

Social Determinants of Health



A partnership among Geisinger Commonwealth School of Medicine, Keystone College, King's College, Lackawanna College, Luzerne County Community College, Marywood University, Misericordia University, Penn State Scranton, Penn State Wilkes-Barre, The Wright Center, University of Scranton, and Wilkes University

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Research Methods and Limitations

A broad literature review was conducted on Social Determinants of Health. Determinants were identified from the literature search, and county-level statistics were extracted for these when available.

Limitation of available data prevented the use of data below county-level. For this reason, the analysis cannot account for intra-county differences, such as rural-urban differences within a county. As census data were used, and 5 year estimates preferred, multiple year data could not be used. This negates the possibility of accounting for year-to-year change.

Executive Summary

Social determinants of health are circumstances that can substantially affect individual and population health outcomes. They may appear as social, economic, or physical characteristics that affect health, risk, and/or quality-of-life. A literature search was conducted for a background on the Social Determinants of Health with a focus on the US and Pennsylvania where available. This resulted in a rich literature covering the built environment, socio-economic status, race and ethnicity, gender, sex, and family composition.

The built environment can include urban form, rurality and the food environment. This encompasses the coincidence of places of leisure, health care, food, or work, with implications for health affecting behaviors and food access. Socioeconomic status is a term that encompasses the result of many of the predictive elements mentioned above related to the social determinants of health. Socioeconomic status can encompass education, literacy, employment, income, and neighborhood context. Elements of family composition, such as adolescent child bearing and single parent household, have also been linked to disadvantageous socioeconomic circumstances, such as poverty. Race and, separately, having been born within the United States have been linked to a number of health outcomes.

While immigrant families are at increased risk of living in poverty, non-white populations fair worse in many measures, such as increased obstacles to obtaining care. Sex and gender have also been connected to health outcomes and epidemiology, both in physical and mental health. Populations of gender and sexual minorities are often at increased risk of being

targets of bullying and / or violence, as well as certain mental health conditions.

Publicly available data were collected for all counties in Pennsylvania for determinants identified in the literature search. A county level analysis was conducted for two measures of health: Infant Mortality Rate, and the County Health Outcome Ranking. Findings included income and poverty as strong determinants of County Health Outcome Rankings, as were family composition and health insurance coverage of the county. The second measure of health, the county's Infant Mortality Rate, was determined primarily by family composition and health insurance.

Key Findings

- Social determinants of health (SDH) are circumstances that can substantially affect individual and population health outcomes. They may appear as social, economic, or physical characteristics that affect health, risk, and/or quality-of-life.
- There are many dimensions of SDH, including income, education, race, ethnicity, LGBT+ status, age, and more. Analysis of statewide data shows that income, education, and health insurance coverage are among the factors most correlated with health outcomes.
- Analysis of regional data showed that in Northeastern Pennsylvania, effects of social determinants on health outcomes are likely at least as strong a statewide comparison.

Social Determinants: Background

Social determinants of health (SDH) encompass a set of circumstances into which people are born, grow, live, work, and age. These may include patterns of distribution in power, value, and resources at different levels of social organization. They may appear as social, economic, or physical characteristics that affect health, risk, and/or quality-of-life. One initiative from the U.S. Department of Health and Human Services included five broad categories in a framework for understanding determinants. These categories were (i) Neighborhood and Built Environment, (ii) Education, (iii) Economic Stability, (iv) Health and Health Care, (v) Social and (vi) Community Context.¹ The presentation of this background will differ slightly, as education, economic stability, and social and community context are presented under the umbrella of socio-economic status, and sex and gender are added as separate determinants.

Built Environment

The built environment includes conditions that have the capacity to facilitate or hinder healthy behavior patterns. These may include infrastructure, walkability and urban form, rurality, and the food environment. The physical structure of the community and its broad impact, provide one area where SDH are seen. Community design dictates much about the population's lifestyle. Coincidence of, or accessibility to, places of worship, leisure, health care, food, or work, can impact the patterns of behavior in communities.²



These behaviors have implications for health as they format relationships related to environmental danger and physical activity. In 2012, 80 percent of U.S. workers drove or rode in a car to work (private transit). Of all transportation trips, about forty percent were for two miles or less; just under 75 percent of these were taken by car.³ In 2016, there were 37,461 people killed in crashes on U.S. roadways, with increases from the previous year across every category of passenger vehicle (passenger cars and light trucks).⁴ Risk exposure from transportation goes further than accidents, as the prevalence of materials produced by modes of transportation can play a significant role in the health of the local population. Pollution and allergens can contribute to asthma,⁵ and many of the pollutants affecting cardiovascular outcomes have, at least in part, been traced back to transit traffic.⁶

Risk for obesity has been shown to increase with additional time spent in cars, while walking has displayed an inverse relationship.⁷ Decisions to own or ride in cars, as well as walk within the community are largely influenced by the built environment, specifically by physical features of the community and alternative transit options. Walking is associated with neighborhood design, as well as access to quality public transportation. Additionally, walkability and public transit may reduce the need and / or desire for a car. Public transit users are encouraged to walk (almost) by design (first and last mile), and have shown an increased likelihood of meeting daily milestones of physical activity.⁸

In any setting, specific modes of transportation may influence health by facilitating physical activity. Transportation becomes a critical component of nutrition by facilitating access to

food where sources may be distant, the extreme end of this condition is known as a food desert. Rural areas are at higher risk of being food deserts than metropolitan areas, and both are more likely than suburbs or metro areas outside principal cities.⁹ Areas with higher poverty levels have higher likelihoods of being food deserts, independent of rurality.¹⁰ It is food access that links transportation, distribution of food retailers, nutrition, and health, to socioeconomic status. Although rurality is considered a risk factor, other risk factors exist in relation to the density of the population.

Quality measures include structural, process, and outcome measures. Structural measures include such indicators as the ratio of patients to providers, the use of electronic medical records, and the proportion of board-certified physicians. Process measures include such indicators as the percentage of people receiving preventative services and the percentage of people with diabetes that have had their blood sugar tested. Outcome measures include such indicators as the percentage of patients who died as a result of surgery, and the rate of surgical complications or hospital acquired infections. The most recent report on disparities in quality measures from 2013-2015 from the Centers for Disease Control (CDC), reported that noncore and micropolitan areas showed deficits of 35 and 30 percent, respectively, in reported quality measures, when compared to the strongest group (large fringe metro).¹¹ As the built environment interacts with race and income, low socio-economic status (SES) Black and Hispanic populations have been shown to be specifically vulnerable to the deleterious effects of low food access.¹²

Socioeconomic Status

Socioeconomic Status (SES) is a term that encompasses the result of many of the predictive elements mentioned above related to SDH. These include education (namely educational attainment), and income and economic stability, as well as occupation. Documentation of the link between SES and general health indicators such as morbidity has existed for decades¹³(links between poverty and health go back centuries¹⁴). The persistence of this link, through radical changes in the landscapes of healthcare and disease has led some authors to refer to it as the “fundamental cause” of health inequality.¹⁵ However, the mechanisms by which SES impacts health are varied and nuanced.



Education and Literacy

Education is strongly linked to literacy, a 2001 study suggested that factors related to lower educational status account for nearly half of the deaths of US working-age adults.¹⁶ Dimensions of SES have shown relationships to different health conditions. Economic hardship is predictive of many chronic conditions such as depression, obesity, and diabetes,¹⁷ while level of or lack of educational attainment has shown an association with risk of suicide.¹⁸ Some

widely recognized channels from education to health include education as facilitation of health knowledge and literacy, and education as permitting gains in income and employment (then increasing access to healthcare and / or to quality in neighborhood or built environment). The confluence of these two is seen in nutrition, where health knowledge and access to healthy foods can permit higher levels of engagement in healthy eating.¹⁹

Health literacy is broadly understood to include a set of skills that people need to function effectively in the health care environment.²⁰ This includes locating, reading, and understanding text, such as documents, food or drug labels, as well as the ability to adhere to medication regimes. Health literacy also includes the ability to communicate effectively (both speak and understand) in health care settings. Health literacy is primarily determined by educational attainment. One 2006 analysis of a national health literacy assessment found nearly 50 percent of adults who had not completed high school (and were not currently enrolled) to have “below basic” (the lowest rating) health literacy. This percent dropped to 15 percent for high school graduates, and 3 percent for bachelor’s degree recipients.²¹ Health literacy is a strong predictor of both self-reported health, and clinical assessment. That is, low health literacy is associated with low self-reported health and clinical assessment.^{22,23}

Employment and Income

Educational attainment has broad implications for health through employment. Those with less formal education are often at increased risk of having low-wage employment, and / or harsher work-related conditions.²⁴ Not only can the cumulative effect of harsh working conditions such as longer hours, physical demands, and environmental conditions, have severe

implications for health status,^{25,26} but income, occupation and education have relationships to a series of important health behaviors. Persons with more years of education are less likely to smoke, be obese (BMI standard), and not exercise. Lower income brackets have also been associated with higher likelihoods of cigarette smoking and not exercising.^{27,28} Additionally, when compared with high income patients across a large number of quality measures taken from 2013 to 2016, poor and low income patients had worse outcomes on over 55 percent, while middle income patients fared worse on over 40 percent. Among these, the largest disparity was found in emergency department visits for asthma in poor children and adults, as both rates were just under three times that of their high income comparisons.²⁹



Income, along with education, is a strong predictor of mortality and health risk behaviors.³⁰ Employment and income can also affect health through choices in the built environment, as lower income families are at increased risk of low quality housing. Materials such as lead or asbestos when ingested may contribute to cognitive or physical conditions.^{31,32}

Low wage labor may also immediately impact access to health care. Income from employment is the primary source of income for most households, consequently a low wage worker is often from a low income household. However, income is not the only means of access to

healthcare, as many workers rely on employment benefits for access to healthcare. Lower-wage jobs are often less likely to offer health related benefits, including paid leave, childcare, retirement, and health insurance. In some cases, even when insurance is offered, constraints on income limit access through premiums, copayments, and deductibles.³³ When compared to those with private insurance on a broad array of quality measures taken from 2013-2015, uninsured patients were shown to fare worse on 65 percent, while those with public insurance fared worse on over 35 percent.³⁴

Neighborhood Context



Neighborhood context can impact health through interactions with socioeconomic status as well as through the material structure of the built environment. Living in a higher poverty neighborhood is associated with higher probabilities of a series of health conditions, including diabetes, obesity, as well as worse outcomes in general health and mental health status.^{35,36}

Family Composition

The composition of households is often associated with a range of health influencing circumstances. Specifically, children in single-parent households are at increased risk of experiencing poverty as well as food and / or housing insecurity. Poverty is also associated

with increased likelihood of a household becoming single-parent. Additionally, adolescents from low-income households may be more likely to have children of their own.³⁷



Race and Ethnicity

Race and ethnicity are widely recognized as important elements in disease epidemiology, as well as health outcomes. In quality measures, Black or African American patients have shown worse outcomes on over 40 percent, the same on 45 percent, and better on 13 percent when compared to White patients in quality measures taken from 2013-2016. Hispanic patients were shown to have worse outcomes on just under 40 percent, with the same percentage in equal outcomes. When these disparities were contextualized with measures from 2000, neither group had experienced improvement in more than 20 percent of these measures.³⁸ Beyond quality measures, Black or African American, Hispanic, Asian, as well as American Indians and Alaskan Natives have more obstacles to accessing or utilizing care than their White comparisons. The same group, with the exception of Asian, have all shown an increased likelihood of not seeing a doctor for necessary care because of cost.³⁹



While the full range of conditions that can be predicted (at least in part) by race and ethnicity remain outside the scope of this study, some widely recognized examples include cancer and obesity. Black and African American men have the highest cancer incidence and death rates of any racial demographic, higher than White men for every site other than kidney, and about twice that of the demographic with the lowest rates, Asian/Pacific Islanders.⁴⁰ Black and African American patients also have lower stage-specific survival for most types of cancers,⁴¹ the Latino population has been shown to have elevated mortality rates when compared to all persons in several categories, including diabetes mellitus, several types of cancers, liver disease and cirrhosis, HIV, homicide, and work-related injury.⁴²

Foreign-Born and Native Born

The majority of Pennsylvania immigrants were born in Asia, Latin America, and Europe, with less than ten percent from Africa, North America, and Oceania.⁴³ Immigrant families are at increased risk of living in poverty, with this risk magnified in single parent families. Many of the health and income barriers seen in legal migrants may be magnified when the definition of immigrant is expanded to include those without documentation.⁴⁴

Within-race differences have also been found when separated by nation of birth. HIV diagnoses are more likely to occur in foreign born non-Hispanic Black population, than in their native born comparisons. They are also at increased risk of late diagnosis, and being diagnosed with AIDS within 12 months of receiving an HIV diagnosis. Although injection drug use accounted for more late HIV diagnoses than any other mode of infection in both the foreign and native born Black populations, the primary mode of infection in the native born population was male-to-male sexual contact, while heterosexual contact account for more diagnoses in the foreign born populations.⁴⁵

The intersection of health literacy, ethnicity, and nation of birth offers further insight. The foreign-born Hispanic population has been shown less likely to have others seek information related to cancer, has lower self-efficacy in seeking information and finds information harder to understand.⁴⁶ The foreign-born Latino population also has elevated rates of work-related injury and death; this persists despite concerns that work-related injuries in this population are underreported.⁴⁷ Perhaps partly due to risks emerging from health literacy and work-related injury, the health of Mexican American immigrants has been shown to deteriorate with further acculturation, the rate of this deterioration is often stronger for men than women (however, concerns exist that these may be the result of unawareness of sickness).⁴⁸

Culture

Culture is often conceptualized as integrated and evolving patterns of belief and behavior. The culture of a community may any number of values or behaviors that have implications for health or the use of healthcare. One example that is frequently seen, is beliefs related to

childbirth. This may include sets of beliefs related to the appropriate age for motherhood, the number of children, and the role of healthcare in reproductive health.⁴⁹ Immediate implications for the clinical engagement can include, beliefs related to the role of medicine, such as when is appropriate to seek care as well as prohibitions or inducements for specific types of treatment. Also, the subjective experience of illness and pain can be modified by a patient's culture.⁵⁰ Some researchers have suggested that conditions emerge from the patient's culture, as well as the culture of the provider from which they are seeking care, consequently, patient-centered care cannot be culturally-neutral.⁵¹



Sex and Gender

Biological sex and the set of norms often associated with its expression have received attention as social determinants of health. Although biological sexes and gender are complex phenomenon, the SDH literature has focused mainly on discrepancies between male/female and masculine/feminine. Sex differences have commonly been reported in clinical entities, such as stroke, which is more common in women (although females' higher average life expectancy may explain part of this discrepancy). Most autoimmune diseases are more frequent in women than in men, as is osteoporosis. Men have shown increased

likelihood of certain categories of heart failure and cancer.⁵²

Gender is an important factor in the determination of risk for disordered eating. Social and cultural explanations include norms and expectations related to 'negative femininity' (passivity, dependence, etc.). Some evidence exists suggesting women are a majority of those seeking psychological services. Anxiety and depression are more common among females, and females are less likely to be optimistic about an illness they have. Separately, women make up a majority of victims of domestic violence which can have immediate impacts on health, as well as affect economic well-being.⁵³ Further connections have been suggested between socio-economic standing and health, as in the US where a large gender gap in earnings exists (that is, females earn less, on average), which may affect women's health.⁵⁴ Women are also more likely to live alone later in life and depend on outsiders for help (rather than a spouse); in lower age brackets they are more likely to be a single head of a household.⁵⁵

State Trends

Health outcomes are effected by social circumstances throughout the world. In this respect, Pennsylvania is no exception. However, geographical boundaries can play an important role in the provision and delivery of care, as well as the lifestyle of patients. For these reasons particular attention is paid to evidence from Pennsylvania.

The most recent data on quality measures (2015) from Pennsylvania shows low income patients "far away from the benchmark" (below 50 percent of benchmark) on 100 percent (13) of quality measures that are available to be

separated by income. This is in comparison to just over 45 percent of those for high income patients.⁵⁶ The most recent full, healthcare disparities report for Pennsylvania was produced in 2012,⁵⁷ and highlighted some state specific disparities.

Pennsylvania Disparities: Race and Ethnicity

Pennsylvania hospital diagnoses show significant disparities between populations of Black or African American patients and White or Caucasian counterparts. Black or African American patients had worse outcomes in asthma, spinal cord injuries, as well as multiple age groups of congestive heart failure. Black or African Americans also have the highest mortality rates in Pennsylvania within heart disease, cancer, stroke, HIV, homicide, diabetes, and renal failure. Disparities in drug poisoning, injuries and accidents were erased in 2009, however new disparities surfaced in death by fire, smoke and flame, several other types of cancers and digestive disorders. Despite these disparities, the Black and African American population in Pennsylvania has shown increased participation in preventative medical care, such as sexually transmitted disease (STD) testing and mammograms. The Pennsylvania population of Asian and Pacific Islander's second leading cause of death was suicide (a rate near equal that of Black or African Americans), with only a slight difference between genders. Asian and Pacific Islander males had lower rates than female counterparts, however this discrepancy was smaller than seen in several other groups (viz. Black or African American and Hispanic). Rates of HIV/AIDS related death among Hispanic residents were four times higher than that of non-Hispanic Caucasian comparisons. Additionally, large disparities exist between these two groups in almost every category of

STDs. The most recent data on quality measures (2015) from Pennsylvania shows Black or African American patients "far below" (achieving less than 50 percent) established benchmarks on over half of all quality measures. Hispanic patients are far below on 36 percent, followed by White (32) and native Hawaiian and other pacific islanders (27).⁵⁸

Pennsylvania Disparities: Sexual Orientation Gender Identity and Expression

Lombardi, as cited in the 2012 report, found that just under 45 percent of a sample of gender and sexual minorities (GSM) reported having depression, anxiety, or other emotional disorders. Separate data showed that 41 percent of all transgender respondents had attempted suicide.⁵⁹

Discrimination and violence are catalytic in the lives and health of transgender men and women, as they often have increased difficulty in finding housing, as well as health problems as a result of violence. Further, violence and bullying have been shown to disproportionality affect Pennsylvania GSM youth.⁶⁰ Additionally, about a quarter of transgender men and women from one sample reported having been denied medical care because of their gender identity.

GSM populations are also at increased risk of engaging in risky health behaviors. These may include, abuse of alcohol and other substances or cigarette smoking.^{61,62,63,64}

Best Practice for Addressing SDH



Housing improvements have received more attention than any other as a possible intervention point. A 2016 review found 10 of 12 housing studies reported positive results in a series of health outcomes including obesity, diabetes, asthma, self-reported health status, mobility, HIV outcomes, and health spending (decrease).⁶⁵ The most common (3) successful interventions included offering housing improvements and renovations such as central heating, ventilation, rewiring, and reroofing,⁶⁶ interventions that coupled nurses and occupational therapists with improvements/renovations⁶⁷, as well as offering in-home services to aging tenants,⁶⁸ or moving tenants into an LEED certified (green) building.⁶⁹ Two of these housing interventions supported the provision of housing to those without it.⁷⁰ These housing interventions had implications for affecting HIV outcomes⁷¹ and health costs, among others.⁷²



Nutritional support saw seven of the 11 interventions produce positive results. The Supplemental Nutritional Assistance Program (SNAP) and the Special Supplemental Nutrition program for Women, Infants, and Children (WIC) have both been shown to be effective in combating social determinants. The effected outcomes from these include a series of those related to births such as weight, prematurity, Neonatal intensive care unit (NICU) placement, as well as measures of obesity, and depression.⁷³ Additionally, one telephone and web-based intervention included coaching for nutrition and physical exercise for overweight adults with disabilities was found to be effective in reducing body weight.⁷⁴



Case Studies in Addressing SDH

An ambitious effort to decrease the impact of social determinants can be seen in Gaston, North Carolina where a partnership between residents, community leaders, local government, and health care providers has emerged to challenge SDH with focus on a select health condition: obesity. This began as an initiative to build capacity toward a community health centered model of care involving a 125-thousand-dollar investment in 2015 from a health maintenance organization. Meetings in the community began in 2016 and four Key Performance Metrics (KPM) were established. These included goals for the

initiative to be met by 2020, such as maintaining financial support, specifically doubling the level of investment (\$250,000). The second KPM related to community stakeholder involvement, seeking to more than double the number of residents (from the target neighborhood) on the partnership's advisory council. The final two KPMs related to the execution of the project, as they implicated the use of the Social Determinants of Health Screening tool, seeking to double the number of providers using the tool as well as widening the scope of its use (from ten patients in one month to patients with obesity-related diagnoses for two years), the final KPM involved the inception of a Community Health Worker (CHW) in the community. The CHW is described as a resident of the community whose job description includes working with patients identified by providers, modeling desired health behaviors, and identifying community level barriers. They also provide updates with unique social media pages related to community events and health and wellness resources, and seek news coverage with an identified committee chair as spokesperson.⁷⁵



Balancing community engagement and data capture, a case study in community engagement is found in Mosby, Virginia, where a group of public health professionals suggest they shifted from being “data driven” to “community driven.” Interested in improving

birth outcomes, the team initially struggled with the confidence of the community. However, this was redressed by securing the help of a champion of the community, a local politician who had grown up in the community. This permitted “visioning sessions” and survey research that resulted in a partnership between nearby universities, the housing authority, community groups, and local government that resulted in establishing a health and social service center near the identified areas.⁷⁶

Separately, in the late 2000's, the Colorado State Department of Health became aware that the magnitude of health disparities had remained static despite public health efforts. This motivated an investigation to provide possible explanations. The investigation resulted in the development of a formalized framework which explains the links between dimensions of health disparities and social determinants in their communities. These links included national influences (policy, culture), life course (birth and on), conventional social determinants (income, education, racism etc.), and health factors (behaviors such as smoking, nutrition, and substance abuse). The organization's prevention staff were trained in the use of these understandings in the deployment of effective upstream interventions. Training necessitated deepening cooperation with other organizations, including “nontraditional” partners, such as those in criminal justice and education. The organization dedicated time to building capacity to execute the framework with the formation of a new strategic map which prioritized health equity and environmental justice. Part of the effort to enhance organizational capacity included workgroups focused on data capture, workforce development, community involvement, and policy development. In 2013, the state of

The numerators are taken from Pennsylvania Certificates of Death. (n = 55)

ii. The County Health Outcome Rankings (CHOR)

This is the product of a collaboration between the Robert Wood Johnson Foundation and the University of Wisconsin Population Health Institute. They employ county-level measures from a variety of national and state data sources. Health outcomes are a combination of data representing health behaviors, clinical care, social and economic factors, and physical environment. Each county is ranked from 1 (the best health outcomes) to 67 (the worst health outcomes in Pennsylvania) (n = 67).

Note: IMR was not available for 12 counties, reducing the sample size of IMR to 55.

Factors identified in the background above for which county level data were not available included built environment, gender identity and expression, and sexual orientation.

Simple linear regression was used as an initial test of correlation (and variable selection) between social determinants and the two measures of health outcomes. Further analysis was performed using the strongest determinants of the two health measures analyzed in Pennsylvania in order to reveal more about the interplay of various factors. The determinants identified included county median income, percent of residents with income under

the federal poverty level in the last 12 months, the percent of households with income under 25,000 dollars, the percent of county residents who have completed a bachelor's degree (or higher), the percent of residents who have completed high school or equivalent, the percent of county residents who have health insurance, the percent of all households that are single parent households, as well as single parent households when broken up by male or female head.

As these measures of health are taken as broad indicators, the form of the relationship was not known before the analysis began. The initial approach including multiple variables was done using Generalized Additive Models (GAM).

Beyond the five determinants identified in simple regression, two additional variables were added. One dummy variable for Luzerne and Lackawanna Counties, the other coded Luzerne, Lackawanna, and three in-state peer counties identified previously by The Institute based on demographic and socioeconomic makeup: York, Blair, and Erie.

This allowed estimators to capture any regional effect. In other words, are social determinants better or worse predictors of health outcomes in different regions?

The information gathered from the GAMs performed included both the form of the relationship as well as the strongest models. The GAM revealed that while the relationships between the two health outcomes and many of the determinants is linear, others are best characterized as curvilinear. For this reason, a linear model (ordinary least squares), with squared terms were appropriate was used (polynomial regression). The advantage to this approach is the increased interpretability (relative to the GAM).

Results

The tables below show R² values for each pairing. Values near zero indicate little or no correlation between the social factor and the health measure across the 67 counties in the Commonwealth; the R² represents the amount of variance in the dependent variable (CHOR or IMR) explained by the independent variable (the social determinant).

Table 1 shows the variance explained in CHOR by each social determinant. It shows the dimensions of income / poverty are the strongest predictors of CHOR. The prevalence of single parent households and bachelor's degree attainment were moderately correlated with the CHOR. The percent of the county's population that is foreign born, has health insurance, a high school degree, lives in an urban area, was shown to be weakly correlated with the health outcomes ranking. The measure of transience, population density, and the percent of non-white showed little or no correlation with the CHOR.

Table 1

County Health Outcomes Ranking ~ Social Determinant		
Table of R-Square Values	Health Outcomes Rank	
% households with income < \$25,000/year	0.4285	Strong
% population below poverty level	0.3627	
median household Income	0.3621	
% family households with single parent	0.2407	Moderate
% all households with single parent	0.2015	
% female headed single parent homes	0.1867	
% at least bachelor's degree	0.1839	
% male headed single parent homes	0.127	
% foreign born	0.0601	Weak
% speak language other than English at home and speak English less than "very well"	0.0291	
% population with health insurance coverage	0.0221	
% at least high school or equivalent	0.0199	
% urban	0.01	
% lived in same home as 1 year ago	0.0085	None
population density	0.0012	
% nonwhite, non-Hispanic	0.0011	

Table 2 shows the variance explained in the IMR by each social determinant. It shows that no single determinant was strongly correlated with infant mortality (R² of .25). The percent of the population with health insurance and the percent with GED or higher were the strongest determinants of IMR. Single parent family, and the dimensions of income all showed moderate correlations with the county IMR. Population density, percent non-white, and English as a second language were weakly correlated with the IMR. The percent of the county's population in urban settings, and the percent foreign born, showed no relationship to the County IMR.

Table 2

Infant Mortality Rate ~ Social Determinant		
R-Squared	Infant Mortality Rate	
% population with health insurance coverage	0.2292	Moderate
% at least high school or equivalent	0.2006	
% households with single parent	0.1583	
% all households with single parent	0.1515	
% female headed single parent homes	0.1408	
% households with income < median household income	0.1307	
% population below poverty level	0.129	
% at least bachelor's degree	0.1192	
% male headed single parent homes	0.0802	Weak
% speak language other than English at home and speak English less than "very well"	0.0713	
population density	0.0414	
% non- white, non-Hispanic	0.0299	
% lived in same home as 1 year ago	0.0211	
% urban	0.0142	
% foreign born	0.01	None
	0.0015	

Table 3 shows the results of the approach which included multiple variables. The table includes those which resulted in an adjusted R² above .5. It shows that over 50 percent of the variance in CHOR can be explained by income, family composition, education, and health insurance

status. Recall that adjusted R^2 penalizes for added covariates. This is exemplified in the first two models, as the addition of the percent of the population with a bachelor's degree or higher adds just enough value to offset its penalty.

Table 3

GAM results: CHOR				
X1	X2	X3	X4	R-squared
% households with income < \$25,000/year	% family households with single parent	%	% at least bachelor's degree	0.554
median household income			% at least bachelor's degree	0.554
% households with income < \$25,000/year		population with health insurance	% at least bachelor's degree	0.548
% population below poverty level		% population with health insurance	% at least bachelor's degree	0.528
		% population with health insurance	% at least bachelor's degree	0.519
		% population with health insurance	median household income	0.514
			% population below poverty level	0.514

The dimensions of income were shown to be the strongest predictors in each model. Median income of a county was the weakest measure of three dimensions of income. The percent of households under the poverty level in the last twelve months, and the percent of households with income under 25 thousand dollars annually were capable of explaining 36 and 42 percent of the variance in CHOR, respectively. The addition of family composition can add over 10 percent

to these figures, and smaller increases from education and health insurance.

Table 4 shows the top performing models for the Infant Mortality Rate, those with R^2 above .35. No model was capable of explaining above more than 35 percent of the variance in the IMR without the percent with health insurance and the percent of households that are single parent. One example is included showing the addition of a covariate and a reduction of adjusted R^2 . As the addition of income under 25 thousand reduces R^2 . Other cases like this are not shown.

Table 4

GAM results: IMR					
X1	X2	X3	X4	R-squared	
	% all households with single parent	% population with health insurance	% least high school or equivalent	0.399	
% households with income < \$25,000/year				0.397	
median household income				0.386	
				0.371	
				0.371	
% population below poverty level				0.365	

Although IMR is also explained by dimensions of income, it is more strongly determined by health insurance status of the county and family composition. Health insurance, family composition, and education are capable of explaining just under 40 percent of the variance in county level IMR. Also, Table 4 displays that, while income can explain an additional 15 percent in the context of family composition and health insurance, this effect is negated when education is included.

The dummy coded region, the counties of Luzerne, Lackawanna, Erie, York, and Blair, showed little to no effect in even the simplest models. Those where the region was regressed on IMR and CHOR for conditional mean with regional effect on and off.

However, a visual representation of Robust Linear Models fit to CHOR across two dimensions of income, as well as one measure of family composition, is shown below. Estimators are visualized separately for the Region (and Peers) and the remaining 62 counties in of Pennsylvania. A higher CHOR

value corresponds to less desirable health outcomes. The visualizations tell a compelling story regarding the distribution of health in Pennsylvania, as well as in the Region with Peers. In the Northeastern Pennsylvania region (with peer counties added to the analysis to increase the sample size), health outcomes appear to be at least as dependent on income factors as they are statewide.

Figure 1, below, shows CHOR when regressed on the percent of the population with income under the poverty level for the past 12 months.

Figure 1

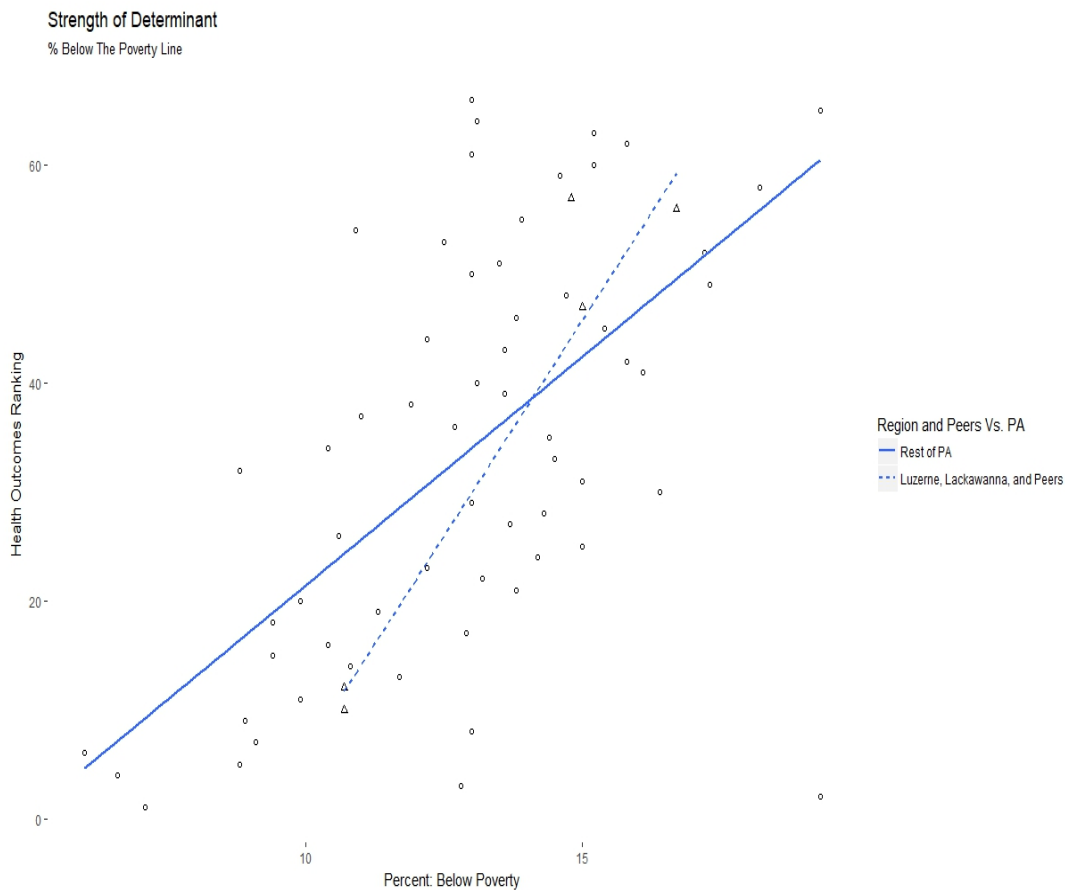


Figure 2, below, shows CHOR when regressed on the percent of population within a county with income below 25 thousand dollars annually.

Figure 2

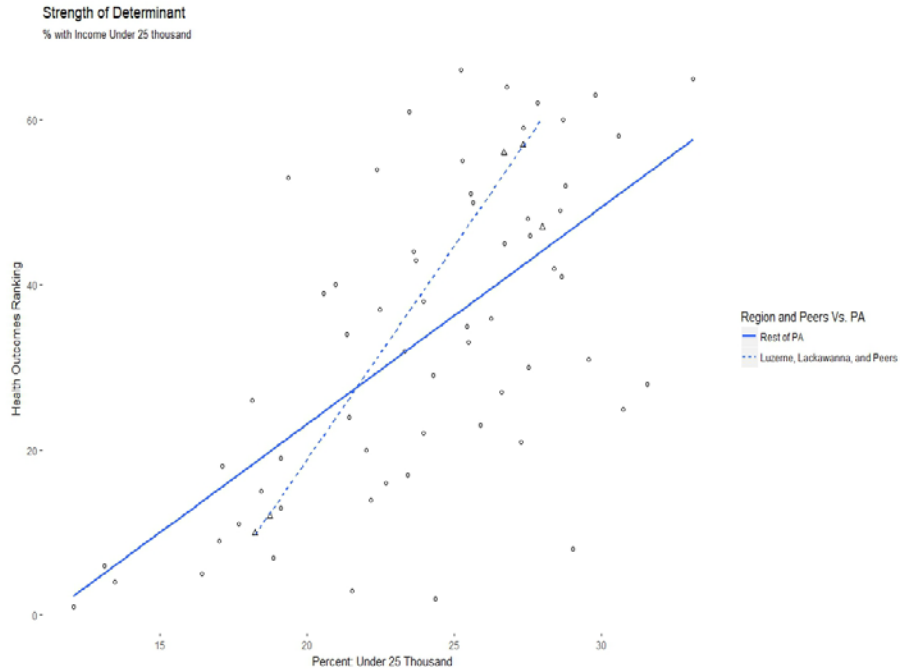
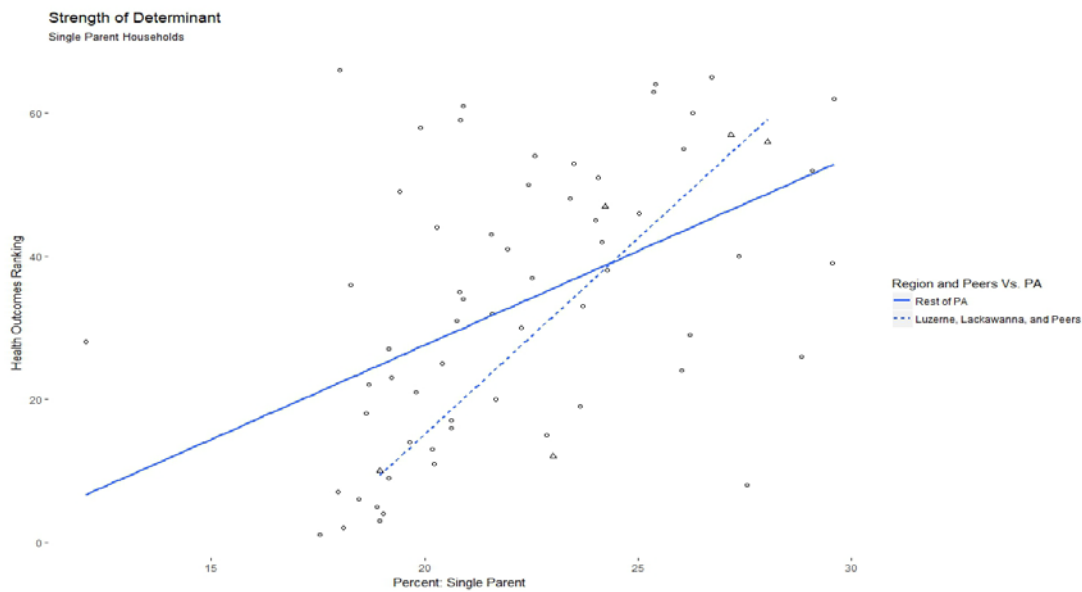


Figure 3 shows the percent of all households in each county that are single parent households, when regressed on CHOR.

Figure 3



Parametric Approach

The move to general linear models (ordinary least squares with Huber-White standard errors) saw little information loss as seen in the difference between Adjusted R^2 . A full table of the results is included in Appendix 1.

Findings from this analysis included significant association of income, family composition, and health insurance with CHOR. While little evidence was found for the first degree term of health insurance, stronger evidence was found on the squared term, with a negative coefficient in each model. This suggests that the improvements to CHOR come more rapidly at higher rates of insurance coverage. Higher percentages of single parent households were associated with higher CHOR. Lower median wage and higher percent of the population with income under 25 thousand dollars annually, were also associated with worse CHOR.

Notably, the significance of the measures of income, health insurance, and family composition, were sustained in each of the top three models of CHOR. Weak evidence was found for the measure of education included.

The top performing models for county IMR included family composition and health insurance. No model saw improvements beyond four covariates. Similar to health insurance in the CHOR analysis, the number of single parent households was found to be associated with the IMR in a non-linear fashion (concave down). This suggests that the association of single parent households and IMR may be reduced at higher values of single parent households. It approaches a ceiling at the highest values of single parent households seen in Pennsylvania, and should not be interpreted outside these values. The measure

of education was significant in some models, however, this was not robust to the inclusion of health insurance coverage.

Summary

Taken together, these approaches provide evidence that income, family composition, education, and health insurance are the strongest predictors of health in Pennsylvania. Also, that these associations persist in Lackawanna and Luzerne Counties to at least the same degree as the rest of the state.

Stated generally, in Pennsylvania, higher incomes or lower rates of poverty in a county are associated with better health. Higher prevalence of attainment of educational milestones (high school diploma or bachelor's degree) in a county is associated with better health. Higher rates of health insurance coverage within a county are associated with better health, and lower rates of single parent households in a county are associated with better health.

Recommendations

Dean & Fenton suggest "It is increasingly unacceptable for those planning and delivering prevention services to claim that addressing SDH is outside their jurisdiction, thereby absolving themselves of further action."⁸² There are several steps that can be taken in order for health care delivery systems to fully account for socioeconomic differences with the goal of reducing health outcomes disparities.

Identify Collective Objectives. Overall, approaches should be community wide, with public-private partnerships where applicable. Objectives can be identified through cross-sector communication. This may include

responsibilities for funding, implementation, and measurement.

Improve data collection and access.

Measurement and assessment are critical analytic tools in service delivery. Currently, limitations on data collection and / or accessibility prevent the use of data from Pennsylvania for systems below county, further some data are not available at the county level. Giving the research and practice communities access to community-or-neighborhood-level-data may enhance the ability to target interventions and improve outcomes.

Recommendations for Care Delivery Systems

The following represent recommendations for health care providers and other stakeholders within the healthcare delivery system.

Greater emphasis on socioeconomic factors in education and training and continuing education for practitioners that help front line health care workers understand how social determinants impact the health of their patients.

Further facilitate and expand cultural competency among healthcare and public health practitioners. This can include differences in race, language, country of birth, sex, sexual orientation and gender identity or expression, age, socio-economic status, and others, including diversity within these categories.

Seek to untangle healthcare access with employment and income. Expand access to free

and low cost health services, particularly in underserved communities. Access is critical for urban, suburban, and rural communities with low household income and elevated poverty rates.

Recommendations for Population Health

The following represent recommendations for health care providers and other stakeholders with interest in population or public health.

Consider a systemic approach to health. Public health practitioners and policymakers should consider how addressing social determinants may help advance their goals. In the context of their communities, the practice community can assess how interventions aimed at determinants such as poverty, income, employment, or housing may affect health outcomes.

Continue striving for equitable access to active transportation and recreation. Ensure that the built environment is conducive to active transportation and that low and moderate income neighborhoods have adequate access to a variety of physical recreation facilities.

Continue striving for environmental justice. Public health practitioners and policymakers can consider the distribution of impact from air and water quality, soil, as well as access to measures to redress these issues.

Comprehensive planning that incorporates housing, transportation, health care, and social services in land use plans and is a component in permitting of new development.

Appendix

OLS results: CHOR															
X1	β	SE	X2	β	SE	X3	β	SE	X4	β	SE	X5	β	SE	(ADJUSTED) R-squared
% of Households with Income < \$25,000/year	1.723	0.04906 ***	% of Family households	1.723	0.4732 **	% of Population with Health Insurance Coverage	-0.2408	17.5215	% of Population with Health Insurance Coverage	-36.44	14.78 *	% with at least Bachelor's Degree	-0.3	0.33	0.5369
Log of Median Household Income	-67.234	12.1865 ***	% of Family households with single parent	1.379	0.3385 ***	% of Population with Health Insurance Coverage	-29.447	19.1819	% of Population with Health Insurance Coverage	-33.78	14 *	% with at least High School or Equivalent	1.96	0.85 *	0.5463
% of Households with Income < \$25,000/year	2.3514	0.378 ***	% of Family households with single parent	1.06	0.3965 **	% of Population with Health Insurance Coverage	-33.122	18.7933 ^v	% of Population with Health Insurance Coverage	-37.61	12.81 **	% with at least Bachelor's Degree	1.6	0.84 ^v	0.5564
Log of Median Income	-50.876	18.483 **	% of Family households with single parent	1.5	46.5741 **	% of Population with Health Insurance Coverage	2.1386	18.334	% of Population with Health Insurance Coverage	-36.72	15.47 *	% with at least Bachelor's Degree	-0.11	0.43	0.5101
OLS results: Log of IMR															
Log of Median Household Income	-1.9E-06	1.82E-06	% of Family households with single parent	6.7E-02	1.92E-02 **	% of Family households with single parent	-8.39E-04	2.77E-04 **	% of Population with Health Insurance Coverage	-0.045	0.015 **				0.3657
% of Households with Income < \$25,000/year	7.0E-03	0.00425	% of Family households with single parent	7.2E-02	1.77E-02 ***	households with single parent	-9.07E-04	2.57E-04 ***	% of Population with Health Insurance Coverage	-0.048	0.014 ***				0.3734
				0.651	0.0183 ***	single parent	-8.48E-04	2.62E-04 **	% of Population with Health Insurance Coverage	-0.045	0.014 **				0.3787

Significant at ***.001 **0.01 *0.05 ^v0.1

squared terms in CHOR are orthogonal
standard errors are Huber-White

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