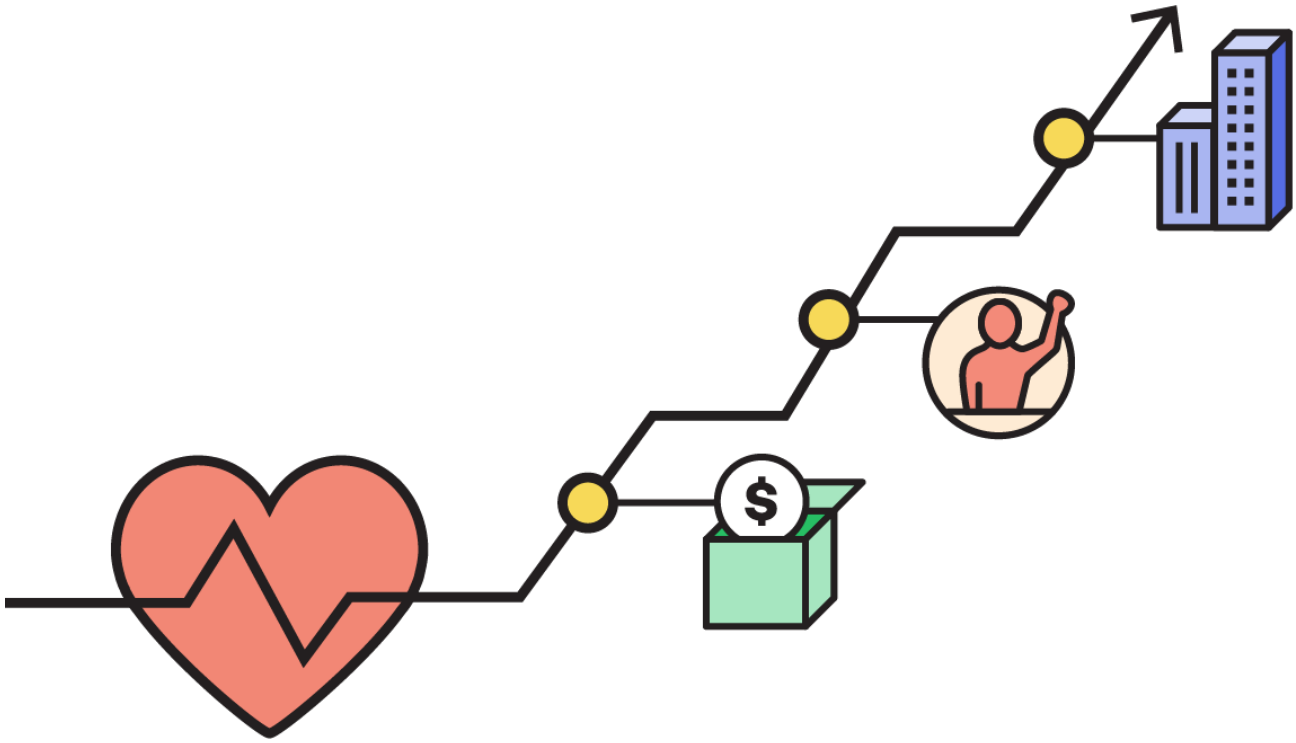
Linking Health and Economic Prosperity: A Study of U.S. Metro Areas



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Introduction

Does population health in metro areas influence economic vitality?

This study examines the relationship between population health and economic activity in metropolitan areas in the United States through an analysis of longitudinal data that spans a 15-year period. Overall, we found evidence that worse population health in metro areas is linked to a less robust regional economy.

Researchers from Wilder Research and the Federal Reserve Bank of Minneapolis conducted this study in response to a call by the Robert Wood Johnson Foundation and AcademyHealth for research to build the evidence base for private sector investment in population health.

This exploratory study addressed the following research questions:

- How do population health trends in metro areas correlate with trends in economic activity?
- How does relative population health and economic activity change for metro areas over time?
- How do overall rates of health-promoting behaviors and overall rates of morbidity in metro areas influence overall levels of economic activity?
- Do businesses consider the health of a region in major relocation decisions for their firms?
- Does the pattern of moves for business headquarters reflect any preference for healthier regions?

To date, most studies of health and economic well-being have focused on the effects of economic well-being on health. Research has paid less attention to the effects of health on economic well-being, particularly at a macro-level. This study, which asks how population health influences economic activity in metro areas across the United States, contributes a unique new perspective.

Why focus on metropolitan statistical areas (MSAs)?

Most residents of the United States live in metropolitan statistical areas (MSAs). [1] In 2015, 86% of the population in the United States lived in MSAs (Bullard, 2017). Most economic activity occurs in MSAs. The Brookings Institution reported that, in the United States, metropolitan areas generate the majority of their state's respective economic output in 47 out of 50 states (Berube & Nadeau, 2011). In 2017, total Gross Domestic Product (GDP) for all MSAs comprised about 90% of total GDP in the United States (The United States Conference of Mayors, 2018).

[1] From this point on, for simplicity, we will refer to metropolitan statistical areas as "MSAs" or as "metro areas". For a longer description of the rationale for focusing on MSAs, and for a detailed description of the process used to define them, see Appendix A.

Metropolitan statistical areas (MSAs) provide a set of geographic regions defined in a consistent manner, which allows for data collection, analysis, and reporting that compares like with like (Bureau of Labor Statistics, 2018). They also demarcate geographic areas of 50,000 inhabitants or more that have a "high degree of social and economic integration," largely based on commute sheds between counties and core cities (United States Census Bureau, 2018). MSAs were selected as the unit of analysis for this study because they constitute population and economic hubs, and because they accurately reflect the health and economic contexts in which people live— contexts that transcend county, and even state, borders.

Methods

Our study involved the construction of a longitudinal data panel, the fielding of a small survey, and the application of several analytical approaches to answer our exploratory research questions.

The data panel

We identified 74 data indicators related to population health, economic activity, social determinants of health, and policy. Using the 2015 definition of MSAs in the United States, we incorporated these into a data panel for 382 metro areas, where available. Most indicators were available from the early 2000s to 2015.[2] This report focuses primarily on 19 population health and economic activity indicators: general health (self-rated), heart disease, high blood pressure, high cholesterol, obesity, diabetes, smoking, exercise (in the past month), mental health (poor), net job creation, net establishment creation, and labor force participation for the total population and for five subgroups— all expressed as rates and GMP per capita and median household income— both expressed in real dollars.[3]

Data sources for the panel

Two data sources comprise the majority of the panel data used for this study:

- Census Bureau – Decennial Census, Current Population Survey, American Community Survey
- Centers for Disease Control and Prevention – Behavioral Risk Factor Surveillance System

These sources provide data at regular intervals ranging from every year to every ten years.

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[2] Not all indicators were available for each year. While some indicators were available as far back as the late 1970s, our primary data sources become available in the early 2000s. Our two largest data sources are BRFSS data, which was available from 2002 to 2015, and Census/ACS data, which was available for the year 2000, and then from 2005 to present.

[3] We intend to do additional analysis that will make use of additional indicators. Also, we plan to make the full panel available to other researchers.

Additional data sources in the panel include:

- Americans for Nonsmokers' Rights
- Bureau of Economic Analysis
- Business Dynamics Statistics
- National Establishment Time-Series (NETS) Database

Statistical analysis of panel data

We sought to understand the linkages among population health trends, economic trends, and other socio-demographic trends that most likely affect each other in different ways over time. If health trend A and economic trend B change over the years, how do these changes correlate with one another? Does change in one cause change in another? Many difficulties exist in trying to answer such questions and clarify these relationships.

To quantify the relationships between the health and economic indicators in our data panel, we used the following approach:

First, we plotted data points over time for each of the 19 data indicators included in this study. We looked at data trends in order to understand both the general direction and the amount of change that had occurred during the study period.

Second, we examined the correlations among the indicators. We calculated Pearson correlation coefficients to identify statistical associations among trends in population health and economic activity observed for all MSAs with available data.

Third, we assessed whether change in one indicator preceded or followed *c*hange in another indicator. Population health conditions, economic conditions, and other demographic characteristics of metro areas change over time. From year to year, it might appear that changes in A cause changes in B, but in actuality, changes in B might cause changes in A. Therefore, we used the Granger test to statistically indicate whether A precedes and might cause B, or whether B precedes and might cause A, or whether A and B mutually reinforce each other over time. Note: The Granger test does not conclusively establish causality. The Granger test establishes whether changes over time in one indicator *precede* changes in another indicator – in a pattern that suggests that changes in the first indicator can *predict* changes in the second. To answer our research questions, we had a particular interest in whether population health trends predict or mutually reinforce trends over time in economic activity. If so, such evidence would be consistent with the notion that population health influences economic activity.

Fourth, we calculated the significance of the effects of population health on economic activity. We wanted to test: Even if population health seems to influence economic activity, might that influence disappear if we consider the independent effects of other characteristics of metro areas, including poverty, racial composition, education levels, and the proportion of older adults among the population? Therefore, we constructed a fixed-effects regression model to provide further evidence.

Fifth, we grouped MSAs into four categories, based on their relative population health and economic activity, and we took two snapshots in time to determine whether their positions categorically changed from before to after the Great Recession of 2009. To sort MSAs into these categories, we used the k-means cluster analysis method. In particular, we wanted to understand how the positions of metro areas with relatively worse population health changed.

Survey of businesses that moved

To gain qualitative insight into whether the health characteristics of a region might influence where business firms decide to locate, we conducted a small survey of businesses that had moved their firm's headquarters to a new MSA five years earlier.

Analysis of firm relocation data

We also looked for patterns among all U.S. firms with 100 employees or more that moved their headquarters in 2013. We determined whether 1) a firm had moved its headquarters within the same MSA or to a different MSA, and 2) whether firms, overall, seemed to favor moving to, or remaining in, regions with relatively better population health.

Literature review: Moving from existing research to our analysis

What do we know about the effects of population health from existing research literature? We reviewed studies published as of 2018 related to three overarching topic areas:

- Economic activity and population health
- Social determinants of health and population health
- Policy interventions and population health

In initiating our study, we attempted to identify major findings that could serve as a starting point and baseline to ground research questions, hypotheses, and analysis for this exploratory study. The literature also informed our selection of indicators for the data panel. A detailed description of the results of the literature review, with citations, appears on the Wilder Research website (Connell, 2019a).

Existing research offers a strong evidence base for the linkages between individuals' health, economic status, and other social determinants of health. Existing research also demonstrates, cross-nationally, that economic development affects population health characteristics, such as life expectancy. Both of these findings provided context for our work.

Studies show that a positive relationship exists between the economic well-being of individuals and their physical health. This likely occurs because financial well-being increases the availability of resources that bolster physical health, and those resources, in turn, increase access to health care, including preventative care. Previous research also suggests that healthier people less often miss work, have higher wages, and are less likely to leave the workforce due to unemployment or disability.

Studies indicate that typical health concerns, such as headaches, back problems, the common cold, seasonal allergies, gastrointestinal distress, and depressive symptoms affect the productivity of the American workforce through both absenteeism and "presenteeism" (reduced productivity while at work).

The literature on social determinants of health makes clear the importance of social determinants for understanding the complex interactions between population health and regional economic activity. In particular, racial inequality affects health and economic well-being in metro areas, both directly and indirectly.

Legislative policies, which sometimes differ across metropolitan regions, can also influence population health and economic activity, both intentionally and unintentionally.

Our study builds on previous research, but adds a new dimension: We examine the characteristics of metro areas over time to learn how population health, economic activity, and socio-demographic characteristics relate on a macro-level. Based upon evidence gathered to date, economic well-being influences health. Our study explores whether the opposite is true— does health in any way drive economic well-being?

The results of the literature review informed our decision on which indicators to include in our analysis. If previous evidence suggested a possible link between a regional population health indicator and a regional economic activity indicator, we tried to build a test of that link into our study. Some of the literature led us to omit certain indicators for now, but pointed to important questions for future research beyond the scope of this study.

Brief overview of trends

A brief look at social, health, and economic trends in metro areas helps to provide context for interpreting the results of our analysis. A few facts, which describe the characteristics of MSAs based on averages, appear below. Additional details, including graphs that show change over time in the study's indicators, appear in a separate report (Connell 2019b).

The average population of the MSAs included in our analysis grew from approximately 833,000 in 2000 to 970,000 in 2015. The median population grew from approximately 324,000 in 2000 to 370,000 in 2015.

Racial diversity in MSAs has increased over the past two decades. In 2000, residents of color comprised, on average, 27% of the population of their MSA. In 2015, that proportion rose to 35%.

The average proportion of adults in metro areas who rate themselves as having "good" or better health was 4 out of 5 in 2015 and had remained relatively consistent since 2000. However, adult rates of obesity, diabetes, and high blood pressure trended upward during that same period.

Gross Metropolitan Product (GMP) increased during our roughly 15-year study period. Across all MSAs, adjusting for inflation, the mean GMP in 2001 was $32,258 million, which grew to $103,459 million in 2015[4]. Large MSAs pulled the average upward. In 2001, real median GMP was just $8,565 million, which grew to $37,105 million in 2015.

Per capita GMP, adjusted for inflation, shrank slightly during the study period. In 2005, average per capita GMP was $68,290, which decreased to $66,790 in 2015.

Average labor force participation rates in metro areas remained relatively constant during the study period. Poverty rates trended slightly upward.

[4] Unless otherwise noted, all references to "adjusting for inflation" and "real" dollars indicate the expression of monetary values in 2016 dollars.

Metropolitan area health and economic activity: Simple correlations

How do trends in population health and economic activity correlate with one another in Metropolitan Statistical Areas over time? This section describes the correlations we observed by looking at all the metro areas in our data panel across all the years of our study.[5]

Recall that this study focuses on regional-level indicators. So, for example, the negative correlation between the heart disease rate and real median household income does not indicate that individuals with heart disease have lower incomes (although this might be true). What the data do show is that, in metro areas with higher rates of heart disease, median household incomes tend to be lower.

The tables on the following three pages provide Pearson correlation statistics that help to understand how the study's population health and economic activity indicators relate to one another. That is, do any pairs of indicators have a relationship? If so, how strong is it? When one is high, is the other high or low?

Key observations:

- As expected, several economic activity indicators correlate positively with one another. For example, in metro areas with higher median household income, overall rates of labor force participation are higher, and in MSAs with a greater net job creation rate, the net establishment creation rate is greater (Figure 1)[6].
- As expected, risk factors for disease and morbidity– high blood pressure, high cholesterol, obesity, heart disease and diabetes – correlate positively with one another (Figure 2).
- Risk factors for chronic disease and morbidity correlate negatively with good health behaviors. For example, in metro areas where more adults report exercise (in the past month), the rate of diabetes is also lower (see Figure 2).
- Economic activity indicators correlate negatively with most of the population health indicators in the analysis. For example, metro areas with higher GMP per capita and higher median household income have lower rates of disease and health risk factors. Economic activity indicators correlate positively, and relatively strongly, with self-reported general health status "good" or better and also with exercise (in the past month) (Figure 3).

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5 For details on the correlation analysis, see the Technical Supplement on the Wilder Research website at www.wilder.org/study/linking-health-econ-19.

6 The Census Bureau defines an establishment to be "a single physical location where business is conducted or where services or industrial operations are performed." "Net establishments" in a region is the number of establishments created or entering a region minus the number of establishments that close or exit, in any given year. "Net jobs" in a region is the number of jobs that are created in a region minus that number of jobs lost, in any given year. See: https://www.nap.edu/read/11844/chapter/4#33 and https://www.census.gov/programs-surveys/bds/documentation/glossary.html

1. Bivariate correlations among economic activity indicators

IN U.S. METRO AREAS	GMP per capita (real)	Median household income (real)	Labor force participation	Male labor force participation	Female labor force participation	Parent labor force participation	Male parent labor force participation	Female parent labor force participation	Net job creation rate	Net establishment creation rate
GMP per capita (real)	1	.512**	.546**	.512**	.436**	.157**	.137**	.144**	NS	NS
Median household income (real)	.512**	1	.404**	.321**	.372**	NS	.052**	-.099**	NS	-.174**
Labor force participation	.546**	.404**	1	.872**	.871**	.397**	.318**	.403**	NS	NS
Male labor force participation	.512**	.321**	.872**	1	.521**	.527**	.529**	.401**	.058*	.172**
Female labor force participation	.436**	.372**	.871**	.521**	1	.169**	NS	.315**	-.129**	-.111**
Parent labor force participation	.157**	NS	.397**	.527**	.169**	1	.920**	.867**	.075**	.134**
Male parent labor force participation	.137**	.052**	.318**	.529**	NS	.920**	1	.603**	.130**	.204**
Female parent labor force participation	.144**	-.099**	.403**	.401**	.315**	.867**	.603**	1	NS	NS
Net job creation rate	NS	NS	NS	.058*	-.129**	.075**	.130**	NS	1	.406**
Net establishment creation rate	NS	-.174**	NS	.172**	-.111**	.134**	.204**	NS	.406**	1

Note: *p < .05

** p < .01

*** p < .001

NS = Not significant

2. Bivariate correlations among population health indicators

IN U.S. METRO AREAS	General health (good or better)	Heart disease	High blood pressure	High cholesterol	Obesity	Diabetes	Smoking	Exercise (in the past month)	Mental health (poor)
General health (good or better)	1	-.568**	-.634**	-.436**	-.525**	-.721**	-.273**	.704**	-.583**
Heart disease	-.568**	1	.575**	.485**	.355**	.512**	.480**	-.525**	.441**
High blood pressure	-.634**	.575**	1	.606**	.693**	.811**	.383**	-.667**	.601**
High cholesterol	-.436**	.485**	.606**	1	.456**	.535**	.251**	-.380**	.411**
Obesity	-.525**	.355**	.693**	.456**	1	.699**	.218**	-.532**	.437**
Diabetes	-.721**	.512**	.811**	.535**	.699**	1	.194**	-.625**	.530**
Smoking	-.273**	.480**	.383**	.251**	.218**	.194**	1	-.358**	.357**
Exercise (in the past month)	.704**	-.525**	-.667**	-.380**	-.532**	-.625**	-.358**	1	-.407**
Mental health (poor)	-.583**	.441**	.601**	.411**	.437**	.530**	.357**	-.407**	1

Note: *p < .05

** p < .01

*** p < .001

NS = not significant

3. Bivariate correlations among economic activity indicators and population health indicators

IN U.S. METRO AREAS	GMP per capita (real)	Median household income (real)	Labor force participation	Parent labor force participation	Female labor force participation	Male labor force participation	Male parent labor force participation	Female parent labor force participation	Net job creation rate	Net establishment creation rate
General health (good or better)	.311**	.397**	.631**	.207**	.536**	.560**	.270**	NS	.063*	.130**
Heart disease	-.235**	-.383**	-.306**	-.181**	-.165**	-.363**	-.279**	NS	-.110*	-.102*
High blood pressure	-.161**	NS	-.399**	-.425**	-.129**	-.568**	-.574**	NS	-.125**	-.476**
High cholesterol	-.205**	-.204**	-.238**	-.118**	-.120**	-.293**	-.219**	NS	-.100*	-.276**
Obesity	-.270**	-.238**	-.394**	-.133**	-.224**	-.466**	-.277**	.117**	-.060*	-.286**
Diabetes	-.235**	-.166**	-.483**	-.300**	-.306**	-.538**	-.415**	NS	-.120**	-.331**
Smoking	-.179**	-.467**	-.149**	-.175**	NS	-.271**	-.334**	.109**	-.136**	-.074**
Exercise (in the past month)	.196**	.384**	.425**	.101**	.309**	.426**	.249**	-.143**	.117**	.161**
Mental health (poor)	-.284**	-.199**	-.414**	-.357**	-.257**	-.472**	-.407**	-.170**	-.102**	-.265**

Note: *p < .05

** p < .01

*** p < .001

NS = Not significant

Multivariate analysis

Since correlation does not indicate causality, we conducted several additional analyses to produce evidence that suggests that better health in metro areas might, in fact, lead to higher levels of economic activity.

Granger test

The Granger statistical test provides a means for determining whether changes in one indicator seem to *precede* changes in another indicator over a period of time. The test does not conclusively determine whether X *causes* Y, but it can establish whether changes in population health conditions are leading changes in economic activity in MSAs, or whether these conditions mutually reinforce one another. We used Granger tests to examine relationships over time between:

- Each of the 9 population health indicators we included in our study – self-reported general health (good or better), heart disease, high blood pressure, high cholesterol, obesity, diabetes, self-reported mental health (poor), smoking, and exercise (in the past month); and
- Each of 10 economic activity indicators we included in our study –Gross Metropolitan Product per capita (in real dollars), median household income (in real dollars), labor force participation rates (for the total population, for males, for females, for all parents, for female parents, and for male parents), net establishment creation rate[7], and net job creation rate.

By applying the Granger method, we test whether past values of variable X are statistically significant in their ability to predict future values of variable Y. This test can help to determine the temporal order of changes in indicators, such as those in our study.[8]

To meet our study's aims, we focused on two types of Granger test results:

1. Results that show that past values of a given population health indicator are predictive of future values of a given economic activity indicator. This suggests, though does not "prove," that changes in population health might cause changes in economic activity.
2. Results that show that a given population health indicator and an economic activity indicator mutually reinforce one another. This suggests that, over time, each type of change (health or

[7] The Census Bureau defines an establishment to be "a single physical location where business is conducted or where services or industrial operations are performed." "Net establishments" in a region is the number of establishments created or entering a region minus the number of establishments that close or exit, in any given year. "Net jobs" in a region is the number of jobs that are created in a region minus that number of jobs lost, in any given year. See: https://www.nap.edu/read/11844/chapter/4#33 and https://www.census.gov/programs-surveys/bds/documentation/glossary.html

[8] Some economists call this "Granger causality." However, we refrain from using that term, because the test does not conclusively determine that X causes Y. Conservatively described, it shows that changes in variable X precede and can statistically predict later changes in variable Y

economic) might influence change in the other type. That is, at one point in time, A influences B, but then in the next point in time, B influences A. This makes a lot of sense in light of the interdependencies of population health and economic conditions in metropolitan areas over time.

The tests revealed five instances where population health indicators are predictive of economic activity indicators. The tests also revealed 20 instances where population health indicators and economic activity indicators mutually reinforce one another. The following lists describe these results. [9] Note that the Granger test does not indicate whether the relationship between two indicators is positive or negative; it simply establishes the temporal order of change.

In metro areas, some population health changes are PREDICTIVE of future changes in economic activity.

Changes in the proportion of adults who report exercise in the past month are predictive of future changes in:

- Total labor force participation rate
- Labor force participation rate for males
- Labor force participation rate for females

Changes in the rate of adults with diagnosed high blood pressure are predictive of future changes in:

- Labor force participation rate for females

Changes in the proportion of adults who reported their health as "good" or better (which includes the categories of "very good" and "excellent") are predictive of future changes in:

- Net job creation rate

In metro areas, several instances exist where changes in population health and economic activity are MUTUALLY REINFORCING.

Changes in the proportion of adults who reported their health as "good" or better (which includes the categories of "very good" and "excellent") are mutually reinforcing of changes in:

- Total labor force participation rate
- Labor force participation rate for males
- Median household income (in real dollars)

Changes in the rate of adults with diagnosed heart disease are mutually reinforcing of changes in:

- Total labor force participation rate

[9] For details on the results of the Granger tests, see the Technical Supplement on the Wilder Research website at www.wilder.org/study/linking-health-econ-19.

- Labor force participation rate for males

Changes in the rate of adults with diagnosed diabetes are mutually reinforcing of changes in:

- Labor force participation rate for males who are parents
- GMP per capita (in real dollars)
- Median household income (in real dollars)

Changes in the rate of adults who are obese are mutually reinforcing of changes in:

- Median household income (in real dollars)

Changes in the rate of adults who are smokers are mutually reinforcing of changes in:

- Labor force participation rate for parents
- Labor force participation rate for males
- Labor force participation rate for male parents
- Labor force participation rate for female parents
- Median household income (in real dollars)

Changes in the rate of adults with diagnosed high cholesterol are mutually reinforcing of changes in:

- Total labor force participation rate

Changes in the rate of adults with diagnosed high blood pressure are mutually reinforcing of changes in:

- GMP per capita (in real dollars)
- Median household income (in real dollars)

Changes in the proportion of adults who reported their mental health as "not good" in the last two weeks are mutually reinforcing of changes in:

- Labor force participation rate for females
- Labor force participation rate for parents
- Labor force participation rate for male parents

Digging deeper: Regression analysis

The analyses in the previous sections suggest that relationships exist between population health and economic activity in metro areas. Population health and economic characteristics correlate with one another; some population health characteristics of metro areas are predictive, or mutually reinforcing, with respect to some economic characteristics. Thus, we wanted to dig deeper in our exploration to answer questions such as:

- How do population health characteristics influence economic characteristics of metro areas? For instance, if population health indicators show better health for a metro area, do economic indicators show higher levels of economic activity, or lower? Do population health characteristics of metro areas have a strong, or weak, influence on economic characteristics?
- Might a relationship, if it exists, between a population health indicator and an economic indicator be the result of some third factor? Could something else explain why it appears that specific population health characteristics influence specific economic characteristics? Does A really predict B, or does something else influence both of them?

A procedure called fixed-effects regression analysis can address these questions statistically. We used this form of regression analysis to look more closely at the relationships between population health and economic characteristics in metro areas. The next few pages summarize the regression results. In each regression, the population health indicators were the independent variables and an economic activity indicator was the dependent variable. [10].

In addition, in all of the regression analyses, we took into account the other socio-demographic characteristics of metro areas that might influence population health, economic activity, and the way that population health affects economic activity. We statistically controlled for the following characteristics: the proportion of adults age 25+ who have a college degree; the proportion of the population who are age 65+; the proportion of the population who are people of color; time trend variables (year, year squared); and year 2009 to account for the Great Recession. It was important to account for the influence of these socio-demographic characteristics in order to increase confidence in the validity of any statistically significant relationships that we uncovered.

Metropolitan statistical areas, not individual people, constituted the unit of our analysis. So, for example, where regression results reveal that the rate of heart disease in metro areas has a negative and statistically significant relationship with real median household income in metro areas, this does not mean that individuals with heart disease have lower incomes (although that very well might be true). What the data do show is that, in regions with higher rates of heart

[10] We regressed each of our economic activity indicators on our set of population health indicators and included lags for our independent variables. For more details on the regression analysis and results, see the Technical Supplement on the Wilder Research website at www.wilder.org/study/linking-health-econ-19.

disease, households tend to have less income, even after controlling for other potential influencers of household income.

The following paragraphs describe the relationships between population health indicators and economic activity indicators which seem important based on the combined results of the Granger tests and the regression analyses.

In some instances, population health had a lagged effect on economic activity— sometimes two, four, or six years later. This means that a change in a population health indicator was not associated with a change in an economic indicator during the same year, but that the change in one was associated with change in the other in a later year. The following paragraphs and the accompanying statistical tables (Figures 4 and 5) identify whether an effect was significant and whether it was contemporaneous or lagged.[11]

General health

The results of our fixed effects regression analyses showed that the proportion of the adult population who self-reported their health as "good" or better was positively associated with real GMP per capita. This relationship had a lagged effect; that is, in U.S. metro areas, higher rates of "good" or better self-reported general health were statistically associated with higher GMP per capita four years later.

"Good" or better self-reported general health was positively associated with real median household income. That is, in U.S. metro areas, higher rates of "good" or better self-reported general health were statistically associated with higher median household income. However, with a two-year lag, the effect was opposite: higher rates of "good" or better self-reported health were statistically associated with lower real median household income two years later.

A positive association appeared between "good" or better self-reported general health and the net establishment creation rate for businesses, with a four-year lag. That is, in U.S. metro areas, higher rates of "good" or better self-reported general health among adults were statistically associated with higher net establishment creation rates four years later.

The regression analysis also revealed a positive association between "good" or better self-reported general health and the labor force participation rate. That is, in U.S. metro areas, higher rates of "good" or better self-reported general health were statistically associated with higher total labor force participation. This positive association was also true for both male and female labor force participation rates, independently. Higher rates of "good" or better self-reported health were also positively associated with parents' participation in the labor force, although the effect had a two-year lag.

[11] A lagged effect can be interpreted as in this example: The table shows that self-reported general health has a positive four-year-lagged effect on per capita GMP. This means that when a 1-unit increase in the rate of adults reporting good or better health occurs, four years later the data show higher GMP per capita.

Mental health

The proportion of the adult population that self-reported poor mental health for 14 or more days in the last month was negatively associated with the net establishment creation rate and also real median household income. That is, in U.S. metro areas, higher rates of self-reported poor mental health were statistically associated with both lower net establishment creation rates and also lower median household income.

Heart disease

The rate of heart disease was negatively associated with real median household income. That is, in U.S. metro areas, higher rates of heart disease were statistically associated with lower median household income.

The rate of heart disease was also negatively associated with female labor force participation. That is, in U.S. metro areas, higher rates of heart disease were statistically associated with lower female labor force participation.

The rate of heart disease was positively associated with parents' participation in the labor force, with a four-year lag. That is, in U.S. metro areas, higher rates of heart disease were statistically associated with higher labor force participation four years later. The positive association between heart disease and parents' labor force participation was found to be true for both male parents and female parents independently, also.

Obesity

The obesity rate was positively associated with real median household income, with a two-year lag. That is, in U.S. metro areas, higher obesity rates were statistically associated with higher median household income two years later.

The obesity rate was negatively associated with parents' participation in the labor force. This negative association existed for male parents independently, but was statistically insignificant for female parents. That is, in U.S. metro areas, higher obesity rates were statistically associated with lower labor force participation for parents, and particularly for male parents.

Diabetes

The diabetes rate was negatively associated with real GMP per capita, with a four-year lag. In addition, the diabetes rate had a negative association with the net establishment creation rate four years later, and even more significantly, six years later. That is, in U.S. metro areas, higher diabetes rates were significantly associated with lower GMP per capita and lower net establishment creation rates, but the effects were lagged.

The diabetes rate was positively associated with the parent labor force participation rate, with a six-year lag. That is, in U.S. metro areas, higher rates of diabetes were statistically associated with higher parent labor force participation six years later. The same was true for male parents, independently.

Smoking

The proportion of adults who smoke was positively associated with GMP per capita, with a two-year lag. However, this relationship changed to a negative association after a six-year lag. That is, in U.S metro areas, higher rates of smoking were associated with higher GMP per capita two years later, but lower GMP per capita six years later. One possible explanation is that, in the short run, smoking might have a positive association with GMP per capita due to an income effect: consumption of cigarettes rises when income rises, and so does economic output as a result of more production. However, in the long run, the negative effects of smoking on the quality and quantity of the labor force, due to morbidity, reduce future GMP per capita.

The proportion of adults who smoke was negatively associated with real median household income. That is, in U.S. metro areas, higher rates of smoking were statistically associated with lower median household income.

The proportion of adults who smoke was also negatively associated with the net establishment creation rate and female labor force participation. That is, in U.S. metro areas, higher rates of smoking were statistically associated with both lower net establishment creation rates and lower female labor force participation.

Regression results also showed that the proportion of adults who smoke was negatively associated with net job creation, with a two-year lag. That is, in U.S. metro areas, higher rates of smoking were statistically associated with lower net job creation rates after two years.

Exercise

The proportion of the adult population that reported exercise that occurred at least once in the past month was positively associated with the net establishment creation rate. That is, in U.S. metro areas, higher rates of adults who exercised at least once in the past month were statistically associated with higher net establishment creation rates.

Higher rates of exercise among adults were negatively associated with total labor force participation in the short run. That is, in U.S. metro areas, higher rates of adults who exercised at least once in the past month were statistically associated with lower labor force participation, contemporaneously. However, this association turned positive after a two-year lag. This negative contemporaneous relationship was also true for male labor force participation, independently, but not for female labor force participation, independently.

Figures 4 and 5 summarize the results of our Granger tests and regression analyses combined. In these tables, cells which are gray represent insignificant relationships; cells which are white represent statistically significant relationships in the regression analyses; and cells which are colored represent instances where *both* the relationship was statistically significant in the regression and the Granger test result showed that the population health condition was *either* predictive or mutually reinforcing of economic activity.

The arrows indicate the direction of the correlation coefficient in the regression and the number of asterisks indicate the level of significance in the regression. Recall that, in our regression analyses, we included lags for each of our predictors, to see whether changes in population health had any lagged effects on economic activity. If the population health predictor had a significant lagged effect, it is noted in parentheses.

4. Details of Granger Tests and Regression Analyses Combined (1 of 2)

IN METRO AREAS, HIGHER RATES OF _____ WERE ASSOCIATED WITH…	GMP per capita (real)	Median household income (real)	Net establishment creation rate	Net job creation rate
General health (good or better)	* (4-yr lag) ↑	*** ↑ *** (2-yr lag) ↓	*** (4-yr lag) ↑	
Mental health (poor)		*** ↓	** ↓	
Heart disease		** ↓		
High blood pressure				
High cholesterol				
Obesity		** (2-yr lag) ↑		
Diabetes	*** (4-yr lag) ↓		* (4-yr lag) ↓ ** (6-yr lag) ↓	
Smoking	* (2-yr lag) ↑ * (6-yr lag) ↓	*** ↓	**↓	*** (2-yr lag)↓
Exercise (in the past month)			*** ↑	

↑ Positive associations, ↓ Negative associations

*, **, *** significance levels for these associations: *p < .05; **p < .01; ***p < .001

Insignificant relationships (gray)

O Relationships that are significant in fixed effects regression only (white)

Relationships that are significant in fixed effects regression AND a Granger test result that confirms health is predictive or mutually reinforcing (red)

5. Details of Granger Tests and Regression Analyses Combined (2 of 2)

IN METRO AREAS, HIGHER RATES OF _____ WERE ASSOCIATED WITH…	Labor force participation	Male labor force participation	Female labor force participation	Parent labor force participation	Male parent labor force participation	Female parent labor force participation
General health (good or better)	** ↑	* ↑	** ↑	* (2-yr lag) ↑	* ↑	
Mental health (poor)						
Heart disease			** ↓	*** (4-yr lag) ↑	* (4-yr lag) ↑	*** (4-yr lag) ↑
High blood pressure						
High cholesterol						
Obesity				***↓	*** ↓	
Diabetes				** (6-yr lag) ↑	** (6-yr lag) ↑	
Smoking			** ↓			
Exercise (in the past month)	** ↓ ** (2-yr lag) ↑	** ↓				

↑ Positive associations, ↓ Negative associations

*, **, *** significance levels for these associations: *p < .05; **p < .01; ***p < .001

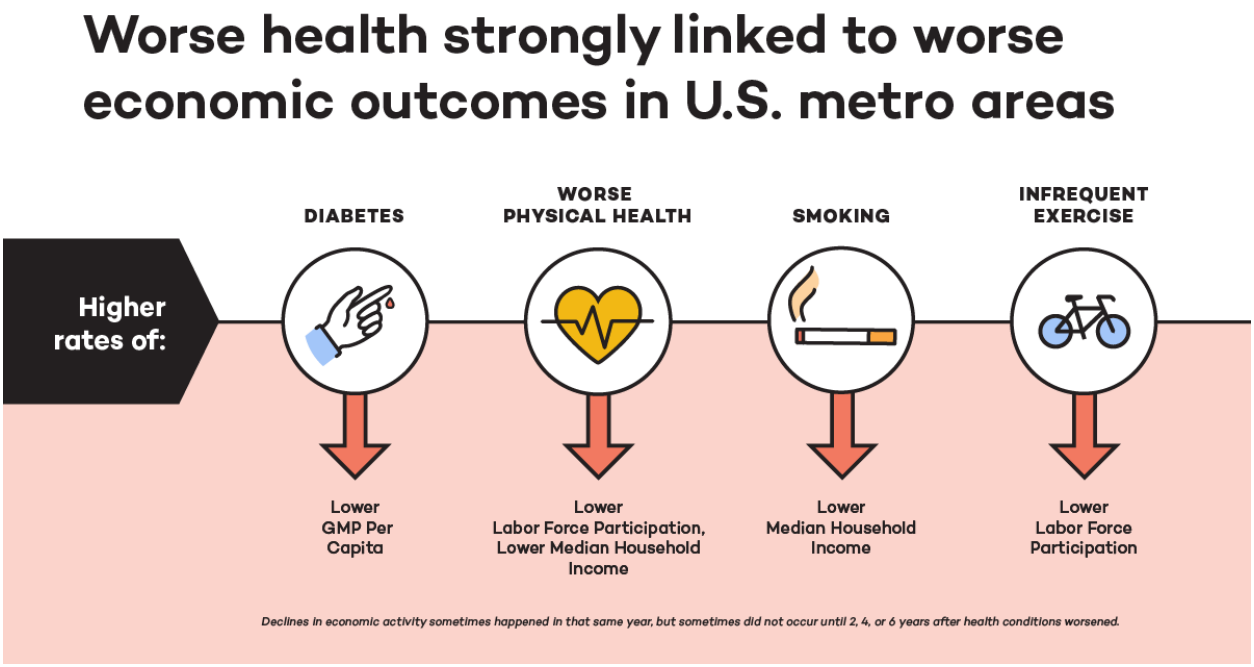
● Insignificant relationships (gray)

○ Relationships that are significant in fixed effects regression only (white)

● Relationships that are significant in fixed effects regression AND a Granger test result that confirms health is predictive or mutually reinforcing (red)

Figure 6 provides a pictorial representation of our Granger tests and regression analyses combined. Where there was a statistically significant relationship in the regression and the Granger test also showed that population health was *predictive* or mutually reinforcing, we would suggest that population health probably does influence economic activity. Note that, in some instances, population health had a lagged effect on economic activity— sometimes two, four, or six years later.) In U.S. metro areas, higher rates of diabetes, worse physical health (as measured by self-reported general health), smoking, and infrequent exercise (as measured by exercise in the past month) are linked to lower GMP per capita, lower labor force participation and lower median household income.

6. Population health and economic activity in U.S. metro areas are linked



Taking a holistic look: Cluster analysis

For this exploratory study, we decided to examine the data in another way beyond the approach described in the preceding sections of this report. We wanted to explore whether, on the whole, metro areas with higher levels of health or economic activity looked different over time in comparison with metro areas with lower levels of health or economic activity.

We placed metro areas into clusters based on their health and economic indicators, and we took two snapshots (one in 2007 and one in 2015) to determine how the relative population health of an area might affect changes in relative economic activity in that area, and vice versa. This type of analysis enabled us to examine the relationship between regional population health and economic activity in a way that differs from regression analysis. Whereas the regression analysis focused on statistical associations between indicators of population health and indicators of economic activity, the cluster analysis places metro areas into groups, taking into consideration both their relative population health and relative economic activity, and then examines how the metro areas in each group change over time. The following paragraphs describe our process and findings.

Forming the clusters

We grouped metro areas into two population health clusters (Better Population Health and Worse Population Health), using eight indicators: self-reported general health "good" or better; rates of heart disease, high blood pressure, high cholesterol, obesity, diabetes, smoking, and exercise (in the past month).

We also grouped those metro areas into two economic clusters (Higher Economic Activity and Lower Economic Activity), with three indicators: real GMP per capita, real median household income, and employment to population ratio[12]. We used the k-means method for our cluster analysis.[13]

Our cluster analysis included only metro areas (n=76) that had complete data in both 2007 and 2015 for the eight population health indicators and the three economic activity indicators that served as the basis for the clustering. We selected those two years because it allowed us to examine changes pre- and post-Great Recession.

---

[12] This indicator differs from the labor force participation rate that we used in the regression analyses. The Technical Supplement on the Wilder Research website at www.wilder.org/study/linking-health-econ-19 contains the rationale for using this indicator.

[13] Note that the cluster analysis does not evenly split areas into two clusters. Rather it groups each area with other areas most similar to it. Also, note that for this analysis we selected subsets of the health and economic indicators which worked optimally to create distinct clusters. For details on the k-means analysis, see the Technical Supplement on the Wilder Research website at www.wilder.org/study/linking-health-econ-19

We cross-classified the metro areas based on the two sets of clusters, which created four categories, as depicted in Figure 7 for both years, 2007 and 2015.

Are the metro areas in these four categories really different?

The cluster analysis statistically sorted the metro areas into different groups. To interpret the results, we need to ask: Do those groups differ meaningfully in their economic and health characteristics? The answer is yes.

In 2007, these differences existed between the clusters, for economic activity:

- Real per capita GMP in the Lower Economic Activity cluster – average was $69,000, compared with $83,000 in the Higher Economic Activity cluster.
- Real median household income in the Lower Economic Activity cluster – average was $39,000, compared with $46,000 in the Higher Economic Activity cluster.
- The employment to population ratio in the Lower Economic Activity cluster – average was 69%, compared with 73% in the Higher Economic Activity cluster.

In 2015, for economic activity:

- Real per capita GMP in the Lower Economic Activity cluster– average $68,000, compared with $89,000 in the Higher Economic Activity cluster.
- Real median household income in the Lower Economic Activity cluster – average $51,000, compared with $62,000 in the Higher Economic Activity cluster.
- The employment to population ratio in the Lower Economic Activity cluster – average 69%, compared with 73% in the Higher Economic Activity cluster.

In 2007, for population health:

- In the Worse Population Health cluster, – average 84% for general health self-reported as "good" or better, compared to 88% in the Better Population Health cluster.
- In the Worse Population Health cluster, – average 9% diabetes rate, compared with 6% in the Better Population Health cluster.
- In the Worse Population Health cluster, – average 20% smoking rate, compared with 16% in the Better Population Health cluster.

In 2015, for population health:

- In the Worse Population Health cluster, – average 83% for general health self-reported as "good" or better, compared to 87% in the Better Population Health cluster.

- In the Worse Population Health cluster, – average 11% diabetes rate, compared to 8% in the Better Population Health cluster.
- In the Worse Population Health cluster, – average 18% smoking rate, compared to 14% in the Better Population Health cluster.

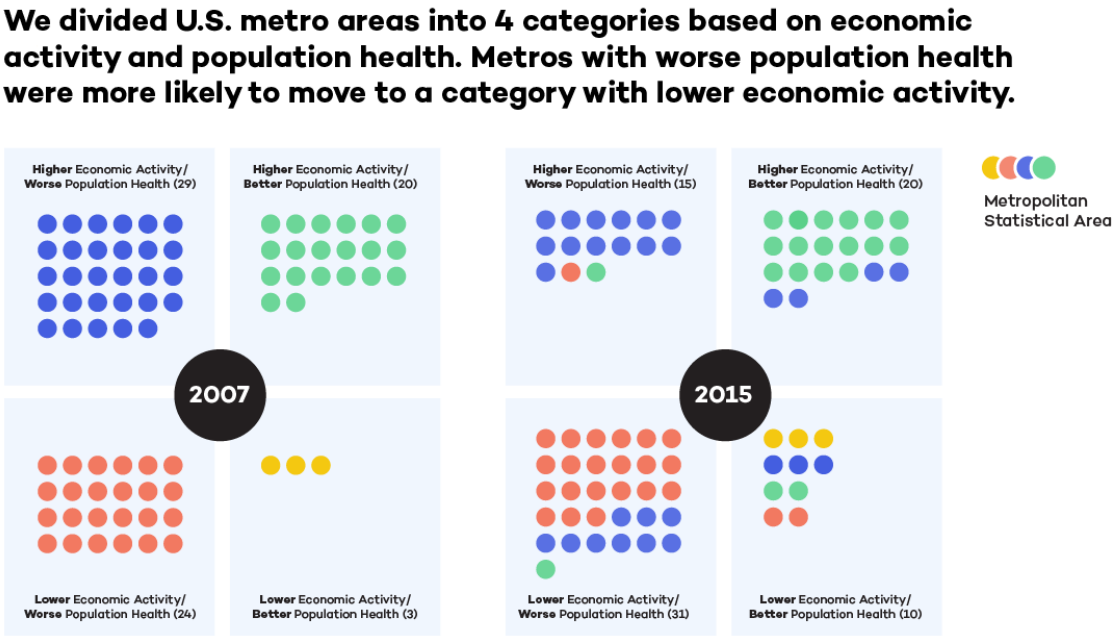
How did metro areas change over time, and what difference did population health make, if any?

As noted earlier, we used the clusters to cross-classify metro areas into four categories based on both the relative population health and the relative economic activity of each area. We labeled these categories:

- Higher Economic Activity / Better Population Health
- Higher Economic Activity / Worse Population Health
- Lower Economic Activity / Worse Population Health
- Lower Economic Activity / Better Population Health

We then examined whether and how the metro areas changed over time. Looking at two snapshots in time, 2007 and 2015, we observed that most metro areas tended to remain in the same category, as Figure 7 indicates.

7. U.S. metro areas categorized by relative population health and economic activity (2007 and 2015)



- Most metro areas that started in the Lower Economic Activity / Worse Population Health category in 2007 appeared in that same category in 2015. That is the "worst" of the four categories, and few areas left it.
- All of the metro areas that started in the Lower Economic Activity / Better Population Health category in 2007 appeared in that same category in 2015.
- Metro areas that started in the Higher Economic Activity / Better Population Health category in 2007 had no better category into which they could move. In 2015, some appeared in a relatively worse position. Four out of 20 appeared in quadrants with lower population health and/or lower economic activity in 2015.
- Notably, one category exhibited more change – and for the worse; 12 of 29 metro areas in the Higher Economic Activity / Worse Population Health category in 2007 appeared in one of the two categories with relatively lower economic activity in 2015.

These shifts are consistent with two notions: worse population health in a metro area region might contribute to deteriorating economic conditions; better population health in a metro area region might offer some protection against economic shocks.

Business survey and headquarters relocation

Do metro areas with better population health attract businesses? We used both quantitative and qualitative data to explore this question.

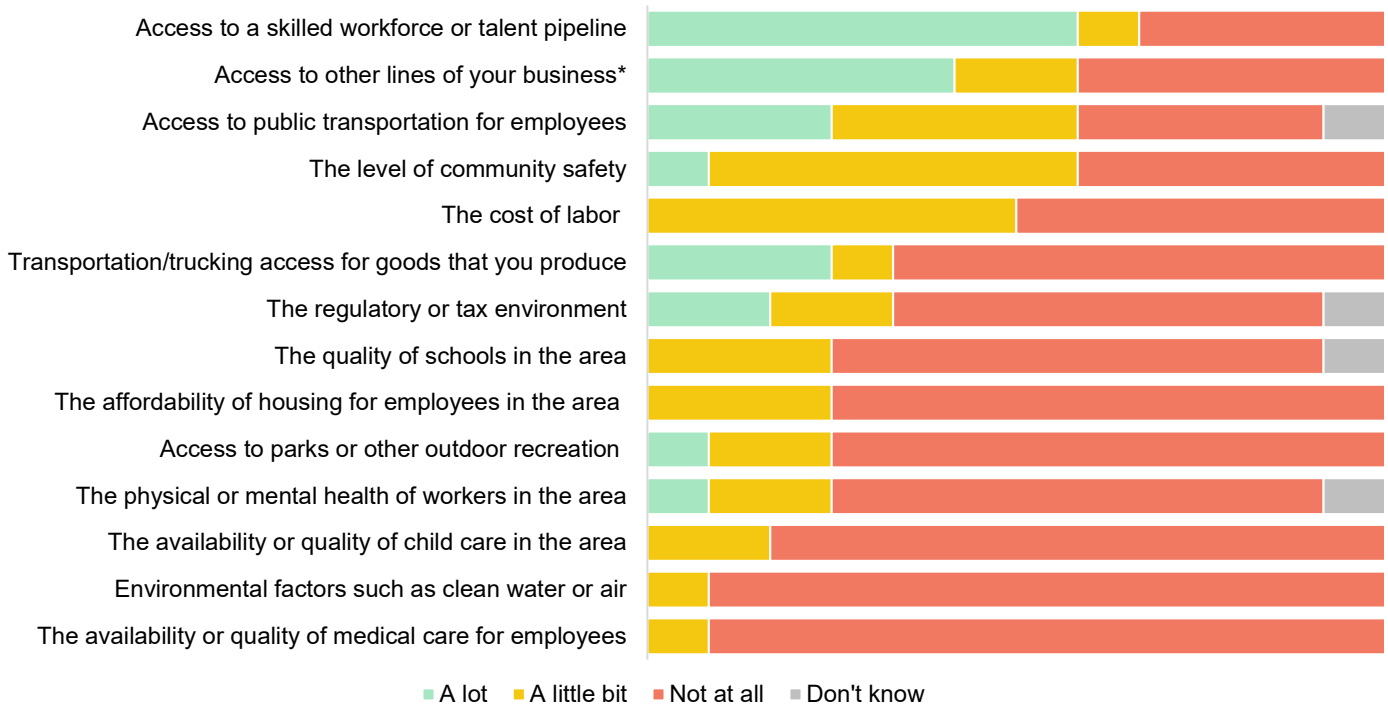
Survey of businesses that moved

To assess the degree to which U.S. businesses actively consider population health in their decision to relocate to, or remain in, a particular MSA, we attempted to find some firms with at least 100 employees in 2018 that made a headquarters move in 2013 (that is, five years earlier). We collected information from 12 firms; different industries in all regions of the country were represented among them. Our respondents rated a list of factors that might have influenced their firm's selection of a new location for its headquarters. [14]

At least half of the respondents included in their decision-making the following factors: access to a skilled workforce or talent pipeline; access to other business lines, such as call centers, distribution centers, and manufacturing and parts centers; access to public transportation for employees; the level of community safety; and the cost of labor. Figure 8 illustrates the relative importance of each factor. Factors related to social determinants of health, population health, and healthcare (the bottom seven factors in Figure 8) were most often rated "a little" or "not at all" when asked about their relative importance in the selection of a location.

[14] To view the full survey instrument, see the Engaging Businesses for Health Study Survey on the Wilder Research website at www.wilder.org/study/linking-health-econ-19.

8. Factors that contributed to selection of location for company headquarters (N=12)



* e.g., call centers, distribution centers, manufacturing & parts centers

Headquarters relocation analysis

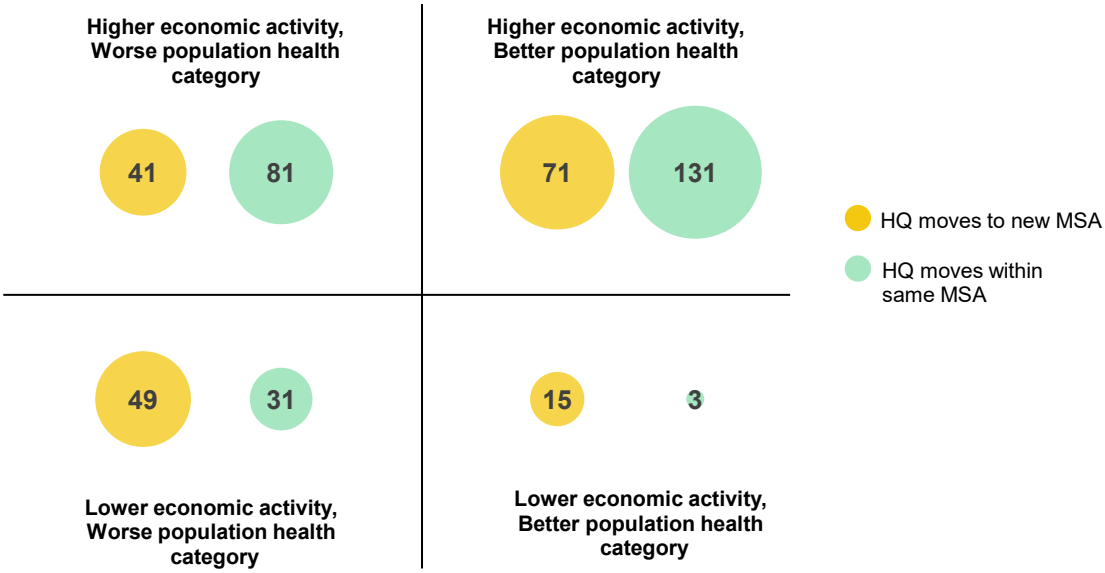
We quantitatively examined the headquarters moves of all U.S. firms that had least 100 employees and a move in 2013 to one of the 76 metro areas included in our cluster analysis using National Establishment Time Series data made available through the Federal Reserve System. These data included 422 headquarters moves and represented 75% of all headquarters moves that occurred in the U.S. in 2013 in this size category. We found that 40% of headquarters moves to a new metro area were to 1 of 20 metro areas that appeared in the "Higher Economic Activity / Better Population Health" category in 2015. Figure 9 provides a pictorial representation of this key finding that emerged from overlay of our headquarters relocation analysis and cluster analysis.

9. Summary of headquarters relocation analysis and cluster analysis combined

The data also showed that 54% of headquarters moves within the same region —those who stayed in the same metro area—were in areas that appeared in the "Higher Economic Activity / Better Population Health" category in 2015. Figure 10 illustrates the destinations of all U.S. headquarters moves by cluster analysis category. [15]

This one-year snap shot of data suggests that both economic activity *and* population health within regions influence the direction of headquarters moves. Additional research can further examine this.

10. Destinations of headquarters moves in 2013 by cluster analysis category



Source: National Establishment Time Series Data 2014, Analysis by Federal Reserve Bank of Minneapolis

[15] For further details on Nets Establishment Time Series data analysis, see the Technical Supplement on the Wilder Research website at www.wilder.org/study/linking-health-econ-19.

Summary and conclusion

This exploratory study provides new evidence that, for metropolitan statistical areas (MSAs) in the United States, some population health changes are predictive of future changes in economic activity. Study results also identify several instances where changes in population health and economic activity in metro areas mutually reinforce one another.

Overall, our research shows that higher rates of morbidity and poor health behaviors in metro areas are linked with a less robust regional economy, as indicated by lower GMP per capita, lower median household income, and lower labor force participation, over time.

Interestingly, increased rates of high blood pressure and high cholesterol, which are often considered markers for increased risk of disease, were not predictive of future declines in economic activity in metro areas. One possible explanation for this is that they are largely "silent" conditions until they progress to morbidity. Additionally, the data only capture adults who have been medically diagnosed, which suggests that they might also be receiving treatment for these conditions.

Key relationships between population health and economic activity include:

- Higher rates of adult diabetes in metro areas are linked with lower GMP per capita.
- Higher rates of adults with a self-reported health rating of "good" or better in metro areas are linked with higher median household income and higher rates of labor force participation for both the total population and for males, independently.
- Higher rates of smoking among adults in metro areas are linked with lower median household income.
- Higher rates of exercise (in the past month) among adults in metro areas are linked with higher labor force participation.

The influence of population health on economic activity sometimes occurred in the same year, but sometimes did not occur until two, four or six years later.

Our findings also suggest that better population health could possibly serve as a protective factor in an economic recession or could help to speed recovery. Looking at two snapshots in time, most metro areas appeared in the same relative positions—in terms of population health and economic activity—in 2015 as they did in 2007. Notably, when change occurred, it tended to occur for metro areas that, in 2007, started in a position with relatively worse population health, and then appeared in a position with relatively lower economic activity in 2015.

Study findings suggest that U.S. businesses might not consciously identify the "health" of a region as a significant criterion in deciding where to locate their headquarters. Nonetheless, a number of U.S. headquarters moves are, in fact, to new locations in metro areas that have both relatively higher economic activity *and* relatively better population health.

Making the business case for investments in population health

Study findings provide a rationale for making the business case for investments in population health. They do so for two key reasons:

- Decreased labor force participation can lead to increased difficulty in finding qualified workers. For businesses, this increases the cost of labor and can limit the ability to expand.
- The diabetes rate in the United States has nearly doubled in the past decade. For businesses, this trend can lead to increases in employer health care costs. The Centers for Disease Control estimates that diabetes costs the U.S. health care system and employers 237 billion dollars a year (American Diabetes Association, 2017).

While our study did not specifically examine how population health affects individual firms, we know that businesses can benefit from improved population health in a number of ways. Better health among a firm's employees and their dependents can improve productivity, reduce absenteeism and reduce health insurance costs. A healthier workforce means that a greater number of potential employees exist for hiring when needed. A healthier population is associated with higher median income and consumers with more purchasing power.

Large scale investments in population health will likely require the development of new incentive mechanisms that could take shape in the form of tax credits, equity funds or other investment vehicles. Presently, business sector investments in community health are largely limited to grants through corporate foundations. This is an important message for policymakers and financial lenders to consider, since they are key stakeholders in creating these types of incentive mechanisms. Actions to address metropolitan area health will likely require collaboration among multiple sectors in those areas in order to succeed.

Issues for future research

The longitudinal data panel that we constructed for this study provides a rich cross-section of 74 indicators related to population health and economic well-being for metropolitan areas, and has much yet to be explored. We plan to make this dataset publicly available to encourage additional cross-disciplinary research.

This study offered several new insights into how changes in population health might influence changes in economic activity, but the results also pose a number of new questions for researchers to consider.

Suggestions for future research, which could make use of the indicators available in the dataset, include:

- Regarding the association between diabetes rates (which has nearly doubled in the past decade) and gross metropolitan product per capita: What are the longer-term implications of a growing diabetes rate for the economy?
- Regarding the association between smoking rates and median household income: What has been the impact of smoking bans and widespread tobacco cessation interventions on household income growth; on income inequality?
- Regarding the association between exercise rates and labor force participation: How do exercise and employment interact?
- Regarding the associations between self-reported poor mental health and economic indicators: How do mechanisms associated with poor mental health influence consumer behavior? Can investments in mental health lead to improved regional economies?
- What is the relationship between the uninsured rate and labor force participation in metro areas? Do states with Medicaid expansion differ from those without?
- What is the relationship between the minimum wage rate and population health in metro areas? Do states with a minimum wage rate above the federal minimum differ from those who are at the federal minimum?
- What is the relationship between housing expenditures and population health in metro areas? Are higher housing costs as a proportion of total household income associated with worse population health?

We look forward to the continued exploration of the relationships between population health and economic activity and encourage readers to contact the authors of this report with questions and ideas.

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Appendix A

Organizing the panel data into metropolitan statistical areas (MSAs): Why and how?

The introductory section of this report briefly offered the reasoning for selecting metropolitan statistical areas (MSAs) as the geographic unit of analysis for this study. This section further describes that reasoning. It also clarifies the distinction between static and dynamic definitions of MSAs, and it describes how, for some indicators, we needed to convert or assign the data from other types of geographic units to a metropolitan statistical area.

MSAs, which the U.S. Office of Management and Budget delineates, provide a set of geographic regions defined in a consistent manner, to allow for data collection, analysis, and reporting that compares like with like (Bureau of Labor Statistics, 2018). They demarcate geographies of 50,000 inhabitants or more that have a "high degree of social and economic integration," largely based on commuting ties between counties and a central core (United States Census Bureau, 2018).[16] In contrast to the somewhat arbitrary borders of a county or state, MSAs reflect residents' patterns of life and interaction within a given geographic area.

Regarding the status of MSAs as economic hubs, most economic activity in the United States occurs in MSAs. The Brookings Institution notes that in the U.S., metropolitan areas generate the majority of their state's economic output in 47 out of 50 states (Berube & Nadeau, 2011). In fact, some states, including Arizona, California, Maryland, and New York, have at least 95% of their GDP generated from metropolitan areas (Berube & Nadeau, 2011). About 90% of exports from the United States are generated by companies located in MSAs (Bullard, 2017). In 2017, the total gross domestic product for all MSAs comprised about 90% of the total GDP of the United States (The United States Conference of Mayors, 2018).

Regarding the status of MSAs as population hubs, most residents of the United States live in MSAs. In 2015, about 86% of the population in the United States lived in MSAs – including 89% of working-age people with post-secondary degrees, and 93% of people employed in science and engineering (Berube & Nadeau, 2011). Clearly, metropolitan areas comprise large containers of human capital.

Because of population shifts toward urban places in recent decades, and due to the economic significance of metropolitan areas, one could argue that metropolitan areas constitute more meaningful and relevant units of analysis now than ever before (Lindner, 2018).

[16] For details on the definition and delineation of MSAs, see: Office of Management and Budget (2010), "2010 Standards for Delineating Metropolitan and Micropolitan Statistical Areas."

In addition, analysis of MSAs allows for comparisons across consistent units, thus diminishing the noise of comparing counties, of which the United States has more than 3,000.

This study uses a dynamic definition for each Metropolitan Statistical Area included. MSA data for each year represent the MSA as defined by the U.S. Office of Management and Budget in the year in which data collection occurred.[17] Therefore, the number of counties and the land area encompassed by a specific MSA during the time of our study could change. In fact, many did increase in size in those two respects. The alternative, a static definition of an MSA, defines an MSA as the counties that comprise it in one year of a study; aggregated data for the MSA include the data solely from those counties during the entire course of the study. Both approaches have their pros and cons.

We chose to use a dynamic definition, rather than a static definition, because the dynamic definition better captures true variation in economic activity and health within a geographic region (that is, an MSA) over time, without the constraints of political boundaries. Since the population of most MSAs tends to grow in numbers and disperse spatially over time, we felt that the measurement of health, economic characteristics, and other features of an MSA's population should reflect, as closely as possible, the attributes of that MSA as it evolves. Measurement of health, economic characteristics, and other features of an MSA's population should not reflect a mix of people, some of whom reside within the MSA and some of whom do not.

As a practical matter, some data sources that fed into the panel dataset created for this study contain information commonly aggregated at the MSA level. (Of particular note is the BRFSS SMART data set, which provides weighted data at the MSA level from 2002 to 2015.[18]) For data available only at the county level, panel construction included procedures to aggregate those data to the MSA level.

Policy data included in the panel offered a special challenge since legislation usually applies to entire states. For this study, state-level policies became attributes of the MSA(s) bounded within that state. For example, Louisiana's minimum wage is assigned to the MSAs of Baton Rouge, Lafayette, and New Orleans-Metairie. For any MSA that crosses state boundaries, the policy of the state with the largest population share became an attribute of that MSA. For example, 77% of the population in the Memphis, TN-MS-AR metro area lives in Tennessee, so Tennessee's minimum wage was assigned to that MSA.[19]

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[17] The Office of Management and Budget analyzes Census data every decade to update statistical area delineations; it has been doing so since the 1950 Census.

[18] For BRFSS weighting procedures, see: https://www.cdc.gov/brfss/annual_data/2014/pdf/Weighting-Data.pdf

[19] Policy data analysis is not included in this report, but will be the subject of other reports. We make note of our procedure for the benefit of other researchers who might use the dataset.

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