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journal homepage: [www.elsevier.com/locate/ypmed](http://www.elsevier.com/locate/ypmed)

## Short Communication

## Risk factors associated with multiple correlated health outcomes in the 500 Cities Project

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## ARTICLE INFO

## Keywords:

Chronic disease  
Multiple outcomes  
Risk factors  
Unhealthy behaviors  
Preventive services

## ABSTRACT

Reducing chronic disease is a major health challenge. Risk factors for chronic diseases are often studied at the individual level, even though interventions and policies may be implemented at the city level. We use an ecologic study design with city-level data, to simultaneously assess the relative impact of unhealthy behaviors and preventive care measures on multiple chronic disease health outcomes. We analyze a newly available, large national dataset called the 500 Cities Project. We examine the associations between city-level prevalence of unhealthy behaviors, clinical preventive service use, and all chronic disease health outcomes in 500 of the largest U.S. cities for year 2014. After adjusting for age and demographic characteristics, using MANOVA we found that the top three risk factors for all health outcomes are smoking (Pillai's trace = 0.95, approx.  $F = 688.7$ ,  $p$ -value < 0.0001), lack of physical activity (Pillai's trace = 0.91, approx.  $F = 380.0$ ,  $p$ -value < 0.0001) and binge drinking (Pillai's trace = 0.91, approx.  $F = 348.8$ ,  $p$ -value < 0.0001), which are statistically significant after adjusting for multiple comparisons. Higher prevalence of an annual dental checkup, a preventive service use measure, is correlated with lower prevalence of several chronic diseases such as diabetes (correlation coefficient  $r = -0.88$ ), poor physical health ( $r = -0.91$ ), stroke ( $r = -0.85$ ), cardiovascular disease ( $r = -0.83$ ) and poor mental health ( $r = -0.82$ ). Identifying important chronic disease risk factors at the city-level may provide more actionable information for policymakers to improve urban health.

## 1. Introduction

Reducing chronic disease is a major health challenge. Nearly half of Americans have at least one chronic disease, while a quarter of Americans have multiple chronic conditions (Ward et al., 2014). These conditions can have detrimental impacts on many aspects of daily life, including health, work, quality of life and function. It is known that several risk factors related to unhealthy behaviors, collectively termed the SNAP (Smoking, Nutrition, Alcohol and Physical activity) risk factors (Fine et al., 2004; Noble et al., 2015), are strongly associated with preventable causes of morbidity. Meanwhile, several clinical preventive services, such as an annual physical checkup, cholesterol screening and colon screening, can be protective against chronic conditions. However, risk factors for chronic diseases are often studied at the individual level, not at the city level, even though interventions and policies may be implemented at the city level.

In this article, we use an ecologic study design with city-level data to explore the relationship between prevalence measures of unhealthy behaviors, clinical preventive service use and health outcomes using the

500 Cities Project. The 500 Cities Project is a newly available dataset that provides city-level small area estimates for 497 of the largest U.S. cities for year 2014 (Scally et al., 2017; <https://www.cdc.gov/500cities/>, 2016), plus 3 other smaller cities to ensure inclusion of cities from all 50 states. Together, these cities have a total population of 103,020,808, representing approximately 33.4% of the total U.S. population. The populations of the different cities range from 42,417 in Burlington, Vermont to 8,175,133 in New York City, New York. Prevalence measures for these 500 cities are based on information from their corresponding census tracts (> 28,000 in total) (<https://www.cdc.gov/500cities/>, 2016). There are between 8 and 2140 census tracts per city, and in general, census tracts average about 4000 individuals ([https://www.census.gov/geo/reference/gtc/gtc\\_ct.html](https://www.census.gov/geo/reference/gtc/gtc_ct.html), 2018). The CDC chose a set of thirteen health outcomes to be included in the 500 Cities Project, because they believe these outcomes represent chronic disease priorities, and are the most common, costly, and preventable health outcomes (<https://www.cdc.gov/500cities/>, 2016). It is possible that these health outcomes may have potentially contrasting etiology, and that unhealthy behaviors and

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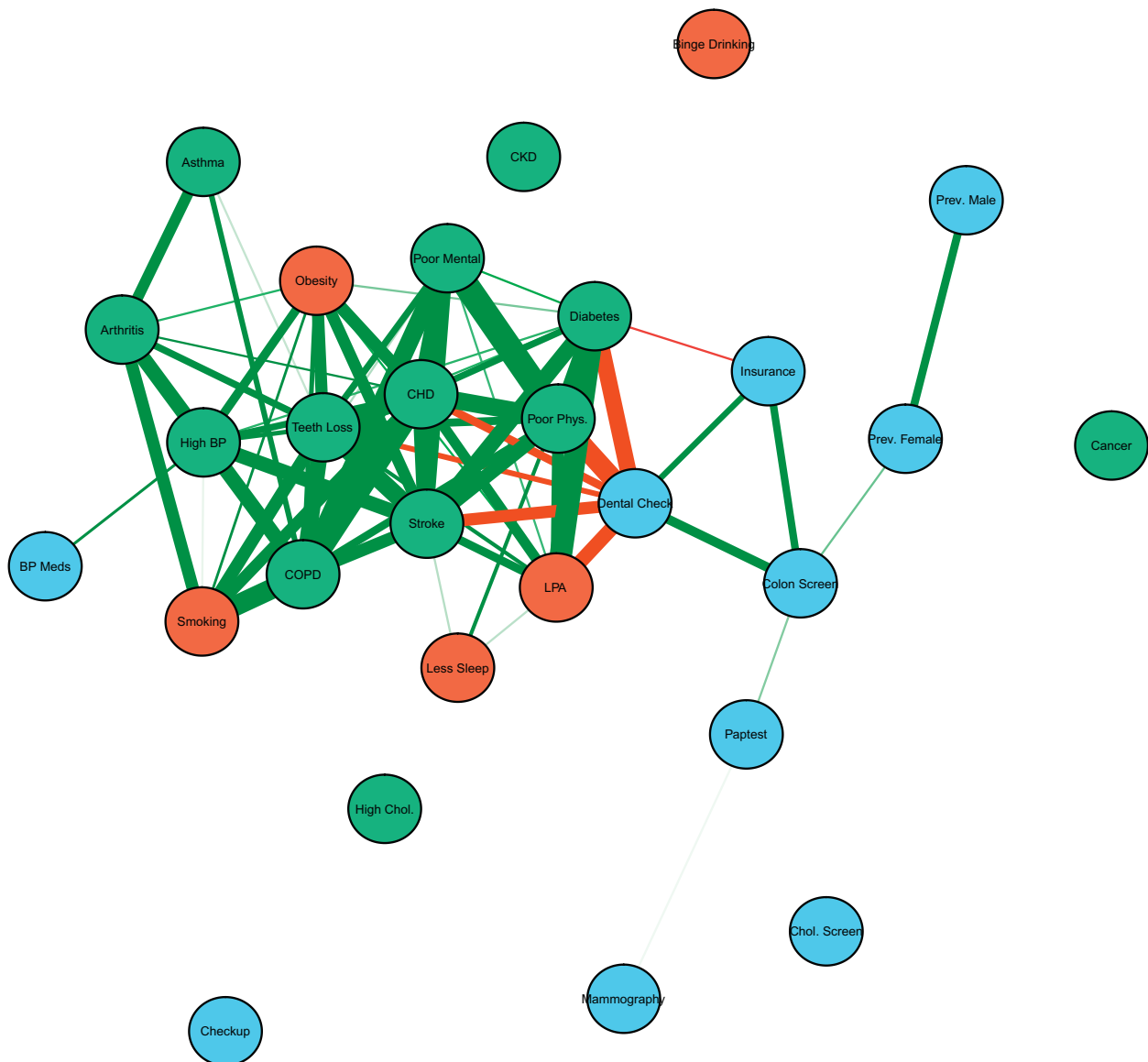


Fig. 1. Associations between unhealthy behaviors, prevention measures and health outcomes. Only  $|r| > 0.75$  is plotted; thicker lines indicate stronger correlation; green indicates a positive association; red, negative association. Unhealthy behaviors are colored in red circles; prevention measures, in blue circles; health outcomes, in green circles. Data is from the 500 Cities Project, which contains US city-level data from 2014. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

preventive care factors may affect each health outcome differently. However, our goal is to show at the city level, the potential impact of unhealthy behaviors and preventive care towards the overall burden of chronic disease health outcomes.

A key difference between our approach and that of previously reported literature on risk factors of chronic disease, is that we investigate these associations at the city-level, not the individual-level. Specifically, we seek to simultaneously assess the relative impact of different unhealthy behaviors and different clinical preventive service use measures on multiple chronic disease health outcomes. We use network analysis to visualize the correlation between prevalence of unhealthy behaviors, clinical preventive service use, and health outcomes at the city level. We also use multivariate analysis to identify risk factors associated with all health outcomes.

## 2. Methods

### 2.1. Sample

Data from the 500 Cities Project contains city-level adjusted prevalence of unhealthy behaviors, clinical preventive service use, and health outcomes. City-level prevalence is adjusted for age, race/ethnicity, sex, education, and county-level poverty (<https://www.cdc.gov/500cities/>, 2016). Data from the 500 Cities Project is based on adult samples (age  $\geq 18$  years, unless otherwise noted) from the Behavioral Risk Factor Surveillance System (BRFSS), a nationally representative self-reported health surveillance survey (<https://www.cdc.gov/500cities/>, 2016).

### 2.2. Unhealthy behavior covariates

We include five measures on unhealthy behaviors (Scally et al., 2017; <https://www.cdc.gov/500cities/>, 2016): *Binge drinking* ( $\geq 5$

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