SUPPLEMENT

Derivation of annual out-of-pocket spending for patients with private health insurance

For patients with private health insurance, their estimated out-of-pocket (OOP) spending for inpatient trauma care was based on three factors: annual general deductible, cost-sharing in the form of coinsurance or copays, and their plans' annual OOP spending limit. Every year, the Kaiser Family Foundation (KFF) performs an Employer Health Benefits Survey[1] which provides national estimates of cost-sharing among patients with private health plans. Table A shows the parameters of the model we used to estimate OOP spending for privately insured patients.

	2012	2013	2014	2015	2016	2017
A) Deductible						
% with a deductible	**72%**	**78%**	**80%**	**81%**	**83%**	**81%**
Avg. deductible individual plan	$ 1,097	$ 1,135	$ 1,217	$ 1,318	$ 1,478	$ 1,505
Avg. deductible for family plans	$ 2,194	$ 2,270	$ 2,434	$ 2,636	$ 2,956	$ 3,010
B) Additional Cost Sharing						
% with coinsurance	**67%**	**69%**	**72%**	**76%**	**74%**	**70%**
Avg. inpatient coinsurance rate	0.18	0.18	0.19	0.19	0.19	0.19
% with co-pay[1]	**14%**	**14%**	**13%**	**8%**	**10%**	**13%**
Avg daily co-pay	$ 221	$ 264	$ 297	$ 281	$ 281	$ 257
% with no additional cost sharing	**19%**	**17%**	**15%**	**16%**	**16%**	**17%**
C) Out of Pocket Maximum[2]						
Avg. Gold Tier OOP Max	$ 6,054	$ 5,406	$ 4,892	$ 5,000	$ 3,000	$ 3,000
Avg. Silver Tier OOP Max	$ 6,678	$ 6,091	$ 5,603	$ 5,769	$ 6,000	$ 6,000
Avg. Bronze Tier OOP Max	$ 6,780	$ 6,497	$ 6,252	$ 6,088	$ 7,150	$ 7,150
Avg. Catastrophic Tier OOP Max	$ 7,150	$ 6,850	$ 6,600	$ 6,350	$ 10,000	$ 10,000
% Gold Tier Plans	33%	33%	9%	8%	8%	8%
% Silver Tier Plans	38%	38%	55%	55%	57%	60%
% Bronze Tier Plans	15%	15%	36%	36%	34%	31%
% Catastrophic Tier Plans	14%	14%	0%	1%	1%	1%
Avg. Individual OOP Max	$ 6,553	$ 6,032	$ 5,779	$ 5,827	$ 6,178	$ 6,163
Avg. Family OOP Max	$ 13,107	$ 12,064	$ 11,557	$ 11,655	$ 12,355	$ 12,327
D) Out of Pocket Maximum - For Sensitivity Analyses[3]						
i. Estimating Upper Limit						
National limit - Individual	$ 7,500	$ 7,500	$ 6,350	$ 6,600	$ 6,850	$ 7,350
National limit - Family	$15,000	$15,000	$ 12,700	$ 13,200	$ 13,700	$ 14,700
ii. Estimating Lower Limit						
Best Gold Plan - Individual	$ 3,000	$ 3,000	$ 3,300	$ 3,300	$ 4,450	$ 4,500
National limit - Family	$ 6,000	$ 6,000	$ 6,600	$ 6,600	$ 8,900	$ 9,000

Table A. Parameters used to estimate OOP spending for privately insured patients. Authors' interpretation of data from the KFF annual Employer Health Benefits Survey. Notes: 1. Co-pay estimated as a daily payment for each inpatient day; 2. "Metal levels" were not in effect until 2014 so the 2012-13 data is based on 4 tiers of reported OOP maximums; 3. There was no mandated maximum OOP limit in 2012-13, so this is an underestimate

For example, data from Table A were combined with census data and the total charges from the trauma registry to determine the average deductible and the average cost-sharing amount that an individual patient would pay on average. If this estimated spending was greater than their estimated maximum OOP limit, then the estimated OOP spending for that patient was replaced with their estimated maximum OOP. Of note, these numbers are likely *underestimates* of spending because they do not take into account money spent on annual premiums or charges associated with any post-discharge care.

In order to create an upper and a lower bound to the estimated risk of CHE among privately insured patients in our sample, we performed two sensitivity analyses based on the parameters in part D of Table A. To generate lower bound estimate, we assumed that all privately insured patients had plans with OOP spending limits equivalent to the best "gold level" plan available on the individual market in the state of Washington that year. To generate an upper bound estimate, we assumed that all patients were required to pay a deductible and that all privately insured patients had OOP spending limit equivalent to the national limit set by the federal government for the year in question.

Derivation of post-subsistence annual income for all patients

Once we calculated OOP spending for each patient, we needed to compare that value to their estimated post-subsistence income—that is, annual income minus food and housing expenses. In order to estimate annual household income, we used US Census data which provided income information for all ZIP Codes in the state of Washington. We then used data from the U.S. Bureau of Labor Statistics' (BLS) Consumer Expenditure Survey,[2] which provides averages expenditures on food and housing broken down by annual household income, to estimate annual subsistence spending.

For the current study we used US Census data from the 2013-2017 American Community Survey[3] to obtain the median household income and the distributions of household incomes for all ZIP Codes in the state of Washington. Because some patients living in ZIP Codes with a low median income may have a very high income and vice versa, neither median nor mean income are sufficient estimators. *Salem and Mount 1974*[4] have demonstrated that the gamma distribution is an effective model for income distribution in a population, and thus allows for some high-income households in lower income ZIP Codes and some low-income households in higher income ZIP Codes. Details of the methodology are outlined in *Shrime et al. 2015*[5] and *Scott et al. 2018,*[6] but the parameters of a gamma distribution include a shape parameter, which represents the relative distribution of incomes across individuals in the population, and a scale parameter, which is defined as the mean income of the population divided by the shape parameter. We used the distribution of incomes within each ZIP Code to calculate a ZIP Code-specific gini coefficient which was then converted into the shape parameter.[4] We then calculated the scale parameter by dividing the ZIP Code-specific median household income by the shape parameter.

Supplemental Figure 2 shows the resultant gamma distributions of incomes for the 25 most common ZIP Codes in our dataset. Table B compares the outcomes of our income estimation microsimulation model to published data from the US Census 2013-2017 American Community Survey.[3] Ultimately, our modeled estimations are within 0.7% and 1.3% of median and mean household incomes, respectively, for the state of Washington.

Table B. Testing Income Estimation Model	Median	Mean
Estimated Income from Microsimulation Model	$ 65,709	$ 89,673
Five-year rolling average from US Census (2013-2017)*	$ 66,174	$ 88,563

**Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates*

Estimation of CHE Risk for all patients

To calculate a patients' risk for CHE, we used their ZIP Code-based gamma distribution to estimate annual household income (as above), subtracted estimated subsistence spending based on BLS data, and compared their estimated OOP spending to this estimated post-subsistence income. If OOP spending was ≥40% of post-subsistence spending they were defined as being at risk for CHE. We then ran this process 10,000 times for every patient, selecting a different probability-weighted annual household income from their ZIP Code-based gamma distribution each time. We then took the average of these 10,000 estimated to generate a probability that they would be at risk for CHE. As such, each patient in the database was assigned a CHE risk ranging from 0 to 1.

Interim calculations used to determine CHE risk

The median estimated annual income for patients in our sample was $65,709 (interquartile range(IQR): $29,222-$122,536). Per data from the BLS,[2] households making <$15,000 per year spend 16.0% of their income on food and 39.8% on housing, while households making $200,000 per year spend 10.1% of their income on food and 29.4% on housing. Median hospital charges were $57,195 (IQR: $ 28,714-$115,793). All numbers from years 2012-2016 were converted to 2017 dollars using the consumer price index.[7]

Details of variables used in our risk-adjustment models

As described in the main text, we ran linear regression models to adjust for potential pre-/post-policy variation in covariates that could impact our outcomes. Age and sex were supplied directly from the trauma database. Race was divided into non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific Islander, and other. Injury type was defied as blunt or penetrating. Injury mechanism was divided into the following 10 categories: fall, motor vehicle crash, motorcycle crash, struck, cut/stabbed, pedestrian struck, gunshot wound, bicyclist, and other. Injury severity score was treated as a categorical variable divided up as mild (1-8), moderate (9-15), severe (15-25), and critical (>25). Shock index at presentation was calculated as heart rate divided by systolic blood pressure in the emergency department and was treated as a categorical variable divided up as <0.4, 0.4-0.49, 0.5-0.79, and ≥0.8. Traumatic brain injury (TBI) was defined based on the head anatomic injury (AIS) score and divided up as no TBI, minor/moderate TBI (head AIS 1-2), serious/severe (head AIS 3-4), and critical (head AIS 5). Need for mechanical ventilator support was divided up as no mechanical ventilation, 0-48hrs of mechanical ventilation, or >48hr of mechanical ventilation.

Assessment of "charity care" use before and after Medicaid Expansion

Throughout the text we describe "risk of" CHE because we do not have information regarding actual collections and actual out-of-pocket spending at the individual patient level. Many institutions, including ours, patients who are unable to pay their bills might be eligible for some form of discount, payment plan, charity care, or other form of financial assistance. While our trauma registry does not provide information on actual collections or hospital-level payments from programs such as the disproportionate share hospital payments, it does indicate whether a patient had any proportion of their bill covered by charity care. This metric is more telling of the financial impact on the hospital than it is on patients. It does not comment specifically on the patient-level needs, but it does give some information on how much of the financial burden of trauma care is being unmet by collections from insurers or patients. An important limitation of this metric is the fact that eligibility may have changed over time. Finally, the hospital's use of charity care funds to pay for trauma care is only one component of the financial impact of Medicaid expansion on the hospital. We are unable to comment on county, state, and federal payments through programs such as the Medicaid Disproportionate Share Hospital program. With these limitations in mind, we did calculate the proportion of patients receiving any degree of assistance through the hospital's charity care program was calculated for each year. We found that the proportion of patient's receiving some degree of charity care during the study period fell from a high of 26.4% (95%CI: 24.7-28.1%) in 2013 and fell to a nadir of 5.5% (95%CI: 4.7-6.4%) in 2017 (Supplemental Figure 3).

Supplemental References

1. Kaiser Family Foundation. Employer Health Benefits Annual Survey Archives. Updated October 3, 2018. Available at: https://www.kff.org/health-costs/report/employer-health-benefits-annual-survey-archives/ (accessed June 5, 2019)
2. Consumer Expenditures in 2017. US Bureau of Labor and Statistics, 2017. Available at: https://www.bls.gov/cex/2017/combined/income.pdf (accessed June 5, 2019)
3. U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates. Available at: https://factfinder.census.gov/ (accessed June 5, 2019).
4. Salem A, Mount TD. A convenient descriptive model of income distribution: the gamma density. *Econometrica*. 1974;42(6):1115-1127.
5. Shrime MG, Dare A, Alkire BC, Meara JG. A global country-level comparison of the financial burden of surgery. *British Journal of Surgery*. 2016;103(11):1453-61
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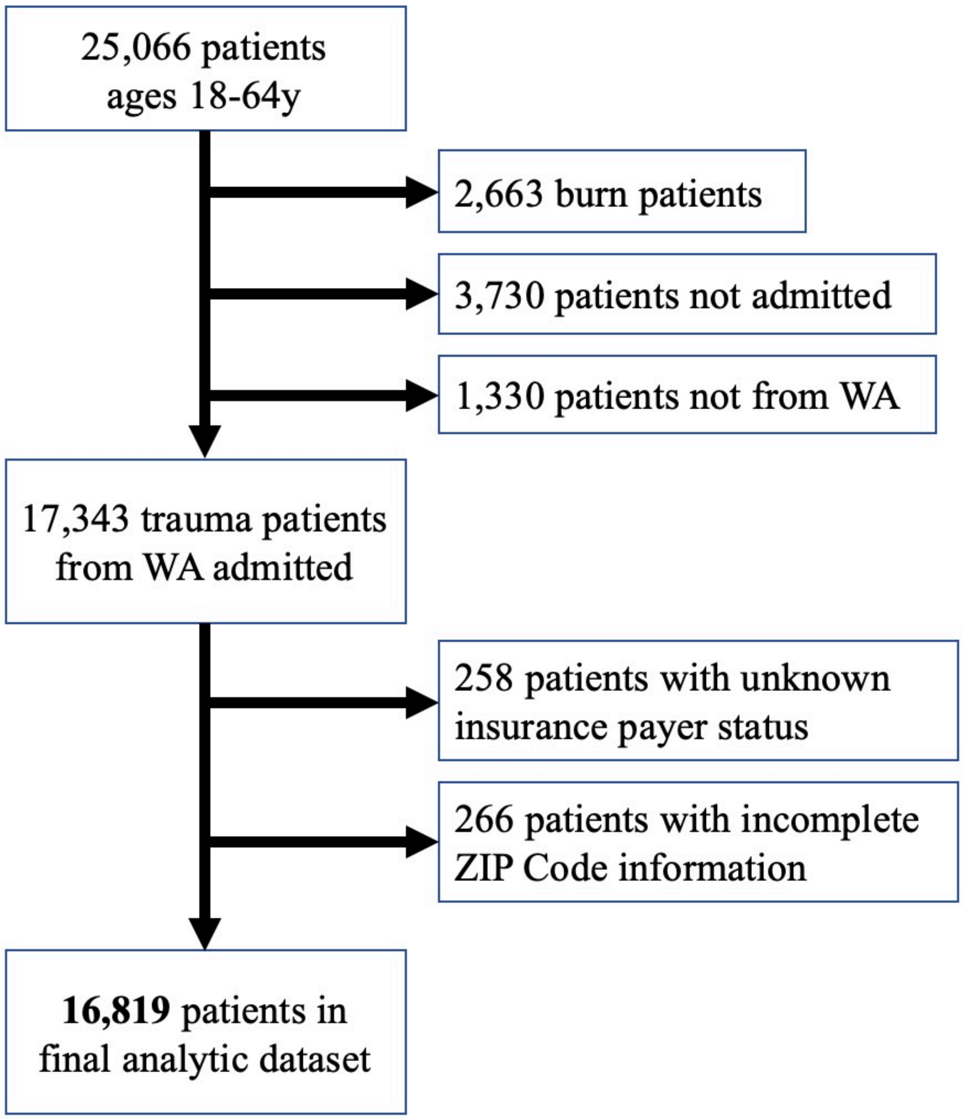
7. U.S. Bureau of Labor Statistics. Consumer Price Index. Available at: http:// www.bls.gov/cpi/. http://www.bls.gov/cpi/ (accessed June 5, 2019).

SUPPLEMENTAL TABLES/FIGURES

Supplemental Table 1. Pre- vs Post-Policy Differences in Insurance Coverage

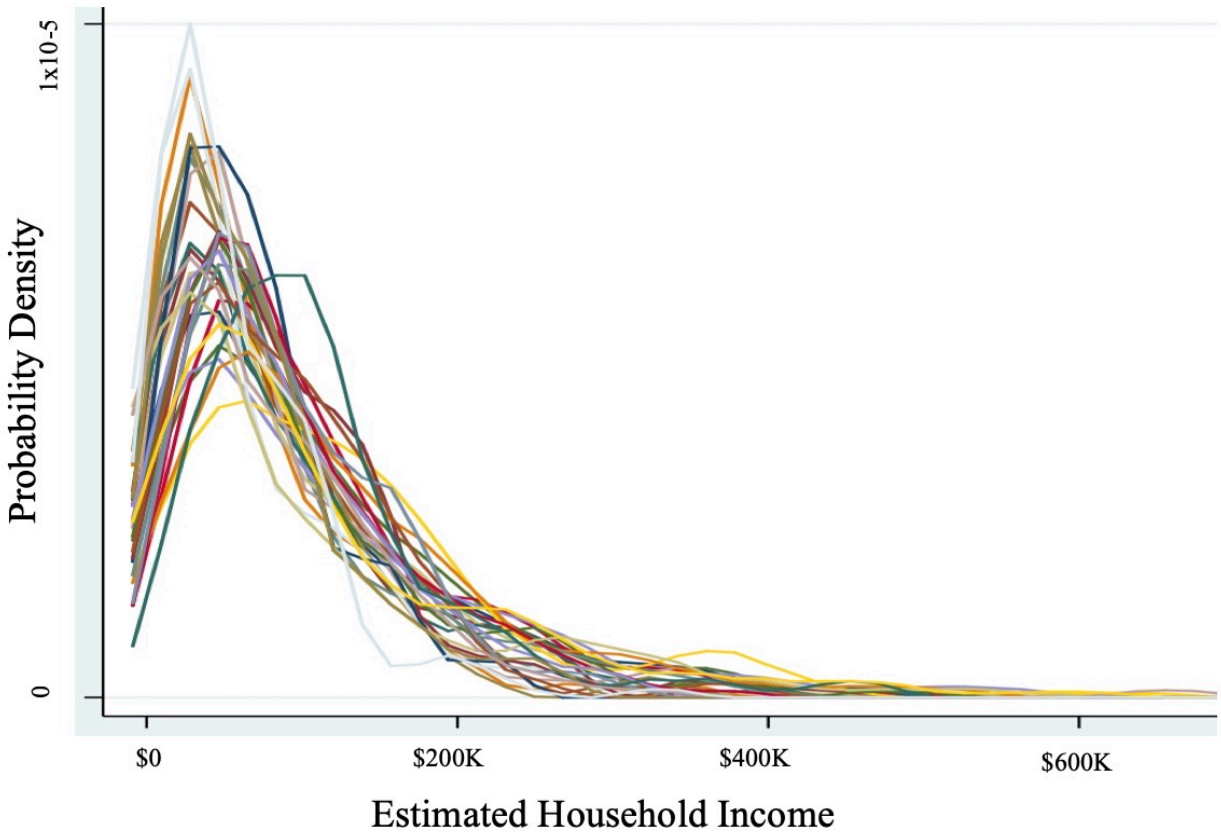
	Pre-policy average (2012-13)	Post-policy average (2014-17)	Unadjusted absolute difference	Adjusted[a] absolute difference	p-value
Uninsured	19.2%	3.7%	-15.6%	-14.6%	<0.001
Medicaid	20.4%	41.0%	20.7%	17.8%	<0.001
Private	38.3%	36.0%	-2.3%	-1.7%	0.183
Medicare	7.8%	7.4%	-0.4%	0.8%	0.183
Other[b]	14.4%	11.9%	-2.4%	-2.3%	<0.01

Source: 2012-2017 Harborview Trauma Registry. **Notes**: ***a.*** Insurance status adjusted for age, sex, race, and year. **b.** "Other" insurance includes workers compensation, labor and industry, and other governmental insurance plans.



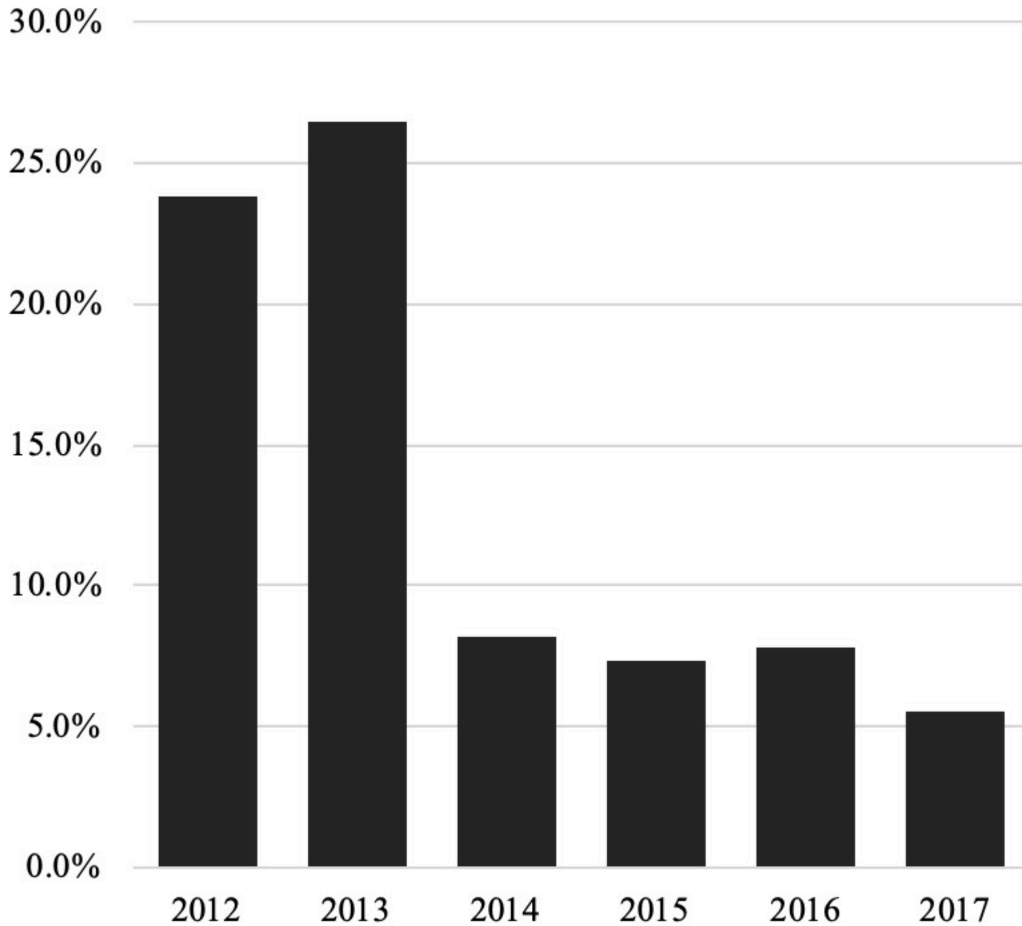
Supplemental Figure 1. Derivation of analytic dataset.

Source: Harborview Medical Center Trauma Registry, 2012-2017. **Note**: WA, Washington state



Supplemental Figure 2. Income distribution of Washington ZIP Codes

Output based on microsimulation model used to estimate annual household income by ZIP Code. Each line represents the distribution of estimated household incomes for a different ZIP Code in the state of Washington. The 25 most frequent ZIP Codes in the database are shown.



Supplemental Figure 3. Proportion of patients receiving some degree of charity care over time.

Source: Harborview Trauma Registry. Notes: The amount of the total hospital bill covered by the charity care fund may vary by patient.