Bachelor’s degree+	19.9%	22.6%
Unknown	0.3%	0.2%
Region		
Midwest	22.1%	32.8%
Northeast	10.9%	7.8%
South	48.5%	41.0%
West	18.5%	18.5%
Pre-trauma 12-month OOPC		

$0	5.9%	4.3%
$1-499	50.9%	34.5%
$500-999	10.9%	11.3%
$1,000-10,000	16.7%	32.1%
>$10,000	15.6%	17.8%
Hospital admission, %	14.2%	21.5%
Injury severity score, %		
Mild	93.5%	89.4%
Moderate	5.0%	7.7%
Severe	1.0%	1.8%
Profound	0.5%	1.1%
LOS, %		
0 days	90.7%	85.4%
1 days	1.4%	2.3%
2+ days	7.9%	12.3%
12-month OOPC diff after trauma, median (IQR)	$168 ($0-850)	$905 ($0-2,763)

***All p-values <0.001 using Wilcoxon-Mann-Whitney test for continuous variables and chi square test for categorical variables**

Abbreviations: n=number of patients; IQR=Interquartile range; diff=difference

Table 2: 12-month out-of-pocket costs by health utilization category*

	Pre-injury			Post-injury		
	Median (IQR)	Mean	% pts	Median (IQR)	Mean	% pts
ED	$0 ($0-0)	$43	17%	$107 ($25-282)	$255	94%
Surgery	$0 ($0-0)	$106	29%	$3 ($0-192)	$275	65%
Prescriptions	$65 ($0-278)	$238	75%	$88 ($19-310)	$260	88%
Radiology	$0 ($0-0)	$87	43%	$26 ($0-162)	$185	81%
Clinic visits	$59 ($0-157)	$116	77%	$90 ($23-206)	$149	87%
Adm medications	$0 ($0-0)	$92	8%	$0 ($0-0)	$222	18%
DME/Supplies	$0 ($0-0)	$22	17%	$0 ($0-2)	$85	43%
SNF	$0 ($0-0)	$24	9%	$0 ($0-0)	$62	20%
Diagnostic test	$0 ($0-0)	$20	51%	$0 ($0-1)	$24	61%
Laboratory/Pathology	$0 ($0-24)	$57	66%	$0 ($0-34)	$66	74%
Dental/Vision/Hearing	$0 ($0-0)	$6	12%	$0 ($0-0)	$7	14%
Mental health	$0 ($0c-0)	$17	7%	$0 ($0-0)	$19	9%
Home health	$0 ($0-0)	$1	<1%	$0 ($0-0)	$2	1%
Other	$0 ($0-29)	$79	37%	$23 ($0-136)	$172	75%
Inpatient OOPC	$0 ($0-0)	$303	18%	$0 ($0-0)	$574	19%
Outpatient OOPC	$65 ($0-353)	$388	66%	$444 ($82-1,333)	$993	81%
Total OOPC	**$169 ($25-696)**	**$691**	**84%**	**$853 ($305-2,095)**	**$1,568**	**100%**
Copay	$65 ($0-194)	$157	84%	$187 ($0-385)	$281	100%
Deductible	$25 ($0-421)	$400	84%	$252 ($0-1,071)	$762	100%
Coinsurance	$0 ($0-59)	$263	84%	$1 ($0-461)	$525	100%

*All p-values are <0.05 from Wilcoxon paired sign rank test, using median cost values
Abbreviations: n=number of patients; IQR=interquartile range; ED = emergency department; DME=durable medical equipment; SNF: skilled nursing facility; OOPC=out-of-pocket costs

Table 3: Adjusted predicted 12-month OOPC after trauma*

	Full sample n=426,945		Hospital admission n=65,601		ED discharge n=361,344	
	12-month OOPC after trauma	95% CI**	12-month OOPC after trauma	95% CI**	12-month OOPC after trauma	95% CI**
Injury severity score						
Mild	$1,563	$1,555-1,570	$2,844	$2,813-2,875	$1,330	$1,324-1,336
Moderate	$1,914	$1,883-1,944	$3,481	$3,421-3,542	$1,629	$1,602-1,657
Severe	$2,115	$2,038-2,191	$3,846	$3,710-3,982	--***	--***
Profound	$2,219	$2,112-2,325	$4,034	$3,844-4,225	--***	--***
HDHP						
No	$1,277	$1,270-1,282	$2,303	$2,280-2,326	$1,090	$1,085-1,095
Yes	$2,980	$2,952-3,007	$5,371	$5,303-5,438	$2,546	$2,522-2,569
LOS						
0	$1,415	$1,409-1,422	$1,816	$1,802-1,830	$1,342	$1,337-1,348
1	$2,659	$2,579-2,739	$3,412	$3,309-3,515	--***	--***
>2	$2,887	$2,848-2,926	$3,703	$3,655-3,751	--***	--***

*Adjusted for age, sex, Charlson comorbidity index, race, education, geographic division; pre-trauma 12-month OOPC; length of stay, year of encounter

**All p-values <0.001

*** Values excluded from predicted cost calculations as these covariate levels were excluded from the ED discharge cohort

Abbreviations: OOPC = out-of-pocket costs; CI = confidence interval

Table 4: Probability of Catastrophic Health Expenditures*

	Adjusted absolute risk	95% CI	P-value
Injury severity score			
Mild	4.6%	4.5-4.7%	<0.001
Moderate	5.9%	5.6-6.2%	<0.001
Severe	6.0%	5.4-6.6%	<0.001
Profound	8.0%	7.1-8.9%	<0.001
Health plan type			
Traditional	3.1%	3.0-3.2%	<0.001
High-deductible	12.7%	12.4-13.1%	<0.001
Length of stay			
0 days	3.6%	3.5-3.7%	<0.001
1 day	9.1%	8.2-10.0%	<0.001
2+ days	12.4%	12.0-12.8%	<0.001

*Probability of each covariate level taken at reference value of other categorical covariates and mean of continuous variables

Abbreviations: CHE=Catastrophic Health Expenditure; CI=confidence interval