

The U.S. health production function: evidence from 2001 to 2009

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Abstract This study estimates the impact of the 2007 financial crisis upon U.S. health as measured by age adjusted death rates. OLS regression results suggest that the average death rate was lower in the post-crisis period than the pre-crisis period. The majority of the average decline in the death rate was a result of the time period and not a result of changes in the values of the underlying explanatory variables. We continue to find this result even adding state fixed effects. Contrary to other research, we find that the unemployment rate has no statistically significant impact on death rates either for the U.S. as a whole or for any states individually. Rather, the impact of the financial crisis is felt via year fixed effects that increased over time during the post-crisis period.

Keywords Health production function · Financial crisis

Introduction

The Center for Medicare and Medicaid Services released and published its annual review of national health expenditures for 2009 in the January 2011 issue of *Health Affairs* (vol. 30, No. 1, 11–22). The most recent recession which officially ended in June 2009 profoundly influenced the health care spending in 2009. A substantial number of people lost their jobs. As a result, U.S. health care spending grew by 4.0 % in 2009, to \$2486.3 billion, representing the lowest rate of growth since 1980. Despite the historically low rate of growth, health care spending as a share of the economy has increased from 16.6 % in 2008 to 17.6 % in 2009 (see Fig. 1).

At the same time that health care spending had an increasing share of the economy, health as measured by death rates decreased substantially over the same time period in the U.S.

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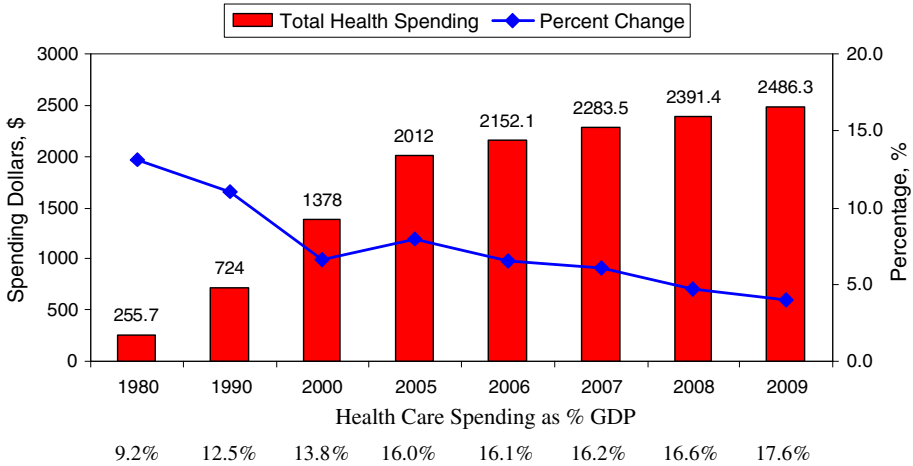


Fig. 1 Health care spending, growth rates and their share of GDP. Source: [Martin et al. \(2011\)](#) exhibits 1 and 2

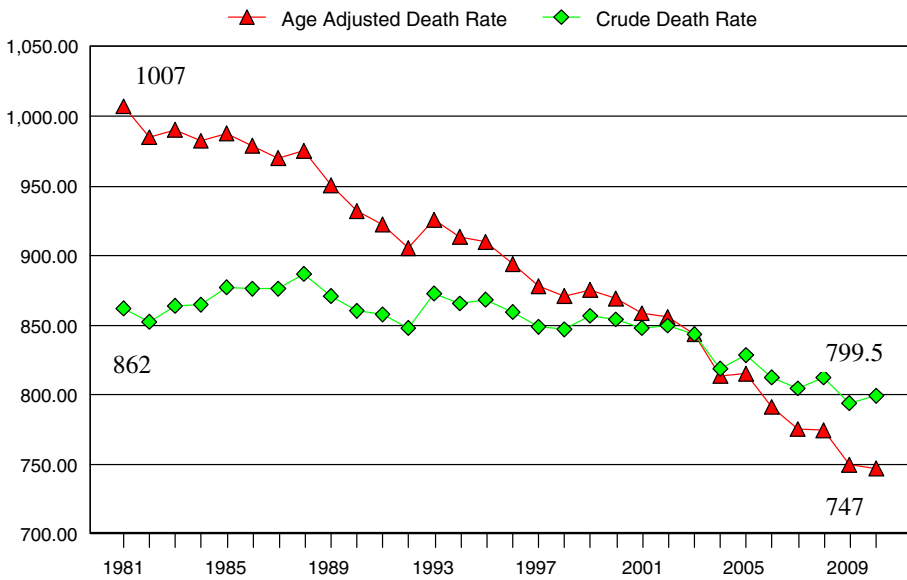


Fig. 2 U.S. death rates 1981 to 2010, deaths per 100,000 population

([Hoyert 2012](#)). For example, the age adjusted death rate fell from 1860 to 747 per 100,000 population from 1935 to 2010, a decrease of 60 %. Even the crude death rate, which does not take into account changes in the age distribution of the population, fell during that same time period by 27 %. Figure 2 illustrates that decreases in especially the age adjusted death rate continued in the more recent past, falling from 1007 in 1981 to 747 in 2010, a decrease of 26 %. In fact, [Hoyert \(2012\)](#) finds that with the exception of the years 1955 to 1968, when the decline was only 2 %, U.S. age adjusted death rates decreased substantially in every other time period since 1935, with the largest decreases occurring since 1969 (41 %).

Hoyert (2012) also documents both consistencies over time and some significant changes in the underlying morbidity related to U.S. death rates over the past 75 years. For example, heart disease and cancer remained the number one and two causes of death over the entire 75 years while stroke always remained in the top five causes of death. Other major causes of death changed substantially over time. Kidney disease was in the top five causes only from 1935 to 1948; influenza and pneumonia also were in the top five during early years and again briefly from 1965 to 1978. Accidents entered the five leading causes only in 1946 while chronic respiratory diseases entered in 1979. Some diseases of early infancy are only in the top five causes from 1949 to 1962 and 1964. Some of these changes are, in fact, suggestive of improvements in medicine but not all of them are. For example, heart disease and cancer accounted for 60 % of all deaths in 1983, which declined to 47 % by 2010 (Hoyert 2012).

The steady decline in age adjusted death rates over this time period, including larger declines more recently at the same time that spending on health care has increased at historically low rates recently (see above) illustrates that it is not only health care spending that affects death rates. Hence, questions arise related to both the efficacy of health care spending and the correct allocation of resources to the health care sector; especially given international comparisons of health care spending and mortality (see Phelps 2013). These questions have not been easy to answer.

Prior empirical studies have applied multivariate regression analysis to examine the impact of medical care on health based on the theoretical health production function framework, where health outcomes (an output) are produced by a set of inputs including medical care, age, education and other socioeconomic status and life styles¹. Within this larger literature estimating health production functions, there exists a more recent but growing literature that examines the relationship between business cycles and health. For example, Ruhm (2000, 2003, 2005a, 2007), Neumayer (2004), Gerdtham and Ruhm (2006) and Miller et al. (2009) generally use state level unemployment rates to measure economic conditions and find that health tends to improve during recessions but worsen during expansions.

Our research fits into this larger literature on health production functions and the impact of economic conditions upon health. Given that the most recent recession which ended in June 2009 was so long and had such profound and cumulative effects on health expenditures, a regression analysis that updates previous research on the health production function is a useful contribution. This study utilizes state level data from 2001 to 2009 to estimate the impact of the 2007 financial crisis upon health.

The initial basic regression results suggest that the average death rate was, controlling for other explanatory variables, lower in the post-crisis period than the pre-crisis period. Following previous research (e.g., Ruhm 2000, 2003, 2005a, 2007), we also add state level fixed effects and state level unemployment rates to refine the regression model. One of the important contributions of our research is our finding that state unemployment rates have no measurable impact upon death rates either when controlling for the post-financial crisis time period or when controlling for year specific fixed effects. More importantly, the refined regressions still find that health improved during the post-financial crisis time period even after controlling for other explanatory variables. However, unlike previous research the impact of the post-financial crisis on health is a result of year fixed effects and not due to variations in unemployment rates.

The results of this empirical study will help us to understand the marginal contribution of medical care to our health status and can serve as a valuable input in illuminating one of the

¹ For example, Auster et al. (1969), Grossman (1972), Newhouse and Friedlander (1980), Rosen and Taubman (1982), Leigh (1983), Berger and Leight (1989), Kenkel (1991) and Thornton (2002, 2011).

Table 1 Variable definitions

Variable	Definition
Death rate	Age adjusted death rate—deaths per 100,000 population
Hospital expenditures	Real hospital expenditures per capita
Personal health care expenditures	Real personal health care expenditures per capita
Tobacco consumption	Packs of tobacco per person sold annually
Alcohol consumption	Gallons of ethanol consumption per person annually
Violent crime	Per 100,000 population (murder, rape, robbery, and assault)
Property crime	Per 100,000 population (burglary, larceny, and motor vehicle theft)
Bachelor's degree	Percent of the population with a bachelor's degree or more
Personal income per capita	Real personal income per capita
Manufacturing employment	Manufacturing jobs as a percent of total jobs
White	Percent of the population that is non-Hispanic white
Black	Percent of the population that is African American
Midwest	Equals 1 if state is in midwest; 0 otherwise
South	Equals 1 if state is in south; 0 otherwise
West	Equals 1 if state is in west; 0 otherwise
Unemployment rate	State level unemployment rate (not seasonally adjusted)
Post financial crisis	Equals 1 if year 2007 through 2009; 0 otherwise

most enduring debates in public policy—whether or not more resources should be allocated to medical care in order to improve the health of the U.S. population by expanding access and subsidizing or covering the rising costs.

The remainder of the paper is organized as follows. “The data and the method of research” section describes the data and the method used in the analysis. “Results and discussions” section reports the regression results while “Conclusions” section contains our conclusions.

The data and the method of research

The current study utilizes aggregate level data for U.S. states and the District of Columbia, from 2001 to 2009 to estimate the impact of the 2007 financial crisis upon health. Sources of data by variable are provided in the appendix. Table 1 presents variable definitions. Table 2 provides variable means by time period while Table 3 presents percentage changes over those time periods. Notice that the post financial crisis dummy variable identifies two time periods in our data set: (1) the time period before the financial crisis in 2007—which includes years from 2001 through 2006 and (2) the time period during and immediately after the financial crisis in 2007—which includes years from 2007 through 2009. Tables 2 and 3 reflect all of these years by showing means of variables (Table 2) and their annual percentage changes (Table 3) for the overall 2001 to 2009 data set as well as for all of the years individually.

Tables 2 and 3 do show the general trend of increasing health expenditures and decreasing death rates over time that were illustrated in Figs. 1 and 2. Table 2 uses two measures of health expenditures to give us more robust empirical tests. One measure, Hospital Expenditures, is generally contained in the second measure, Personal Health Care Expenditures (PHCE) and makes up the largest single portion of PHCE. Notice that health expenditures are 6.64–8

Table 2 Variable means by time period

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2001 thru 2009
Unemployment rate	4.54	5.38	5.63	5.28	4.98	4.51	4.39	5.36	8.47	5.39
Death rate	859.17	854.72	844.51	811.37	813.46	791.54	776.56	776.08	758.30	809.52
Personal health care expenditures	\$5,438.22	\$5,780.10	\$6,048.70	\$6,280.18	\$6,438.52	\$6,568.27	\$6,706.94	\$6,726.91	\$7,011.85	\$6,333.30
Hospital expenditures	\$1,991.02	\$2,105.86	\$2,210.20	\$2,300.38	\$2,392.79	\$2,463.55	\$2,519.62	\$2,541.98	\$2,665.46	\$2,354.54
Tobacco consumption	80,937	79,200	77,820	72,763	71,498	69,620	67,537	62,986	59,873	71,359
Violent crime	444,833	437,598	427,749	414,757	420,720	431,522	427,202	419,480	400,933	424,977
Property crime	3626,820	3615,633	3556,547	3456,757	3378,973	3271,380	3197,706	3133,459	2976,037	3357,035
Bachelor's degree	25,678	26,359	26,706	27,175	27,351	26,729	27,147	27,357	27,590	26,899
Manufacturing employment	9,719	9,100	8,655	8,447	8,281	8,121	7,880	7,631	7,036	8,319
Alcohol consumption	2,282	2,315	2,331	2,350	2,361	2,414	2,444	2,465	2,443	2,378
Personal income per capita	\$36,926	\$36,854	\$37,203	\$38,087	\$38,516	\$39,605	\$40,338	\$40,245	\$39,093	\$38,541

Table 3 Percentage changes in variable means by time period

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2001 through 2009—annual average
Unemployment rate (%)	NA	18.44%	4.70	-6.16	-5.68	-9.43	-2.61	21.94	58.12	10.83
Death rate (%)	NA	-0.52	-1.19	-3.92	0.26	-2.70	-1.89	-0.06	-2.29	-1.47
Personal health care expenditures (%)	NA	6.29	4.65	3.83	2.52	2.02	2.11	0.30	4.24	3.62
Hospital expenditures (%)	NA	5.77	4.95	4.08	4.02	2.96	2.28	0.89	4.86	4.23
Tobacco consumption (%)	NA	-2.15	-1.74	-6.50	-1.74	-2.63	-2.99	-6.74	-4.94	-3.25
Violent crime (%)	NA	-1.63	-2.25	-3.04	1.44	2.57	-1.00	-1.81	-4.42	-1.23
Property crime (%)	NA	-0.31	-1.63	-2.81	-2.25	-3.18	-2.25	-2.01	-5.02	-2.24
Bachelor's degree (%)	NA	2.65	1.32	1.75	0.65	-2.27	1.56	0.77	0.85	0.93
Manufacturing employment (%)	NA	-6.37	-4.89	-2.41	-1.96	-1.93	-2.96	-3.17	-7.79	-3.45
Alcohol consumption (%)	NA	1.44	0.72	0.82	0.45	2.26	1.23	0.83	-0.88	0.88
Personal income per capita (%)	NA	-0.19	0.95	2.38	1.13	2.83	1.85	-0.23	-2.86	0.73

NA not available

% higher during the post financial crisis period as compared to before the crisis. However, health expenditures grew at a slower rate during the post financial crisis than they did prior to the crisis. On average it grew 3.86 and 4.36 % annually (PHCE and Hospital Expenditure, respectively), from 2001 to 2006 but only 2.21 and 2.67 % from 2007 through 2009. In fact, Table 3 illustrates that in only one of the post-crisis years (2009) are health expenditures higher than their average annual percentage increase over the full time period of approximately 4 %. In the other two years, health expenditures increase at either half of that rate (2007) or at less than 1 % (2008).

Second, consider health outcomes as measured by age adjusted death rates. Death Rates fell (i.e., health improved) by 4.24 % overall after the financial crisis as compared to the years before the crisis. However, health improved at a slower annual rate post financial crisis than they did prior to the crisis. On average death rates fell by 1.61 % from 2001 to 2006 but fell by a slightly smaller average of 1.41 % annually from 2007 through 2009. Table 3 illustrates, however, a 1.47 % annual average decrease in Death Rates over the entire 2001 to 2009 time period. Prior to the crisis only two years, 2004 and 2006 had decreases larger than this average, while 2 of the 3 years post-crisis did so (2007 and 2009). These trends in Death Rates are not, of course, corrected for changes in other relevant explanatory variables.

Unemployment rates as a measure of economic conditions indicate, unsurprisingly that conditions are generally good in 2001 and through most of 2007 but poor thereafter, reflected in an 8.47 % average unemployment rate in 2009. Both manufacturing employment and personal income per capita also reflect the economic conditions with manufacturing employment at its lowest (as a percent of total employment) in 2009, almost 11 % lower than in 2007. Likewise, notice that real personal income per capita is lower in 2009 after the recession at \$39,093 than it was at the beginning of the crisis in 2007 at \$40,338, a 3 % decline.

Tables 2 and 3 do provide some evidence of healthier behavior during and after the financial crisis in that the two measures of unhealthy behavior—tobacco consumption and to a lesser extent, alcohol consumption, is either down or, in the case of alcohol remaining steady. Of course, as is evidenced by our own regression results below, tobacco consumption is the real risky behavior and it shows a steady downward trend throughout the entire time period. However, the decrease in tobacco consumption fell faster post-crisis than before the financial crisis, an average annual decline of 4.89 % post-crisis as compared to a 2.95 % pre-crisis average annual decline. Note that this evidence is consistent with more detailed studies of health behavior during economic downturns. For example, [Ruhm \(2005b\)](#) finds that both tobacco use and excess weight drops during downturns helping to explain why health improves during recessions.

Results and discussions

Table 4 presents OLS regression results from four basic models; Models 1 and 2 use PHCE to measure health expenditures while Models 3 and 4 use Hospital Expenditures. Similar to some other results (e.g., [Olsen 1993](#)), health expenditures has a positive and significant impact on death rates—i.e., reduces health. This is true only for the Hospital Expenditures models (Models 3 and 4). That increased spending on health care reduces health suggests that the use of health care in the U.S. during this time period may be inefficient, perhaps increased to the point of negative marginal returns in the health production function. Other explanatory variables have the expected impacts on health. For example, variables with a positive and statistically significant impact on health include higher levels of alcohol consumption,

Table 4 Death rate OLS regression results basic models

Explanatory variables	Model 1	Model 2	Model 3	Model 4
Intercept	820.9*** (21.92)	814.1*** (21.34)	774.2*** (22.17)	773.5*** (21.23)
Personal health care expenditures	-0.00514 (-1.40)	-0.00618 (-1.61)		
Hospital expenditures			0.0168** (2.71)	0.0167** (2.67)
Tobacco consumption	0.596*** (4.89)	0.606*** (4.95)	0.614*** (5.07)	0.614*** (5.05)
Alcohol consumption	-16.82** (-2.87)	-16.60** (-2.83)	-20.01*** (-3.42)	-20.00*** (-3.41)
Violent crime	0.0655*** (4.09)	0.0633*** (3.91)	0.0537*** (3.36)	0.0535** (3.30)
Property crime	0.00143 (0.37)	0.00164 (0.42)	0.00336 (0.86)	0.00338 (0.86)
Bachelor's degree	-5.680*** (-7.59)	-5.718*** (-7.63)	-5.529*** (-7.47)	-5.531*** (-7.46)
Personal income per capita	-0.000903 (-1.25)	-0.000713 (-0.95)	-0.00140* (-2.05)	-0.00139* (-1.99)
Manufacturing employment	-0.772 (-0.76)	-0.979 (-0.94)	0.757 (0.72)	0.743 (0.70)
White	1.841*** (8.40)	1.859*** (8.45)	1.574*** (7.04)	1.575*** (7.02)
Black	5.417*** (14.18)	5.358*** (13.84)	5.091*** (13.03)	5.087*** (12.87)
Midwest	-25.52** (-3.30)	-25.12** (-3.24)	-23.53** (-3.16)	-23.45** (-3.12)
South	0.693 (0.06)	1.129 (0.10)	8.805 (0.80)	8.878 (0.80)
West	10.87 (1.05)	9.233 (0.88)	24.68** (2.61)	24.63** (2.59)
Post financial crisis	-36.99*** (-7.19)	-38.10*** (-7.21)	-42.91*** (-8.60)	-43.01*** (-8.27)
Unemployment rate		1.411 (0.93)		0.107 (0.07)
F statistic	109.76	102.47	111.48	103.81
R-squared	0.7758	0.7763	0.7785	0.7785
Number of observations	459	459	459	459

t-statistics are in parentheses

* Indicates $p < 0.05$; ** indicates $p < 0.01$; *** indicates $p < 0.001$

education, and Personal Income per Capita. Likewise, variables that have a negative and statistically significant impact on health include Tobacco Consumption and Violent Crime.

Most importantly from Table 4, is the impact of the post-financial crisis years of 2007 through 2009, measured by the dummy variable Post Financial Crisis. Recall that our examination of differences in means in Tables 2 and 3 between the two time periods—pre and post-financial crisis—found that the average Death Rate was lower after the financial crisis by an average of 1.41 % annually. However, Table 4 controls for other relevant variables and finds that during the Post-Financial crisis time period the Death Rate still falls approximately by 37–43 points, which represents a 4.7–5.4 % total decline; this represents average annual decreases in Death Rates of 1.56–1.81 %, depending upon the model. Thus, controlling for other relevant variables in the basic models we find that the Death Rate actually decreased at a faster rate during and after the financial crisis than was indicated by the raw averages in Tables 2 and 3.

The literature on the impact of economic downturns upon health has tended to measure economic conditions by using unemployment rates (e.g., Ruhm 2000, 2005a). To test this proposition, we include unemployment rates as explanatory variables in two of the four models presented in Table 4 (Models 2 and 4). However, including unemployment rates in the regressions as explanatory variables does not change the fundamental results nor, in fact, is the impact of the unemployment rate itself found to be statistically significant. The entirety of the impact here is found within the impact of the dummy variable Post Financial Crisis rather than estimated impact of unemployment rates.

Table 5 builds upon the basic models presented in Table 4, by making two changes to the models. First, we include state level fixed effects in all four models presented in Table 5 rather than the region level fixed effects used in the basic models presented in Table 4. State level fixed effects are, arguably, a more accurate measure of unobserved heterogeneity as a given state has more in common internally than do states within regions that are simply geographically contiguous. We continue to include in all of the models in Table 5 the unemployment rate as another measure of economic conditions. In two of the models in Table 5, we continue to use the Post Financial Crisis dummy variable to measure the impact of economic conditions post-crisis. However, in the other two models in Table 5 we use year specific fixed effects rather than the Post Financial Crisis dummy variable. This has the advantage of being more precise in our estimation of the impact of the financial crisis upon Death Rates, allowing the estimated impact of the 3 years to differ for individual years.

Notice that when adding the state fixed effects in Table 5, we now find that both PHCE and Hospital expenditures have a positive impact on health, although only in Models 5 and 7) rather than the negative impact estimated in Table 4. The impact of some of the other explanatory variables are also changed by inclusion of the state fixed effects, most notably increasing alcohol consumption is now found to increase Death Rates as is increasing the percent of employment in Manufacturing jobs. Likewise, notice that the impact of Violent Crime goes from being a positive and statistically significant impact on Death Rates in Table 4 to having no significant impact in Table 5.

Notice, however, that the unemployment rate still has no significant impact on Death Rates in all four of the models presented in Table 5. In fact, although not presented in the paper, we also ran regressions interacting state effects with unemployment rates, to test for the possibility that the impact of the unemployment rate varied by state.² We reject this hypothesis; not only was the impact of unemployment rates generally insignificant statistically but it was also insignificant for each state individually.

² Regression results available upon request.

Table 5 Death rate OLS regression results with state and year fixed effects

Explanatory variables	Model 5	Model 6	Model 7	Model 8
Intercept	-880.7*** (-4.93)	-394.3* (-2.32)	-1063.2*** (-6.26)	-418.8* (-2.38)
Personal health care expenditures	-0.0192*** (-4.63)	0.00534 (1.02)		
Hospital expenditures			-0.0356*** (-5.05)	-0.00287 (-0.37)
Tobacco consumption	0.282* (2.45)	0.0687 (0.67)	0.208 (1.79)	0.0619 (0.60)
Alcohol consumption	26.54* (2.01)	32.16** (2.74)	25.77* (1.99)	34.45** (2.94)
Violent crime	-0.00765 (-0.81)	-0.000162 (-0.02)	-0.00566 (-0.60)	-0.000771 (-0.09)
Property crime	-0.000659 (-0.30)	-0.00304 (-1.60)	-0.000868 (-0.40)	-0.00296 (-1.56)
Bachelor's degree	1.148 (1.51)	0.508 (0.75)	0.834 (1.11)	0.559 (0.82)
Personal income per capita	-0.00156 (-1.65)	0.00111 (1.28)	-0.00177 (-1.93)	0.00120 (1.39)
Manufacturing employment	8.342*** (4.86)	0.682 (0.37)	9.049*** (5.51)	1.119 (0.60)
White	15.20*** (10.22)	8.936*** (5.73)	16.86*** (12.18)	9.345*** (5.73)
Black	29.28*** (9.86)	24.87*** (9.30)	30.75*** (10.45)	25.38*** (9.34)
Post financial crisis	-7.794** (-2.80)		-6.186* (-2.27)	
Unemployment rate	1.330 (1.61)	-0.149 (-0.12)	1.402 (1.70)	-0.107 (-0.09)
2002 Dummy		-3.931 (-1.03)		-1.494 (-0.43)
2003 Dummy		-13.26* (-2.46)		-8.838 (-1.90)
2004 Dummy		-46.33*** (-6.80)		-40.34*** (-6.94)
2005 Dummy		-42.90*** (-5.39)		-35.62*** (-5.12)

Table 5 continued

Explanatory variables	Model 5	Model 6	Model 7	Model 8
2006 Dummy		−64.97*** (−7.02)		−56.73*** (−6.81)
2007 Dummy		−79.35*** (−7.46)		−70.10*** (−7.25)
2008 Dummy		−77.00*** (−6.70)		−67.43*** (−6.36)
2009 Dummy		−90.76*** (−6.50)		−78.91*** (−6.29)
F statistic	231.47	281.95	233.78	281.29
R-squared	0.9731	0.9804	0.9734	0.9804
Number of observations	459	459	459	459

t-statistics are in parentheses; State level fixed effects are included as controls in all regressions

* Indicates $p < 0.05$; ** indicates $p < 0.01$; *** indicates $p < 0.001$

Models 5 and 7 in Table 5 estimate the impact of the post-financial crisis via a dummy variable as was done in Table 4. When including state fixed effects, we still find that a negative and statistically significant impact of the post-financial crisis time period exists upon the Death Rate. However, the magnitude of the impact is approximately 20–25 % the magnitude of the impact that was present in Table 4 before including state fixed effects. Similar to state level interactions with the unemployment rate we also interacted the post-financial crisis dummy variable with the state effects to test whether the impact of the post-financial crisis dummy varied by state.³ These regressions show: (1) the general impact of the Post Financial Crisis variable increased in magnitude to about −25, approximately three times the size of the impact in Table 5, (2) that for most states (36) the interaction term was statistically insignificant, and (3) for the 15 states where the interaction term was significant it tended to either increase the positive impact of the crisis on health (for two states) or to reduce the impact to insignificance (about five states). Thus, our regressions still find a significant positive impact of the post-financial crisis period on health controlling for both state fixed effects and other relevant variables.

Models 6 and 8 in Table 5 use individual year fixed effects rather than the Post Financial Crisis dummy to measure the impact of the crisis on death rates. Unsurprisingly, we find that controlling for other relevant variables and for state fixed effects that the impact of these year fixed effects increases over time, with the largest impact being for the 2009 year dummy in each model. For example, compare the results in Table 5 to the decreases in the raw Death Rate averages given in Tables 2 and 3. We find that most of the impact of the raw decreases in Death Rates in Table 2 remains explained by the year fixed effects presented in Table 5 even controlling for state fixed effects and the other explanatory variables. This result suggests that most of the decline in Death Rates observed in Table 2 is explained by the time period—that is the post-financial crisis time period—rather than by the changes in the other explanatory variables.

³ Again, we haven't included these regression results but they are available upon request.

Conclusions

Our paper examines the impact of the financial crisis upon the underlying health of the U.S. population. Our initial OLS regressions find, after controlling for other relevant variables, a positive and statistically significant impact of the financial crisis upon health; the Death Rate falls approximately by 4.7–5.4 % in total. This represents an annual decline in Death Rates during the post-crisis period of 1.56–1.81 %, which is a faster decline in Death Rates than that indicated by looking only at the raw averages.

Our research makes several important contributions to the research on the impact of economic conditions on health. The previous literature on the impact of recessions upon health also finds that poor economic times tend to improve health (e.g., [Ruhm 2000, 2003, 2007, 2009](#); [Xu 2013](#)). One of the important contributions of our current research is to update the research using data from the most recent economic downturn and confirm the continued positive impact of economic downturns upon health. This is important because the 2007 financial crisis resulted in a particularly steep recession whose impact is still being felt worldwide.

Notice that this earlier research, almost without exception, uses unemployment rates to measure economic conditions. We also presented more complex health production functions that follow this research and include both state unemployment rates and state level fixed effects. Unlike this previous research, however, we find that the state unemployment rate is *not* a statistically significant explanatory variable in our estimated health production functions. In fact, our results show that state unemployment rates have no impact on either death rates generally nor upon the death rates in *any* individual states. This is not to say that we find no positive impact of the financial crisis upon health, quite the contrary. Rather, we find that the negative impact of the financial crisis upon death rates comes via either a post-financial crisis fixed effect or via individual year fixed effects, depending upon the model. We do note, however, that the negative impact of the post-financial crisis period upon death rates, while true generally and true for by far the majority of states, is not true for *all* states.

The primary explanation for improvements in health during poor economic times was found to be a result of life style changes such as decreases in the levels of smoking and stress and increases in exercise levels (e.g., [Ruhm 2005a](#); [Xu 2013](#)). Our results also provide evidence that these life style changes remain important, especially in our regressions the impact of increased reductions in tobacco use during the post-crisis time period.

Hence, our findings point to changes in how economic activity affects death rates and health, via year or time period fixed effects rather than changes in unemployment rates. Our results, therefore, suggests a fundamental change in the impact of economic downturns upon health. Interestingly, recent research ([Ruhm 2013](#)) similarly finds a change in the impact of recessions upon health in the most recent economic downturn, although his findings point to a smaller impact of the downturn upon health and not to a change in the underlying structural relationship. Clearly, our results are quite evocative by providing evidence of fundamental changes to the health production function post financial crisis. More research will be needed to be able to more completely explore not only the reasons for these changes but also whether they are likely to continue into the future.

Appendix—sources of data

Death rate: Measured by age adjusted death rate. Sources: www.cdc.gov

Personal Health Care Expenditures: Measured by real personal health care expenditures per capita. Sources: www.cms.gov, www.bea.gov, www.census.gov

Hospital Expenditures: Measured by real hospital expenditures per capita. Sources: www.cms.gov, www.bea.gov, www.census.gov

Tobacco Consumption: Measured by per capita tobacco consumption; packs per person sold annually. Sources: www.cdc.gov and www.taxadmin.org/fta/tobacco

Alcohol Consumption by State: Measured by per capita alcohol consumption; gallons of ethanol per person annually. Sources: pubs.niaaa.nih.gov

Violent Crime: Measured by violent crime per 100,000 population; includes murder, rape, robbery, and assault. Sources: www.ucrdatatool.gov/

Property Crime: Measured by property crime per 100,000 population; includes burglary, larceny, and motor vehicle theft. Sources: www.ucrdatatool.gov/

Bachelor's Degree: Measured by percent of the population with a bachelor's degree or more. Sources: nces.ed.gov

Personal Income Per Capita: Measured by real personal income per capita. Sources: www.cms.gov, www.bea.gov, www.census.gov

Manufacturing Employment: Measured by manufacturing jobs as a percent of total jobs. Sources: www.bls.gov

White: Measured by percent of the population that is non-Hispanic White. Sources: www.cms.gov/

Black: Measured by percent of the population that is African American. Sources: www.cms.gov/

Unemployment rate: Measured by annual unemployment rate. Sources: www.bls.gov

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