Are Community Health Workers Saving Lives?

A Longitudinal Analysis of State-Level Variation in Community Health Workforce

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HEALTH

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EXECUTIVE SUMMARY

PROBLEM STATEMENT

Sharp increases in health care costs and pronounced health disparities across the United States are leading policymakers and academic researchers to consider alternative models of health care delivery. In part, health care costs in the United States are driven by a rise in prevalence of chronic diseases, such as cancer and diabetes, paired with increasing life expectancy. However, a substantial share of inefficiencies also stem from disparate access to health resources and asymmetric information about healthy behaviors. This is especially true among underserved communities, where language barriers, along with cultural norms and traditions, as well as the prevalence of disease outcomes and risky behaviors present significant challenges and affect treatment adherence and effectiveness.

Leveraging community health workers (CHWs) is a promising intervention towards achieving more integrated, culturally sensitive, and personalized models of care.

However, to date, there is a lack of rigorous, quantitative evaluations of the effect that community worker programs have on both health outcomes and health expenditures.

METHODOLOGY

We constructed a longitudinal panel of state-level occupational data on community health workers from the Bureau of Labor Statistics (BLS). The health system capacity measures came from the Kaiser Family Foundation and the BLS, while demographic characteristics were obtained from the American Community Survey (ACS). The prevalence of smoking and drinking were obtained from the National

Survey on Drug Use and Health (NSDUH) for the period from 2005 to 2015. Using this novel data source, we applied a linear multilevel regression model to gain a better understanding of the statistical association between the number of CHWs and statewide health outcomes.

MAIN FINDINGS AND POLICY IMPLICATIONS

Our findings suggest that states with a higher number of community social workers (CWs) experience statistically significant reductions in mortality rates, a fact that is consistent across all of our alternative econometric model specifications. The results suggest that the relatively small community social workforce of 650,000 people helped prevent 165,000 premature deaths (equivalent to 6.3 percent of all U.S. deaths in 2015), and, when based upon a conservative estimate of the value of a single life, yielded an estimate of $545 billion in long-term economic value. Further, when applying a hypothetical policy intervention of a 20% increase in each state's CHWs, we found this intervention could save up to 17,000 lives per year. However, we observed considerable variation in CHWs effectiveness between states, where states with higher mortality rates display much larger potential gains in mortality reduction from additional CHWs than states that are already at the forefront of using community resources as part of integrated health care teams. To capture the positive health effects and reductions in associated medical care spending of CHWs, it is essential to begin the process of matriculating to a pay-for-performance or accountable care system.

INTRODUCTION

Due to sharp increases in health care costs and pronounced health disparities across the United States, new models of health care delivery have been gaining momentum in recent years.[1] In part, health care costs in the U.S. are driven by the fact that more people live longer than before but with a higher prevalence of chronic diseases such as cancer and diabetes. However, a substantial share of inefficiencies also stems from disparate access to health resources and asymmetric information about healthy behaviors. This is especially true among underserved communities, where language barriers, cultural norms and traditions, along with the prevalence of disease outcomes and risky behaviors might present significant challenges and affect treatment adherence and effectiveness.[2] In response, researchers and policymakers alike are beginning to consider community-oriented solutions and mixed, integrated health teams that rely heavily on representatives of particular neighborhoods and cultural backgrounds to cope with these challenges and to act as linkages between health care systems and the communities they serve. This shift in direction toward a systemic view of health suggests that personal health is as much an outcome of one's behaviors and genetic predispositions as it is an outcome of one's surroundings and environment. Accordingly, personal context is equally important in determining someone's health as the formal health system. To date, the most prominent example of this new policy orientation, sometimes referred to as "social determinants of health," has been the Robert Wood Johnson Foundation's Culture of Health Initiative.[3]

[1] Phalen, J. and R. Paradis. 2016. "How Community Health Workers Can Reinvent Health Care Delivery In the U.S." Accessed May 17, 2017. http://healthaffairs.org/blog/2015/01/16/how-community-health-workers-can-reinvent-health-care-delivery-in-the-us/.

[2] Behforouz, H. L. 2014. "Bridging the Gap: A Community Health Program Saved Lives, Then Closed Its Doors." *Health Affairs* 2064-2067.

[3] Robert Wood Johnson Foundation. 2015. "From Vision to Action: Measures to Mobilize a Culture of Health." Accessed May 17, 2017. https://www.cultureofhealth.org/content/dam/COH/RWJ000_COH-Update_CoH_Report_1b.pdf.

BACKGROUND

Within these highly complex health systems, CHWs have been portrayed as agents of change who have the potential to improve access to health care resources, health outcomes, and the overall quality of life for poor and underserved communities.[4] These Community Health Workers often grew up in the communities they serve and are a part of the environment, adding a contextual and culturally sensitive element to the provision of health care.[5] Specifically, they provide information as well as education about health services and resources. Additionally, they help with care management and treatment choice and adherence. In effect, these workers function as bridges between the health care system and underserved communities that often find it difficult to identify and access appropriate modes of care.[6]

While there are many benefits associated with the emergence of Community Health Workers, various practical issues appear to hinder their effectiveness in improving key health outcomes. Among others, funding sources for CHW programs tend to be grant-based and therefore temporary in nature, which is problematic given that the overall objective of CHW intervention programs often is to achieve long-term, sustainable change in the affected communities. In the absence of continuous funding, it has proven difficult for many CHW programs to build long-term relationships between underserved communities and health care providers. In particular, this issue stems from the fact that Community Health Workers are not considered billable providers under Medicaid unless specifically designated as such by particular states.[7] A second issue is the lack of standardization and credentials. While many Community Health Workers themselves come from underserved communities and often lack access to formal education resources, a certain level of operating standards and training will be needed going forward to convince existing health care providers to broaden their scope to

[4] Rosenthal, E. L. and J.N. Brownstein. 2010. "Community Health Workers: Part of the Solution." *Health Affairs* 1338-1342.

[5] Keane, D. and C. Nielsen. 2004. Community Health Workers and Promotores in California. http://calhealthworkforce. org/wp-content/ uploads/2011/01/2004-09_ Community_Health_Workers_and_ Promotores_in_California.pdf.

[6] Balcazar, H. and E.L. Rosenthal. 2011. "Community Health Workers Can Be a Public Health Force for Change in the United States: Three Actions for a New Paradigm." *American Journal of Public Health* 2199-2203; Goodwin, K. and L. Tobler. 2008. "Community Health Workers: Expanding the Scope of the Health Care Delivery System." https://www.ncsl.org/print/health/ chwbrief.pdf.

[7] National Health Care for the Homeless Council. 2011. Community Health Workers: Financing & Administration. https://www.nhchc.org/ wp-content/uploads/2011/10/ CHW-Policy-Brief.pdf.

include community linkages and to develop mixed health care system teams.[8]

To date, the most rigorous evaluations of CHW programs draw on specific case studies. For example, Fedder and colleagues evaluated the effects of a CHW intervention on health and treatment outcomes in a sample of 117 patients in the Maryland Diabetes Care Program from March 1992 to October 1994. Comparing health care utilization data of patients before and after contact with CHWs, the authors find that emergency room visits and long-term hospitalization rates decreased by 38 and 30 percent respectively, suggesting that CHWs led people to seek more appropriate and cost-effective avenues of care, a fact that led to cost savings of $80,000-$90,000 per CHW and year.[9] In a similar study, Whitley and colleagues carried out a longitudinal experiment among 590 participants in the Men's Health Initiative in Denver, Colorado between January 2003 and June 2004. Using a pre-post design, the study found that interaction with CHWs led to an increase in both primary care visits (from 10% to 14%) and medical specialty visits (from 14% to 21%), while it contributed to a decrease in urgent care and emergency room visits (from 15% to 12%), as well as inpatient (from 4% to 2%) and behavioral health treatment utilization (from 55% to 48%). In essence, the results are very similar to the aforementioned Baltimore study; once again CHW intervention led people from underserved communities toward cheaper, more appropriate health-care resources. For this particular case, the authors estimated annual savings of $95,941 after CHW program costs.[10]

Aside from these cost-effectiveness evaluations, there have been several studies aimed at evaluating the effect of Community Health Worker interventions on health outcomes among underserved populations, especially hypertension, diabetes, and other health conditions that are commonly subject to preventative care.[11]

Despite these efforts, Walker and Jan point out that CHW programs are very difficult to evaluate due to their unstructured and highly

[8] American Public Health Association. 2009. "Support for Community Health Workers to Increase Health Access and to Reduce Health Inequities." Washington, DC: Resolution 2009-1. APHA Governing Council.

[9] Fedder, D. O. and R.J. Chang. 2003. "The Effectiveness of a Community Health Worker Outreach Program on Healthcare Utilization of West Baltimore City Medicaid Patients with Diabetes with or Without Hypertension." *Ethnicity and Disease* 22-27.

[10] Whitley, E. M. and R. M. Everhart. 2006. "Measuring Return on Investment of Outreach by Community Health Workers." *Journal of Health Care for the Poor and Underserved* 6-15.

[11] Swider, S. M. 2002. "Outcome Effectiveness of Community Health Workers: An Integrative Literature Review." *Public Health Nursing* 11-20; Perry, H. and R. Zulliger. 2012. "How Effective Are Community Health Workers? An Overview of Current Evidence with Recommendations for Strengthening Community Health Worker Programs to Accelerate Progress in Achieving the Health-Related Millennium Development Goals." Baltimore: Johns Hopkins Bloomberg School of Public Health.

context-specific nature. The broad definition of goals and objectives, in particular, makes it very challenging to find common metrics for evaluation.[12] In consequence, studies are frequently conducted at the U.S. national level, using nationally representative survey data, or at the local levels, drawing upon selected case studies and pilot programs. Based on a thorough review of the academic and policy literature and the vast health disparities across different regions in the United States, we believe that there is a pressing need to assess the impact of various health interventions on a state-by-state basis. For this study, we specifically consider the effect of community health and community social service workers on key health care outcomes, such as mortality and expenditures at the state level.[13]

[12] Walker, D. G. and S. Jan. 2005. "How Do We Determine Whether Community Health Workers Are Cost-Effective? Some Core Methodological Issues." *Journal of Community Health* 221-229.

[13] Anthony, S. and R. Gowler. 2009. "Community Health Workers in Massachusetts: Improving Health Care and Public Health." Boston: Massachusetts Department of Public Health Community Health Worker Advisory Council; U.S. Department of Health Human Services. 2007. "Community Health Worker National Workforce Study." San Antonio: Regional Center for Health Workforce Studies of the University of Texas Health Science Center; Viswanathan, M. and J. Kraschnewski. 2009. "Outcomes of Community Health Worker Interventions." U.S. Agency for Healthcare Research and Quality; Dower, C. and E. O'Neil. 2006. "Advancing Community Health Worker Practice and Utilization: the Focus on Financing." San Francisco: National Fund for Medical Education.

DATA

In 2010, the Bureau of Labor Statistics established an occupational code (21-1094) for community health workers, effectively creating a fully recognized profession.[14] Taking this change as a starting point, we compiled a new dataset from multiple publicly available databases to assess the impact of community health workers on key health outcomes. However, because a large portion of CHWs operate on a volunteer basis, we found that BLS estimates are substantially lower than the actual number of workers. Specific estimates of the CHW workforce are depicted in Figure 1 below. According to the BLS, between 2012 and 2015, there were between 38,000 and 48,000 registered CHWs across the United States, a fact that is inconsistent with the results of a National Workforce Study on Community Health Workers conducted in 2005, which estimated the size of the CHW workforce at 120,000.[15] In addition to the underestimation issue, the limited time frame of four years (2012-2015) presented a problem in our preliminary analysis. To deal with these issues, we took advantage of the fact that the CHW occupational code is a sub-code of BLS Code 21-1090: Community and Social Service Workers.[16] Specifically, we generated two expanded CHW categories based on the broader occupational code and the 2005 workforce estimate. For the first expansion, we calculated the average share of CHWs in the composite category of Community Social Service Workers and used this measure to impute values for the years preceding the official launch of occupational code 21-1094. However, as evidenced in Figure 1, this strategy results in 37,000 CHWs in 2005, a number much smaller than the value found in the National Workforce Study. We attribute this difference to the fact that a vast share of CHWs operate informally and are unlikely to be registered by BLS. In consequence, we combine our estimate for formal CHWs in 2005 with the full estimate of 120,000 CHWs in that year to account for the share of informal workers. When dividing 37,866 official CHWs by 120,000 total CHWs, we find that we appear to be capturing about

[14] For a detailed description of BLS Occupational Code 21-1094, see https://www.bls.gov/soc/2010/soc211094.htm.

[15] U.S. Department of Health Human Services. 2007. "Community Health Worker National Workforce Study." San Antonio: Regional Center for Health Workforce Studies of the University of Texas Health Science Center.

[16] For a detailed description of BLS Occupational Code 21-1090, see https://www.bls.gov/soc/2010/soc211090.htm.

32% of the workforce when only considering formal workers. Due to the lack of similar total workforce estimates for different years, we use the 2005 measure of 68% under-counting to impute total CHW worker number for all years in our sample.

However, due to the considerable uncertainty surrounding these estimates, we decided to initially focus our analyses on the larger, overarching group of community social service workers as an approximation for community-level health interventions between the years of 2011 and 2015.

Figure 1. Community Health Workforce Estimation Strategy (2005-2015)

Occupation	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Community Social Service Workers (OCC-Code 21-1090)	540,620	568,030	565,020	568,070	602,770	504,090	501,960	629,800	635,420	639,390	643,080
Community Health Workers (OCC-Code 21-1094)	CHWs not reported separately by BLS before 2012							38,030	45,820	47,850	46,840
Share of CHWs in Occupational Code 21-1090	CHWs not reported separately by BLS before 2012							6.04%	7.21%	7.48%	7.28%
Imputed Community Health Workers based on average share of Community Social Workers 2012-2015*	37,866	39,786	39,575	39,789	42,219	35,307	35,158	38,030	45,820	47,850	46,840
% underestimated based on Bureau of Health Professions 2007 National Workforce Study of CHWs**	68.44%	based on estimated CHW workforce of 120,000, compared to imputed BLS workforce of 37,866 in 2005									
Estimated formal and informal CHWs based on imputed workforce and % underestimated workforce	120,000	126,084	125,416	126,093	133,795	111,892	111,419	120,519	145,206	151,640	148,439

*Imputed CHW(t) = Community Social Workers(t)*Average CHW Share = Σ[%CHW(2012-2015)], where t=years between 2005 and 2011
**BLS only reports people who are formally employed under an OCC-Code. We are using the 2005 workforce estimate to impute actual numbers of CHWs for all study years, where Actual CHW(t) = Imputed CHW(t) / (1-%under in 2005) for year t

In addition to our main independent variable (the number of community social service workers by state and year), we obtained state-level covariates (i.e. other variables believed to influence

health outcomes) from a variety of sources, including the Bureau of Labor Statistics, the Kaiser Family Foundation, the Substance Abuse and Mental Health Services Administration (SAMHSA), and the American Community Survey (ACS).

Concerning demographic variables, we gathered information on the breakdown of race and ethnicity, different age groups, different educational levels, and median household income for all U.S. states between 2005 and 2015 from the American Community Survey. In addition, we control for statewide health system capacities by including data on the number of doctors and nurses per 1,000 people, the number of hospital beds per 1,000 people, and the share of people in each state that are currently insured, either privately or publically. Medical occupation data were taken from BLS, while the number of hospital beds, a figure frequently used to denote overall health system capacity, was taken from the Kaiser Family Foundation. To account for differences in medical technologies and research investment in health-care resources, we further included the State Science and Technology Index developed by the Milken Institute.[17] Lastly, using data from the National Survey of Drug Use and Health (NSDUH), a nationally representative survey conducted annually by SAMHSA, we accounted for statewide variation in drinking and smoking prevalence, as these measures have been shown to be major drivers of all of our key health outcomes measures considered below.

In effect, we are interested to find out whether community social service workers have a positive impact on health systems, either through enhancing cost-effectiveness of care or through reducing prevalence of chronic illnesses. Accordingly, we obtained data on per-capita health expenditures from the Kaiser Family Foundation, along with data on mortality rates from the Centers of Disease Control. While our initial aim was primarily to investigate the effect of community social service workers on health care costs, our preliminary analyses suggested that mortality rates might be more responsive to this particular intervention, and we were unable to

[17] DeVol, R., J. Lee, and M. Ratnatunga. 2017. "State Technology and Science Index 2016: Sustaining America's Innovation Economy." Milken Institute, Santa Monica. Accessed May 17, 2017. http://www.milkeninstitute.org/publications/view/827.

fully account for the fact that health care expenditures might be driven by unobservable factors that are unaccounted for in our databases. For example, there are wide variations in the costs of providing the same diagnostic test or medical procedure across states.

Table 1 outlines the basic breakdown of our variables of interest and our state-level covariates. It is interesting to see that states appear to vary substantially with respect to almost all of our demographic and system-level outcomes, a fact that further underlines the need for state-by-state analyses and that suggests great heterogeneity with regards to health outcomes. Given that states display such large variations in their basic demographic makeup, it would not be surprising if impacts of community social service workers also varied in a similarly broad fashion.

Table 1. Descriptive Statistics for Key Variables (2011-2015)

Variable	N	Mean	Std. Dev.	Min	Max
Per-Capita Health Expenditures	255	$ 6,223.76	$ 1,140.09	$ 4,159.00	$ 11,021.00
Mortality Rate per 100,000 people	255	753.406	85.544	584.900	963.700
State Science and Technology Score	250	52.5207	14.4857	25.8375	83.6669
Health Care System and Workforce Variables					
Community Social Workers per 1,000 people	255	2.224	1.103	0.497	8.059
Doctors per 1000 people	255	2.033	0.929	0.701	8.089
Hospital beds per 1,000 people	255	2.729	0.820	1.700	5.900
Demographic Variables obtained from the American Community Survey (ACS)					
Race/Ethnicity: White	255	69.71%	16.03%	22.81%	94.31%
People older than 65 years of age	255	14.34%	1.84%	8.10%	19.40%
Median Household Income	255	$ 53,381.24	$ 9,082.21	$ 36,919.00	$ 75,847.00
Education: Less than high school	255	11.81%	3.11%	6.45%	18.90%
Education: Graduated high school, but not college	255	58.85%	5.57%	33.05%	67.30%
Share of insured people	255	88.02%	4.29%	77.00%	97.20%
Behavioral Risk Factors obtained from the National Survey of Drug Use and Health (NSDUH)					
Past-month drinkers	255	52.68%	7.13%	25.38%	69.07%
Past-month smokers	255	27.60%	4.33%	15.39%	38.46%

Note: All % figures represent shares of a specific group among the statewide population in a given year

METHODOLOGY

The panel nature of the dataset, which covers 50 states over five years, allows us to exploit both within- and between-state variations in key variables using a Fixed Effects (FE) approach, which controls for factors that are unique to each state. According to Wooldridge, this approach requires several assumptions that are specified as follows:[18]

$$Mortality_{it} = \alpha_i + \beta CW_{it} + \sum_{j=1}^{m} \gamma_j\, x_{jit} + \varepsilon_{it} \qquad \text{A1}$$

$$E\left(\varepsilon_{it} \middle| CW_{it}, x_{jit}, \alpha_i\right) = 0 \qquad \text{A2}$$

$$Cov\left(\varepsilon_{it}, \varepsilon_{is} \middle| CW_{it}, x_{jit}, \alpha_i\right) = 0 \qquad \text{A3}$$

$$\left(\varepsilon_{it} \middle| CW_{it}, x_{jit}, \alpha_i\right) \sim N(0, \sigma_\varepsilon^2) \qquad \text{A4}$$

Where the age-adjusted mortality rate in state *i* at time *t* depends on the number of community social workers (denoted as CW in the following), a set of control variables x_j, and a state-specific intercept term α_i. Under the assumptions listed above, A1-A4, the estimation process of the community social workers' coefficient will result in the best linear unbiased estimator of the relationship between CHWs and mortality rates. In other words, if there are unobserved or omitted time-invariant and state-specific confounders, the FE estimator removes these biases and provides the best estimate of how the number of community social workers relate to mortality. But this estimator has one severe limitation. Although the assumption A2 assures the unbiasedness of the estimated impact of community social workers on within-state mortality change, it comes at the price of completely dismissing the differences in mortality across states. Given that over 90% of the variation in mortality in our dataset stems from the differences across states and only a small part comes from within-state changes in mortality over time, the FE approach would discard most of the total variation in mortality.

To overcome the aforementioned limitation of the FE estimator, we use a modified, mixed effect Mundlak approach, which allows us to estimate both the within-state and the between-state effects.[19] In this framework, the population model A1 is transformed into the following form (B1-B3):

$$Mortality_{it} = \alpha + \beta_1(CW_{it} - \overline{CW}_i) + \beta_2\overline{CW}_i + \sum_{j=1}^{m}\gamma_j\left(x_{jit} - \bar{x}_{ji}\right) + \sum_{j=1}^{m}\phi_j\,\bar{x}_{ji} + (u_i + \varepsilon_{it}) \quad \text{B1}$$

$$u_i \sim N(0, \sigma_u^2) \quad \text{B2}$$

$$\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2) \quad \text{B3}$$

Where variables with bars on top denote averages over time for each state. The coefficients β_1 and β_2 represent both the impact of year-to-year changes in the number of community workers within states, as well as the differences in the average number of community workers between states, on mortality rates. The random effect term, u_i, allows intercepts to vary by state. In our final specification, we also allow the marginal impact on mortality from a year-to-year change in the number of community social workers to vary by state.

Since the random effect term is not a parameter or a coefficient, the estimation of the above-specified model (B1-B3), requires u_i to be predicted by a weighted average of state-specific residuals, where the random effect u_i, the average residual, and the weights are defined as follows:

$$u_i = w_i\bar{e}_i$$

$$\bar{e}_i = \sum e_{it}, and\ e_{it} = Mortality_{it} - \hat{\alpha} - \hat{\beta}_1(CW_{it} - \overline{CW}_i) + \hat{\beta}_2\overline{CW}_i + \sum_{j=1}^{m}\hat{\gamma}_j\left(x_{jit} - \bar{x}_{ji}\right) + \sum_{j=1}^{m}\hat{\phi}_j\,\bar{x}_{ji}$$

$$w_i = \frac{\sigma_u^2}{\sigma_u^2 + \dfrac{\sigma_\varepsilon^2}{n_i}}$$

Therefore, the state-specific intercept will be closer to the national average if the number of observations for each state is small (number of years in our case) and if the variation in the mortality rate across states is smaller than the variation in the mortality rate over time.

Although standard maximum likelihood (ML) or restricted maximum likelihood (REML) methods generate comparable estimates to Bayesian hierarchical linear models, uncertainty associated with the estimates from ML, and to a lesser extent in REML, often tend to understate the true uncertainty.[20] In addition to maximum likelihood estimates, we also estimate the above model (B1-B3) using a Bayesian approach. We impose flat priors on almost all parameters, which ensures that the posterior estimates of parameters overlap with those obtained from ML or REML methods, while at the same time presenting more credible uncertainty estimates. The only parameter for which we impose informative priors is the impact of community social workers on mortality. Namely, we assume that more community social workers can either have no impact on mortality or can lead to a reduction in mortality. By doing so, we rule out a scenario where having more community social workers could lead to more deaths.

[20] Browne, W. J. and D. Draper. 2006. "A Comparison of Bayesian and Likelihood-Based Methods for Fitting Multilevel Models." *Bayesian Analysis* 473-514.

RESULTS

This section presents estimates of how the changes over time (CW_{it} - $\overline{CW_i}$) and average differences across states ($\overline{CW_i}$) in the number of community social workers relate to the age-adjusted mortality rate. The results also highlight the role of state-specific demographics and socio-economic factors, propensities for risky health behaviors, availability of healthcare resources, healthcare insurance coverage rate, and utilization of health technologies. To identify how much of the variation in mortality is due to differences across states and how much of it is due to changes in mortality over time, we begin with the discussion of our basic specification with no covariates. Then we describe and interpret the results from our main specifications with covariates.

DECOMPOSING TOTAL VARIATION IN MORTALITY

First, we estimate a simple random intercept model with no covariates of the following form:

$$Mortality_{it} = \alpha + (u_i + \varepsilon_{it})$$

$$u_i \sim N(0, \sigma_u^2)$$

$$\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$$

The estimated value for α in the equation above, which captures the annual national average of the age-adjusted mortality rate, is 753 deaths per 100,000 people. Since the total variation in the age-adjusted mortality is a sum of the variance in the state-specific random effect u_i, σ_u^2, and the variance of the residual term ε_{it}, σ_ε^2, we can calculate proportions of the total variance that are the results of differences across states and time. The estimated variances suggest that 98.8% of the total variation in the age-adjusted mortality rate in the dataset stems from differences across states and only 1.2%

comes from changes over time. When we introduce demographic and socioeconomic covariates, state-specific variance in age-adjusted mortality rates drops by a factor of 8, from 9,494 to 900, and the within-state variation drops by about 24%, from 90.4 to 72.9.

DECOMPOSING TOTAL VARIATION IN MORTALITY

The evidence from a short panel of states indicates that differences in the number of community social workers over time and across states have a statistically and substantively significant association with the age-adjusted mortality rate. Table 2 reports results from a model with random intercept and covariates (Model 1), a model with random intercept and random slope estimated with the traditional ML method (Model 2), and a model with random intercept and random slope estimated under the Bayesian framework with flat priors (Model 3). Although all three models provide qualitatively comparable estimates, we focus on the output from Model 3 because it offers the most credible estimates of parameter uncertainty.

Our findings suggest that, after adjusting for state-specific characteristics, such as median household income, a positive difference of one community social worker per 1,000 between two states is associated with four fewer deaths per 100,000. Similarly, an annual increase in the number of community workers per 1,000 by one worker is, on average, associated with six fewer deaths per 100,000. Both quantities are non-trivial amounts, and when the impacts are added across states, they translate into a significant count of lives saved.

Although we have adjusted for a number of state-specific factors, we will highlight only those statistically significant parameters that explain differences in mortality across states. We find that a one percentage point difference in the population proportion of insured people is associated with roughly five fewer deaths per 100,000. A state with a one percent difference in the proportion of people with

less than a high school education and those with a high school diploma who have not completed college are associated with about eighteen and nine more deaths per 100,000, respectively. We also find that states with an additional percentage point in the share of smokers are associated with ten more deaths per 100,000.

Table 2. Regression Models

Variables	Model 1: Random Intercept			Model 2: Random Intercept and Slope			Model 3: Bayesian Random Intercept and Slope			
	Coeff.	Std. Err.	t-Value	Coeff.	Std. Err.	t-Value	Coeff.	Std. Err.	95% CI	
(Intercept)	805.34	290.27	2.77	814.34	290.22	2.81	-45.89	191.45	-323.40	433.51
State Science and Technology Index Score	-0.83	0.73	-1.14	-0.84	0.73	-1.15	0.58	1.29	-2.18	2.54
Average values = ΣX(it)/n, where i =state and t = year										
Community Social Workers per 1,000 people*	-13.92	7.95	-1.75	-14.13	7.94	-1.78	-3.96	15.13	-38.28	23.79
People older than 65 years of age	-7.34	4.44	-1.65	-7.29	4.43	-1.64	-3.73	7.53	-19.52	7.26
Hospital beds per 1,000 people	-12.49	8.74	-1.43	-12.43	8.74	-1.42	-0.72	13.03	-26.39	27.49
Percentage of insured people	1.25	2.11	0.59	1.18	2.11	0.56	-4.68†	1.62	-6.65	-0.80
Median Household Income	-0.0019	0.0012	-1.5468	-0.0019	0.0012	-1.5524	20.01	16.59	-19.73	48.06
Doctors per 1000 people	20.57	14.41	1.43	20.81	14.41	1.44	37.60	26.39	-7.25	92.54
Education: Less than high school	3.37	3.73	0.90	3.35	3.73	0.90	17.63†	4.26	8.24	26.32
Education: Graduated high school, but not college	-2.56	2.57	-1.00	-2.61	2.57	-1.02	8.59†	2.81	3.76	13.48
Past month drinkers	12.97	2.10	6.17	12.88	2.10	6.13	-1.96	2.74	-5.53	3.93
Past month smokers	-3.52	1.03	-3.43	-3.50	1.03	-3.41	10.08†	4.18	1.43	15.82
Race/Ethnicity: White	0.73	0.52	1.40	0.75	0.52	1.43	1.64	0.78	0.13	3.04
Centered variables = [X(it) - ΣX(it)/n], where i =state and t = year										
Community Social Workers per 1,000 people*	-6.62	2.27	-2.92	-8.70	3.05	-2.85	-5.52†	3.21	-12.06	-0.32
People older than 65 years of age	-4.36	2.29	-1.90	-4.83	2.52	-1.91	-4.24	2.39	-8.92	0.44
Hospital beds per 1,000 people	5.54	9.03	0.61	5.03	8.86	0.57	6.03	8.90	-11.43	23.51
Percentage of insured people	0.71	0.51	1.41	0.54	0.50	1.09	0.61	0.50	-0.38	1.60
Median Household Income	0.0023	0.0007	3.3063	0.0024	0.0007	3.5308	22.76†	6.80	9.43	36.17
Doctors per 1000 people	6.36	2.91	2.19	6.96	2.92	2.38	6.33†	2.91	0.63	12.02
Education: Less than high school	1.84	2.15	0.86	2.02	2.12	0.95	1.71	2.13	-2.47	5.89
Education: Graduated high school, but not college	-2.67	1.72	-1.56	-2.41	1.69	-1.43	-2.65	1.71	-6.01	0.70
Past month drinkers	-0.02	0.58	-0.03	-0.04	0.57	-0.07	-0.27	0.45	-1.15	0.61
Past month smokers	-0.22	0.45	-0.49	-0.33	0.45	-0.73	0.03	0.58	-1.11	1.16
Race/Ethnicity: White	6.92	1.99	3.47	6.34	2.03	3.13	6.60†	2.02	2.63	10.54

* Community Social Workers = BLS Occupational Code 21-1090, including Community Health Workers

† 95% Credible Interval does not include zero, indicating statistical significance at conventional levels

DISCUSSION

This study makes an important contribution to quantifying the positive results of integrating community health workers into the U.S. health care delivery system in underserved or vulnerable populations and communities. Most analyses performed have evaluated the impact of controlled studies for a specific underserved population in a city or state for a demonstration program of limited duration for a particular disease or behavioral modification. Several studies have provided evidence supporting the efficacy of incorporating CHWs in care delivery on health outcomes and cost of care provision in these settings. However, our research uses an econometric approach, utilizing longitudinal data across 50 states over ten years. This affords a controlled environment for evaluating the marginal effectiveness of one additional CHW on health outcomes as measured by the ultimate metric: human mortality. Within-state and cross-state variations provide an experimental laboratory for demonstrating the statistical significance of CHWs in the health service delivery system. For example, our analysis suggests that when controlling for other socioeconomic and demographic factors, the community social workforce employed in 2015 results in up to 165,000 lives saved across the United States.[21]

The cost-effectiveness of incorporating CHWs into the professional, multidisciplinary team management of human health status should be evaluated to determine a rate of investment (ROI) of individual programs and macro applications.[22] In a review of the effectiveness of CHWs programs, Perry and Zulliger noted the dearth of such studies and made a strong recommendation for further clinical study on the subject.[23] There are challenges from numerous perspectives, ranging from designing a methodological approach that can link the applicable cost information to the measurement of health outcomes themselves. Cost-effectiveness analysis is typically evaluated on the cost per unit of health effect, such as an improvement in early

[21] In order to obtain this estimate, we compared mortality across states in the U.S. with current community social workforce employment numbers (i.e., 643,080 CSWs in 2015) to a hypothetical scenario of no CSWs, while holding all other socioeconomic and demographic covariates constant.

[22] Walker, D. G. and S. Jan. 2005. "How Do We Determine Whether Community Health Workers Are Cost-Effective? Some core methodological issues." *Journal of Community Health* 221-229.

[23] Perry, H. and R. Zulliger. 2012. "How Effective Are Community Health Workers? An Overview of Current Evidence with Recommendations for Strengthening Community Health Worker Programs to Accelerate Progress in Achieving the Health-Related Millennium Development Goals." Baltimore: Johns Hopkins Bloomberg School of Public Health.

detection of cancer, hypertension management, or behavioral modifications that address overweight and obesity or smoking cessation. One widely-used approach is disability-adjusted life years (DALYs) which combine partial years lost due to reduced productivity with years lost per premature mortality. There is extensive literature that permits the quantification of the value of a human life using several approaches. Nevertheless, controversy regarding assigning a monetary value to a human life remains a clear and present concern for researchers. Typically, quality of life estimates and associated wage premiums for risky jobs are the most frequent methods for calculating the value of a human life. The quality of life approach yields estimates from $3.3 million to $7.1 million while the wage premium calculation places the value of a human life between $4 million and $9.4 million.[24] Even in taking the minimum estimate of $3.3 million for the value of a life for the 165,000 lives estimated to have been saved by the community social workforce in 2015, CHWs have generated an estimate of $545 billion in economic value. When you compare this to the average compensation of a CHW (approximately $25,000), the ROI is extremely high when valued against a human life.

The magnitude of these calculations can cause one to be skeptical of the methodological approach used to derive them. A plethora of studies have been conducted highlighting the impact of CHWs on the management of chronic diseases such as Type II diabetes, hypertension (which lead to associated co-morbidities in heart disease and stroke), cancer, asthma, and HIV/AIDS (see Perry, Zulliger, and Rodgers for a detailed list[25]). Caring for patients with chronic disease is the most costly for both the health care system and American economy. For example, in 2014 there were 29.6 million cases of Type II diabetes, 71.2 million cases of hypertension (nearly one in three Americans), 42.8 million cases of heart disease, 6.5 million strokes, 8.6 million cancer cases (accounting for one in four deaths and second after heart disease), and 45.1 million cases of asthma in the United States. Underserved low-income communities have a disproportionate prevalence of individuals

[24] Waters, H. and R. DeVol. 2016. "Weighing Down America: The Health and Economic Impact of Obesity." Santa Monica, CA, Milken Institute.

[25] Perry, H. B., R.Zulliger, and M. M. Rogers. 2014. " Community Health Workers in Low-, Middle-, and High-Income Countries: An Overview of Their History, Recent Evolution, and Current Effectiveness." *Annual Review of Public Health* 399-421.

with these chronic conditions. Community Health Workers assist in acquiring access to the health care system, coordinating primary care and preventative services, and managing chronic disease.[26] Based on our analysis, community workers clearly reduce premature mortality. Other evidence demonstrates CHWs play a particularly effective role in reducing resource-intensive services, such as costly emergency room visits and inpatient admissions for at-risk populations. For example, while a Medicare patient with one chronic condition sees four physicians a year on average, those with five or more chronic conditions visit fourteen different physicians.[27] Additionally, through cancer screening and other forms of early detection, these diseases can be managed more effectively, reducing complications and the onset of expensive co-morbid diseases. This illustrates the need to move from today's fee-for-service health care delivery system (sick care) to a truly integrated pay-for-performance health delivery platform that provides financial incentives to prevent and manage high-risk populations more efficiently (accountable care) through the utilization of CHWs.

Using our econometric model, we performed an alternative or counterfactual simulation exploring the impact of a 20 percent increase in the community healthcare workforce on mortality. By holding other socioeconomic and other factors determining health status constant, we evaluate the incremental impact of adding 20 percent more CSWs. Figure 2 demonstrates this simulation across the 50 states. We find that 17,000 lives could be saved on an annual basis. California could save 2,223 lives while New York could prevent 1,494 premature deaths annually. Florida and Massachusetts would be among the biggest absolute beneficiaries, while Vermont, Minnesota, and Nebraska rank as those states witnessing the greatest increase in lives saved per 100,000 population.

[26] Martinez, J., M. Ro, N. W. Villa, W. Powell, and J. R. Knickman. 2011. "Transforming the Delivery of Care in the Post-Health Reform Era: What Role Will Community Health Workers Play?" *American Journal of Public Health* 101 (12)

[27] Vogeli, C., A. E. Shields, T. A. Lee, T. B. Gibson, W. D. Marder, K. B. Weiss, and D. Blumenthal. 2007. "Multiple Chronic Conditions: Prevalence, Health Consequences, and Implications for Quality, Care Management, and Costs." *Journal of General Internal Medicine* 22 (3): 391-395.

Figure 2. Lives Saved per 100,000 People, Given 20% Increase in Community Social Workforce

Lives Saved per 100,000 People
*Number behind each state bar denotes total number of potential lives saved
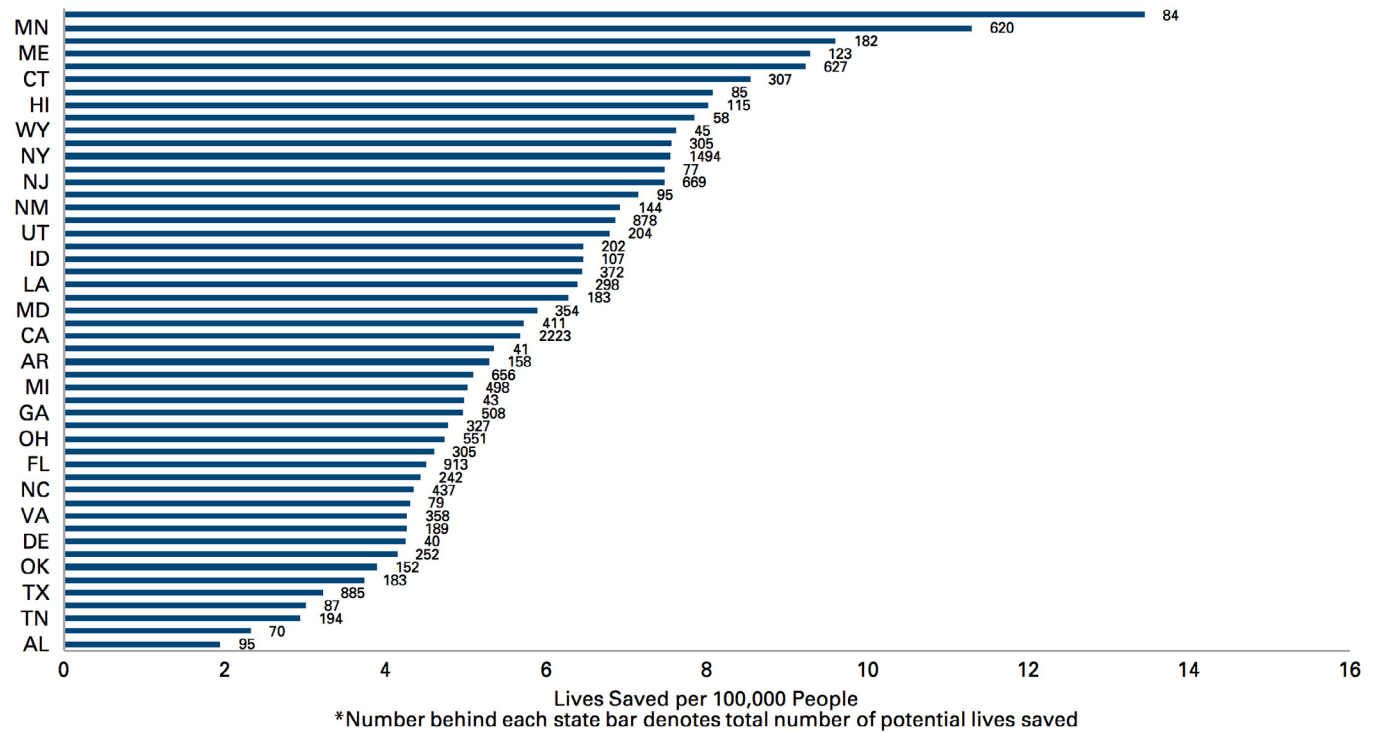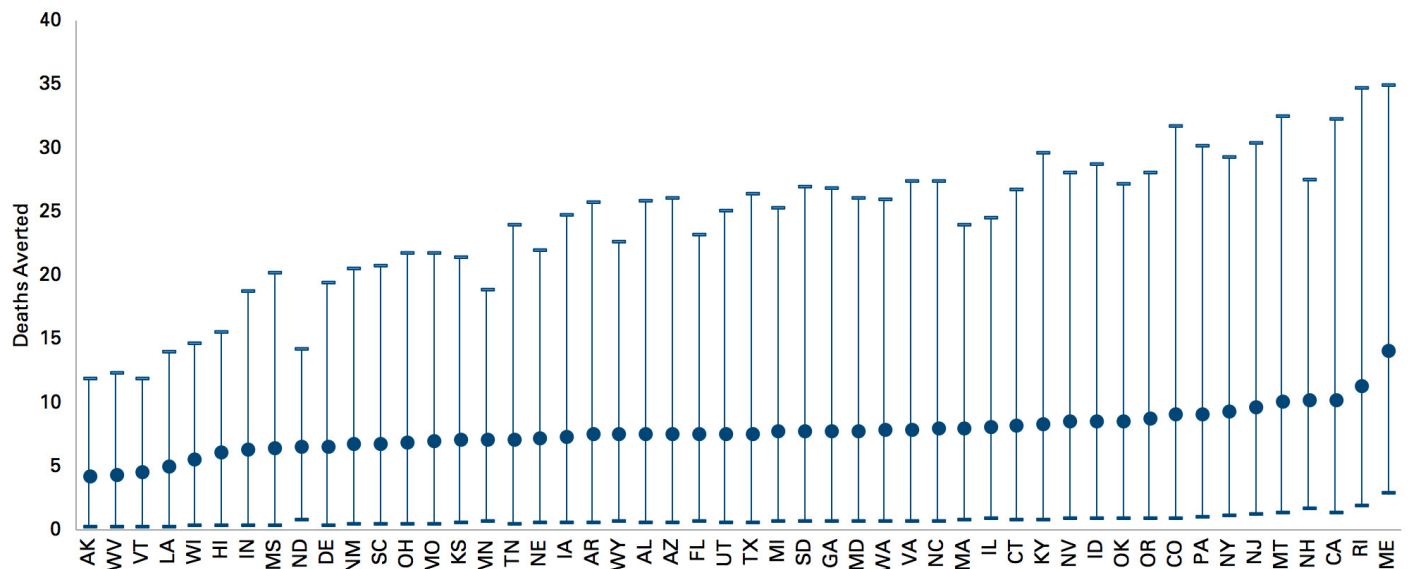
Figure 3. Estimated Mortality Reduction per Additional Community Social Worker Employed (2.5th Percentile, Median and 97.5th Percentile)

CONCLUSION

Our research demonstrates the positive impact of community health workers on the ultimate measure of health status metrics: reducing mortality rates. The econometric evidence adds to the body of studies evaluating demonstration program effectiveness of CHWs in improving health outcomes and reducing medical expenditures. The economic case for greater investment in CHW is very strong. The funding mechanism for CHWs should not be principally based upon short-term funding of demonstration projects. Chronic disease is accelerating health-care cost growth, and the integration of CHWs in prevention and early diagnosis, as well as better disease management, will improve the health of Americans and enhance economic performance. Both publicly-funded and private-market provided health care need to move to a pay-for-performance system and leave the fee-for-service model in the dustbin of history. The path we charter over the next decade will determine whether we bankrupt federal, state, and local governments as well as reduce the competitiveness of firms providing health insurance to their employees. Greater emphasis on incorporating community health workers into a health provision system approach will play a critical role in avoiding such a deleterious outcome.

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