The Tomassi Essay

PEDALING AND PUBLIC HEALTH: EVALUATING A PROPOSED BIKE-SHARE PROGRAM IN PHILADELPHIA FROM A PUBLIC HEALTH PERSPECTIVE

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INTRODUCTION

Transportation infrastructure, policies, and programs are intimately related to public health. They can provide mobility and access to resources and services such as health clinics, grocery stores, and parks. They can provide or deny opportunities for individuals to work physical activity into their daily lives. They can actively promote or passively discourage the development and use of cleaner, more energy efficient technologies. In the United States, the automobile has long been the transportation mode of choice, and this has had considerable implications for public health. Asthma rates have increased across the country,[1] as have incidences of obesity and obesity-related chronic illnesses.[2]

As the public grows increasingly aware of these concerns, and of the environmental impacts of automotive pollution, planners and policymakers have devoted greater attention to alternative forms of transportation. Bike-share programs, prominent in Europe but still emerging in the United States, offer one such alternative, a form of non-motorized public transportation for individual use in cities. Through these programs, individuals are able to access a network of bicycles, generally docked at stations throughout

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the city, usually after paying some sort of membership fee. A member can then acquire a bicycle from one location and ride it to another, where he or she can leave it for the next user to pick up, and ride to his or her destination of choice. Bike-share programs thus provide infrastructure that encourages a shift away from exhaust-producing vehicles and towards active transportation[3]—that is, walking or bicycling—as a basic way of getting around.

As bike-sharing spreads to a variety of cities across the U.S. and Europe, many of the stated goals of such programs have remained relatively consistent irrespective of location. These include considerations at the global, national, and city level. Scholars taking a national or global perspective often focus on the potential for such programs to reduce carbon emissions and improve environmental sustainability within the United States, thus reducing the country's contribution to global climate change.[4,5] More localized arguments for bike-share programs emphasize the programs' capability to not only reduce vehicle emissions,[6] but also reduce traffic congestion and transportation costs,[7,8] promote the use of public transit by offering a solution to the first/last mile problem,[9] and enhance the general livability of cities.[10,11] In addition, some proponents have pointed to individual benefits, including increased access to mobility[12] and physical activity.[13]

Philadelphia is one U.S. city in which the idea of bike-sharing has gained considerable ground. In 2010, just two years after the advent of the country's first city-run bike-share program emerged in Washington, D.C.,[14] the City of Philadelphia released a report that announced the implementation of a bike-share program in Philadelphia to be feasible and provided a proposal outlining what exactly such a program would entail. As has been the case with other such proposals in the United States, the program's advocates have cited the improvement of public health as an important

incentive for the program's implementation.[15,16,17] However, the proposal fails to offer a comprehensive understanding of how the program is expected to improve public health, and whose health it is expected to improve—that is, it does not discuss the distribution of the costs and benefits of the program with respect to health.

This thesis represents an attempt to fill this gap. In this paper, I will investigate whether the bike share program proposed for Philadelphia, which is still in the early stages of conceptualization and planning, should be expected to positively impact public health in the city, and highlight some aspects of the program expected to influence its effectiveness as a public health program. I will begin by providing an overview of the program proposed for Philadelphia. I will then review some of the existing literature investigating the relative costs and benefits of active transportation with respect to public health. This literature review will be used to determine whether a program designed to promote active transportation can be expected to positively affect public health. Following this, I will conduct a series of statistical analyses to determine which geographical areas and sociodemographic groups suffer most from the health conditions most often associated with physical inactivity, and whether they might be likely users of a bike-share program. I will conclude by highlighting the implications of this thesis for the development of the Philadelphia program.

Bike-sharing in Philadelphia

I have chosen Philadelphia as the geographical focus of this project for two reasons. The first concerns the state of public health in Philadelphia, which is surprisingly poor compared to that of other large cities in the United States and other counties in Pennsylvania, especially with respect to physical inactivity.[18] This thesis reflects a belief that public health needs to become a greater priority in Philadelphia,

and that every project undertaken by the city with the potential to impact public health should thus be evaluated from that perspective. Furthermore, the proposed bike-share program for Philadelphia is still in the early phases of development, indicating that there is an opportunity to raise awareness among policymakers and planners involved in the process as to the program's potential effects on health. Thus, the potential impact of a study such as this on a bike-share program in Philadelphia, coupled with my own proximity to and familiarity with the city, makes Philadelphia an ideal city on which to focus my analysis.

Urban planners and researchers expect that a bike-share program would be enthusiastically received in Philadelphia, especially given the current support of the public and institutional sectors and the city's high population and employment densities.[19] Research focusing on active transportation across the United States suggests that Philadelphia may be an especially good city for bike-sharing. One study found that within the United States, active transportation is more common in "older cities with mixed land use (having residential, commercial, and civic buildings interspersed), sidewalks, and well-developed transit systems," such as Philadelphia.[20] The Philadelphia Bikeshare Concept Study, conducted by JzT1 and Bonnette Consulting in collaboration with the Delaware Valley Regional Planning Commission (DVRPC) for the City of Philadelphia in 2010, offers additional evidence for this assertion, claiming that the differences in mode share—the breakdown of the types of transportation used for daily trips—between comparatively older large cities in the United States, including Philadelphia, and European cities in which bike-sharing has already proven successful, are much smaller than are national differences.[21]

The authors suggest that a program in Philadelphia should begin with the deployment of approximately 1,750

bikes in the most densely populated and multi-use developed core of the city, identified as the "core market area," which would contain twenty stations per square mile, each with around fifteen bikes.[22] Because students are expected to be frequent users of the program, it is important that this area encompasses not only the majority of Center City, but also the campuses of the University of Pennsylvania, Drexel University, and Temple University.[23] The core and expanded market areas are estimated to cover approximately 6.5 percent and 21 percent of Philadelphia's population, respectively.[24,25,26] The authors of the study anticipate that after the implementation of a program in this region, bike-sharing could be expanded along the northern, southern and western borders to include more residential neighborhoods, where it is recommended that "bikes be strategically distributed according to a general accessibility-based standard, specifically that all residents should be within a ten minute walk (around 1250 feet) of a bikeshare station."[27] Figure 1, available in the online edition of this publication, provides a map of the program's proposed core and extended market areas. Based on an estimated capital cost for the system of between $1,000 and $3,000 per bicycle,[28] the cost of the initial implementation of this program is projected to fall between $1.75 million and $5.25 million. Ultimately, however, the program's implementation and success will depend on the acquisition of sufficient funding for the construction and maintenance of program facilities, the improvement of biking infrastructure in the city, and the implementation of marketing and education campaigns.[29] Safety should also be a key consideration for both infrastructure improvements and education campaigns, as a lack of adequate attention to safety issues "could result in initial skepticism about the applicability of the concept, and/or denouncing of the program as a public liability."[30] Although this analysis does not directly address either the

safety features of the program or the process of educating its potential users, it is essential that planners dedicate time and resources towards the elucidation of key methods for optimizing the program's safety. To do so, they might consider looking to techniques employed by other city-wide programs, such as Capital Bikeshare in Washington D.C.

Any city hoping to implement a bike-share program, especially in North America, must address the issue of liability, which can create a severe barrier to program implementation. This is because, unlike citizens in many countries that have implemented bike-share programs, those in the United States cannot currently rely on comprehensive national insurance coverage.[31] Capital Bikeshare in Washington D.C. has opted to employ a web-based liability waiver, which requires individuals to assume responsibility for the risks involved in riding before they are permitted to access a bicycle.[32] In addition, as recommended by DeMaio, the program has set a minimum age requirement; all users must be at least sixteen years old to register for a membership.[33] The Philadelphia Bikeshare Concept Study also mentions this as a possible liability scheme, but warns that "the City could still be held liable in various situations."[34] Although the authors recommend that lawyers and insurance providers be consulted on the matter, they do offer a few liability alternatives, including the acquisition of insurance coverage through a transit operator, a non-profit-organization, or the vendor or operator hired to manage the program, though they warn that none of these alternatives would be guaranteed to protect the city from all liability.[35]

Effective marketing strategies and the development of education and infrastructure to promote safety will also be essential to the success of the program. In order to maximize the potential public health benefits of the program, it is especially important that it is marketed in such a way as to encourage the participation of a wide variety of users, rather

than only those who already ride a bike,[36] This can be done in a variety of ways and should influence decisions regarding the utilitarian and aesthetic design of the bikes, the placement of stations, and the cost and payment structures.

Educational campaigns should focus on teaching the public about the effects of bike-sharing on congestion, pollution, and social equity, and on promoting safe use of the program.[37] Educators can promote safety through both workshops and the strategic design and placement of advertisements and signage at the bike-share stations.[38] They should provide information regarding both lawful use of the bike-share system and methods for coordinating multiple modes of transportation on a given street.[39] Safety should also be addressed through changes in infrastructure. According to Bassett et al, the discrepancy between rates of active transportation in Europe and the United States can in part be attributed to the presence of safe and convenient walking and biking infrastructure in Europe, such as traffic calming measures in residential areas and highly visible signage and roadway markings.[40]

ACTIVE TRANSPORTATION AND PUBLIC HEALTH

Arguments in favor of bike-share programs generally assume a connection between active transportation and health, and often frame this connection as a core motivation for the implementation of these programs.[41] Proponents of bike-share programs have good reason to call upon such arguments, which have received support from many public health researchers: Pucher and Buehler have even claimed that "there is a consensus on the need to increase daily walking and cycling levels to promote public health."[42] Despite these seemingly straightforward imperatives, an in-depth consideration of bike-sharing and health must include a discussion of the relative costs and benefits associated with cycling as active transportation and of the overall effects that

those costs and benefits produce. In the following section, I will review the literature discussing the health benefits and costs of cycling for active transportation, as well as their combined effect. I will then briefly consider the implications of these effects for the proposed bike-share program in Philadelphia. I should, however, emphasize that the health effects discussed here are exclusively preventative, rather than curative, except with respect to clinical depression.[43] Active transportation may protect individuals from developing health conditions such as obesity, high blood pressure, and diabetes, but it is unlikely that it alone could serve as effective therapy for individuals already suffering from such conditions. Moreover, it is likely that these conditions would serve as additional barriers preventing the individuals they affect from becoming physically active.

The benefits of physical activity in general for mental and physical health have been well established,[44,45,46,47,48] and studies have now shown that for previously sedentary adults, engaging in active transportation on a daily basis can be as effective for lowering blood pressure and improving cardiovascular health as more structured physical activity.[49] Although active transportation includes both biking and walking, there is evidence that cycling is more likely to provide the cardiovascular intensity necessary to have a significant effect on cardiovascular health and may thus have greater overall health benefits.[50] Furthermore, many studies connecting active transportation to health have focused on the potential for the types of physical activity associated with active commuting to protect against the development of certain chronic diseases. The particular health benefits most often associated with increases in active transportation include reduced risks for the development of obesity, diabetes, cardiovascular disease, and mental health conditions.

Pucher et al investigated the protective effects of active transportation with respect to obesity and diabetes, and followed Bassett et al in suggesting that the disparity in obesity rates between the United States and Europe may in part be explained by the relatively high rates of both active transportation in Europe and automobile use in the United States.[51,52] In addition, Pucher et al found that within the United States, citizens' likelihood of using active transportation in their commute could account for over half of state-level variation in diabetes prevalence and physical activity.[53] The results of this study should be viewed cautiously, because the researchers did not control for potential confounding variables such as differences in socioeconomic or educational status, or access to health and healthy food services among individuals who do and do not bike as a form of transportation. However, other studies with tighter controls, such as that by Gordon-Larson et al, have also reported an association between active transportation and a reduction in obesity in men.[54]

The cardiovascular benefits from active transportation include reductions to cardiovascular mortality and to the risk of developing coronary heart disease, stroke, and hypertension.[55] In 2009, a study conducted among young adults in the United States—which controlled for sociodemographic factors such as age, race, income, and education, as well as health behaviors such as smoking and alcohol consumption—demonstrated a positive relationship between active transportation and overall fitness in men and women.[56] They also reported reductions in specific risk factors for cardiovascular disease, such as body mass, obesity, blood pressure, and triglyceride and insulin levels, among men.[57]

Though these findings may suggest that active transportation yields greater benefits for men than for women, Hamer and Chida's meta-analysis of eight studies

examining the association between active transportation and cardiovascular health suggests otherwise. These researchers found that active transportation, independent of other forms of activity, reduced cardiovascular risk by 11 percent overall, and provided women with additional protection.[58] Overall, these results suggest that active transportation can act to prevent cardiovascular disease and mortality in both sexes.

Although there has been comparatively little research on the relationship between active transportation and mental health, much of the existing literature points to a positive association between the two.[59] In 2011, a study conducted in Sweden noted that when compared to active commuters, those traveling to work via automobiles or public transportation were more likely to suffer from stress, sleep disturbance, exhaustion, and negative perceptions of their own health.[60] Furthermore, after controlling for job stress, occupational physical activity and age, Ohta et al found a correlation between engagement in active transportation for at least thirty minutes and improvements to mental health status among Japanese men.[61] Although this study did not find a significant relationship between active transportation and mental health status in women, an Estonian study of women aged 18-45 demonstrated that "even a low amount of physical activity…is related positively with women's mental health."[62] Studies focusing specifically on the connections between physical activity and clinical depression have reported positive results as well. Carmacho et al reported an association between even moderate physical activity and a reduced risk for depression among adults in Alameda County, which was evident even after controlling for sociodemographic and behavioral factors such as age, income, race, education, and physical disability.[63] It has even been suggested that physical activity may also be an effective manner of treatment with respect to clinical depression.[64]

The connections between respiratory health and bicycling as active transportation are complex, and will be discussed here from two different perspectives: that of the cyclists, and that of individuals living near roadways. For individuals living near roadways, a shift away from motorized forms of transportation is likely to positively affect respiratory health. The health impacts of exposure to near-roadway emissions have been well documented, and include increased risk for childhood asthma[65] and lung cancer,[66] as well as reduced cardiovascular health[67] and pediatric lung function.[68] Each of these studies has controlled for socioeconomic factors and health-related behaviors, and together suggest that exposure to vehicle emissions increases the risk of developing many chronic conditions. This indicates that active transportation, as an alternative to motorized modes of transportation, could have a positive effect with respect to respiratory health by reducing the risks from exposure to vehicle emissions. It is unlikely that a shift towards non-motorized transportation within a city, or even a part of a city, will have a substantial impact on overall exposure to air pollution, but it may decrease the exposure of those living near major roadways to vehicle emissions as a result of reduced automobile traffic.

Although a shift from motorized transportation to cycling has potential benefits for respiratory health at the population level, the act of cycling may itself be a risk factor for exposure to vehicle emissions on an individual level. Especially in the United States, where bike lanes are more often incorporated as part of the road than separated from motor vehicle traffic, cyclists are likely to breathe in exhaust from nearby vehicles, especially carbon monoxide and smog.[69] This has been illustrated by a study conducted by Zuurbier et al in the Netherlands, which found that individuals using all modes of transportation were exposed to concentrations of a variety of vehicle-related pollutants

significantly higher than "urban background concentrations."[70] The authors found that cyclists were exposed to lower concentrations of particulate matter and soot than were bus riders and motor vehicle occupants, but they also reported that because they were engaging in physical activity, cyclists experienced an increased ventilation rate per minute, and as a result inhaled greater doses of all pollutants measured.[71]

The health effects of this increased inhalation of pollutants remains relatively uncertain. The effects of long-term exposure to vehicle emissions have been well elucidated, but cyclists' exposure varies from that of individuals living in proximity to major roadways in that it is limited to the time in which they are cycling and "is characterized by large short-term variability of concentrations, probably related to emissions from individual vehicles."[72] A study conducted by Strak et al specifically examining the effects of cyclists' exposure to particle emissions suggested that such exposure might affect respiratory health, though the study did not report any statistically significant results.[73]

The risk of injuries, primarily from collisions with motor vehicles, constitutes another major concern with respect to the health impacts of cycling. As Beck et al have noted, bicyclists and pedestrians face a greater risk of fatal injuries on any given trip than motor vehicle occupants .[74] As a result of these findings, the authors suggest that a shift from the use of motorized vehicles to active transportation "could result in an overall increase in the numbers of people killed in traffic."[75] It is here that studies focusing on the risks faced by individual bicyclists and those examining the fatalities of the population of cyclists lead to diverging conclusions. In an examination of the risk of collision faced by individual cyclists, Jacobsen found that increasing the number of cyclists on the road results in a decrease in the

risk of collision for any given cyclist.[76] He explains these findings by linking the increase in visibility of cyclists to an enhancement in drivers' awareness of cyclists and modifications in their behavior to accommodate those cyclists.[77] However, Beck et al point out that despite the decrease in individual risk, the total number of fatalities may increase simply due to the increased use of a higher-risk mode of transportation.[78]

Although there have been studies dedicated to comparing the relative risks and benefits of cycling in various European cities, research on this subject is very limited in the United States. Research conducted in Barcelona[79] and Utrecht[80] suggests that the health benefits of cycling outweigh the risks. However, cyclists' risk of fatal collisions is higher in the United States than in either Utrecht or Barcelona. While Beck et al report that cyclists in the United States are 2.3 times more likely than motor vehicle occupants to become fatally injured on any given trip,[81] Rojas-Rueda et al found bicyclists in Barcelona to be only 1.0007 more at risk than motor vehicle occupants.[82] In addition, de Hartog et al declared the Netherlands to be "one of the safest countries in terms of fatal traffic accidents."[83] This discrepancy presents a barrier to directly applying these results to the United States.[84]

Despite the geographical variation in the risk values associated with cycling, the general formulas used to assess the overall relationship between risks and benefits are valid in any geographical setting. The risks and benefits in the United States can thus be assessed by applying the relative risks of fatal accidents for cyclists in the United States to the overall formula presented by de Hartog et al in their cost-benefit analysis for the Netherlands, calculated through a review of the literature on physical activity, air pollution, and traffic accidents.[85] In 2003, Pucher and Dijkstra reported that in the United States, cyclists faced risks 3.6 times higher per

100 million kilometers than in the Netherlands.[86] de Hartog et al predicted that among the 500,00 individuals expected to shift from automobile to bicycle use in the Netherlands, the total gain in life years from physical activity would be 337,896 years, and that the losses due to exposure to air pollution and collisions would be 28,135 and 9,639 years respectively.[87] By multiplying the years lost by 3.6, I estimate that the expected benefit-to-cost ratio of such a shift in the United States would be approximately 5.4, indicating that programs designed to promote bicycling could function as public health initiatives in the US.

Insofar as they promote active transportation, the evidence presented here suggests that bike-share programs will positively contribute to public health. Rojas-Rueda came to a similar conclusion in their 2011 analysis of the health impact of the Bicing program in Barcelona. They conclude that from a health perspective, "low cost public bicycle sharing systems aimed at encouraging commuters to cycle are worth implementing in other cities."[88] The demand for a bike-share program in Philadelphia cited by Krykewycz et al suggests that the implementation of such a program could increase active transportation in the city.[89] There is thus good reason to expect that such a program could provide public health benefits in Philadelphia.

THE PHILADELPHIA BIKE-SHARE PROGRAM AND POPULATION HEALTH

Through the promotion of active transportation, bike-share programs clearly have the potential to provide valuable protection against the development of certain chronic diseases and to reduce all-cause mortality. This suggests that a bike-share program in Philadelphia can be expected to have positive impacts on public health. However, because health conditions are rarely, if ever, distributed

equally across a population, the effectiveness of the bike-share program with respect to public health will be determined in part by its ability to reach those who are most likely to suffer from the health conditions against which it can provide protection.

Just as health conditions are not generally equally distributed across a population, it is unlikely that the membership base of a bike-share program will be equally representative of all sociodemographic groups in the area. According to the Philadelphia Bikeshare Concept Study, professionals, students, tourists, and residents[90] are the primary users of the programs in Lyon, Barcelona and Paris.[91] The authors predict that students and tourists will be important users of the Philadelphia program, given the many tourist attractions and universities within the city.[92]

Practical considerations offer some explanation for this uneven distribution of sociodemographic groups among bike-share users. Although Bae and Mayeres attribute the disparity to a concern with environmental sustainability that "appears to increase with income,"[93] it is also likely that individuals with lower incomes are more likely to work very early or late shifts, or to work farther away from home, and thus may find bicycling a less viable transportation option. Despite this, there are a number of arguments suggesting that, given the proper infrastructure, active transportation may be an especially appealing option for these groups. For example, research has shown that in the United States, "low-income households are much less likely than any other income group to own an automobile"[94] and to spend a greater proportion of their income on transportation than any other income bracket.[95] A bike-share program may provide a more cost-effective means of transportation. Given these considerations, alongside the evidence that transportation decisions are heavily influenced by available resources and infrastructure, it seems likely that a bike-share

program could become a viable transportation option among less economically advantaged sociodemographic groups.

In the following sections, I will conduct a series of analyses in an attempt to identify the geographical areas and sociodemographic groups within Philadelphia County that, from a public health perspective, would likely benefit most from participation in a program designed to promote active transportation. I will also investigate the likelihood that members of these sociodemographic groups would become users of such a program. I have differentiated geographic from sociodemographic groups by using the term 'health target communities' in my geographic analysis, and 'health target groups' in my analysis of sociodemographic factors. I will conclude by highlighting some of the results of this analysis that the City of Philadelphia and urban planners should take into account when developing the bike-share program.

METHODOLOGY

The analysis presented here was conducted using data provided by the 2010 Southeastern Pennsylvania Household Health Survey (HHS)[96] and obtained through the Community Health Data Base (CHDB). The survey, conducted for the Public Health Management Corporation (PMHC) and accessed for this project through their Community Health Data Base, included 4,399 phone interviews of residents of Bucks, Chester, Delaware, Montgomery, and Philadelphia County, though some respondents did not provide information for all questions.[97] The analysis presented here employs only the information of respondents from Philadelphia County. In addition, this analysis used only the information of respondents between eighteen and seventy-four years of age, as adults over seventy-five are unlikely to benefit considerably from a

campaign aimed at the prevention of chronic illnesses, and most children under the age of eighteen are likely to be excluded as potential users of the program because of concerns regarding liability and insurance.[98]

Analysis Of Geographic Health Disparities: Identifying Health Target Communities

The first stage of identifying health target groups was an analysis of the geographical distribution of health conditions. This distribution will be important in determining the role that the proposed bike-share program could play in the promotion of public health in Philadelphia. In order for the program to have the greatest effect on public health, it must be accessible to those who are most susceptible to the types of conditions that could be prevented through active transportation. These individuals are likely to reside in communities that currently exhibit high incidences of those conditions. The geographical distribution of bike-share stations will thus in part determine who has access to it. According to the Philadelphia Bikeshare Concept Study, a station is considered to be accessible to an individual if it can be reached on foot within ten minutes—that is, if it is located approximately 1250 feet (approximately 0.2 miles) from that individual's residence.[99] The effectiveness of the proposed program with respect to the promotion of population health can therefore be evaluated by considering the distribution of planned bike-share stations relative to that of health conditions.

It is important to note that the analysis conducted here examines only one component of the geographical accessibility and usability of the program. Namely, it examines the ability of the bike-share program to solve the first-mile problem. It does not investigate its accessibility as a single component of a longer, and potentially multi-modal commute—particularly common among individuals without

access to an automobile—or in relation to individuals' places of employment within the county. Indeed, as the core market area of the bike-share program has been described as the most richly multi-use center of Philadelphia,[100] it is likely that the proposed program will be accessible from a large proportion of the county's main areas of employment. Thus while the analysis here addresses an important component of geographical accessibility, it addresses only one component, and should be considered a starting point for further investigation, rather than a planning imperative.

The distribution of bike-share stations was mapped based on the core and expanded market areas identified in the Philadelphia Bikeshare Concept Study. The core market area was identified as lying within the street borders identified by the Concept Study. The study's authors therefore highlighted the area within which the bike stations are anticipated to be located, rather than the area that would have access to those stations. The area identified as the expanded market area is less exact, because the Concept Study did not provide precise borders.[101] These street borders were labeled by comparing the rough outline of the service area provided by the Concept Study with a map of Philadelphia.[102]

In order to determine the geographic accessibility of the program to those most likely to benefit from it with respect to health, I superimposed the geographical distribution of the prevalence and incidences of health conditions in Philadelphia County with a map of the service area of the proposed program using ArcGIS Software. Data on these health conditions were collected through the 2010 Southeastern Pennsylvania HHS. I conducted this analysis using the CHDB's Online Data Analysis Tool, accessed through Swarthmore College. This tool allows the researcher to analyze projected values for the entire county, rather than only among those who participated in the survey. Although

the data were originally categorized according to zip code, the sample sizes within each zip code were often too small to allow for an accurate projection to the entire population within that zip code. For this reason, communities, as identified by PMHC, were used as the unit of analysis. Figure 2, which will accompany all subsequent figures in the online version of this publication provides a graphical breakdown of these communities.

The health conditions examined in this analysis were somewhat constrained primarily due to the use of the Online Data Analysis Tool, rather than the original HHS data. Diabetes, high blood pressure (HBP), and obesity were analyzed as primary health conditions. Although excluded from the sociodemographic analysis, the distribution of asthma was examined here as well. This is because asthmatics will benefit not so much from participating in the program as from living in communities in which others have shifted away from automobile use. Although asthmatics should not necessarily be targeted as primary users of the program, the communities in which they live should be.

The analysis presented here focused on the geographical distribution of each of these health conditions across Philadelphia's twelve communities. Distribution is here measured in terms of the density of cases—that is, the average number of cases per square mile across each community. Data regarding the area of each zip code in Philadelphia was collected through the Pennsylvania Geospatial Data Clearinghouse, and the areas of the zip codes in each community were then aggregated. Densities were calculated by dividing the total incidents of a given condition in a community by the total area of that community. The decision to focus on the density of health conditions was based on the importance of a bike-share station's spatial proximity to a targeted community to ensure access. By analyzing the number of cases per square mile,

this analysis offers insight into the relative numbers of individuals experiencing a particular health condition that would have access to the program. After mapping the distribution of each health condition, I calculated the total density of health conditions for each community. Through this final calculation, I was able to determine which of the studied communities had the greatest need, with respect to health, for a bike-share program.

Active transportation only has the potential to prevent the negative health conditions associated with inactivity if the individuals most at risk for experiencing these conditions are also unlikely to engage in regular exercise. In order to investigate which communities would likely accrue the greatest health benefits from a bike-share program, I have conducted an analysis on the percentage of individuals in each community who exercise at least thirty minutes a day, three days a week, rather than the number of individuals who do so per square mile. Admittedly, individuals likely to develop the health conditions investigated here are probably less likely to engage in regular exercise than others living in their communities. However, by combining an analysis of the percentage of individuals in each area who do exercise with the density of individuals in that area it becomes possible to develop a rough estimate of the density of individuals in each community who could lower their risk of developing one of the health conditions of interest by engaging in active transportation.

Analysis of Sociodemographic Health Disparities: Identifying Health Target Communities

If a bike share program is to reach the populations most likely to benefit from its use, marketers and planners must create targeted campaigns designed to reach those who are most likely to suffer from the chronic health conditions that may be alleviated through active transportation, and

especially those among this population who are less likely to join such a program without active encouragement. To do so, however, marketers and planners must first achieve a comprehensive understanding of some of the sociodemographic characteristics of this population. In order to investigate which sociodemographic groups could benefit most from a bike-share program in Philadelphia, I have conducted statistical analysis on disparities in both health status and health behavior—in this case, engagement in physical activity—in the city. In addition, I have looked to rates of access and use of various forms of transportation in order to assess whether a bike-share program would be an effective way of addressing these health disparities, and what challenges such a program may face in recruiting those users whose health would greatly benefit from their participation.

Literature from the fields of epidemiology and health economics regarding health disparities and the social determinants of health heavily influenced the selection of sociodemographic variables used in this analysis—namely, sex, race, education, and poverty status.[103,104,105.106] "Poverty status" here is classified as either above or below 100 percent, 150 percent, and 200 percent of the Federal Poverty Level (FPL), which in 2010 was marked by an annual income below $10,830 for an individual or $22,050 for a family of four.[107] Age is also used as a sociodemographic variable in this analysis, both as a control and a cutoff point after which programs aimed at prevention may be less effective. It stands to reason that the likelihood of developing a chronic condition would increase with age, thus including age as a factor in statistical analysis ensures that any observed increase in risk to a demographic is not simply due to a relatively large proportion of older individuals within the sample of that group. In addition, by establishing the age range at which chronic conditions become significantly more prevalent, the age variable can offer an indication as to

the age range at which prevention programs might be most effectively targeted.

This analysis contains several specifications and limitations that require clarification. The 2010 HHS set the specific parameters that identify respondents as experiencing a particular health condition. All cases of asthma, diabetes, high blood pressure, and mental illnesses reported in the 2010 HHS have been diagnosed by a health professional at some time in the respondent's life. Although this is certainly the most accurate way to measure incidences of illness, it may lead to underreporting among individuals with little access to health care resources, especially with respect to mental health conditions. Measurements of obesity are based on respondents' BMI, using a scale recommended by the CDC, whereby individuals with a BMI below 18.5 were classified as underweight, those with a BMI between 18.5 and 24.9 are considered to be at a healthy weight, those with a BMI between 25 and 29.9 are considered overweight, and those with a BMI above 30 are considered obese. Stress was measured on a self-reported scale ranging from 1 to 10.

Small sample sizes in the original survey imposed some limitations on this analysis, resulting in the exclusion of a number of cases. Though they were included in the 2010 HHS, incidences of diabetes and high blood pressure occurring exclusively during pregnancy were eliminated from analysis due to limitations in sample size. Individuals self-identifying as Asian, bi- or multiracial, Native American, or a racial group not included in the survey have been excluded from the analysis due to small sample size as well. It should also be noted that because survey respondents were selected through their phone numbers, it is likely that students attending colleges or universities in Philadelphia, many of whom may have phone numbers from other areas, are considerably underrepresented in the data presented here.

I used this data to determine the relative impacts of each of the selected sociodemographic factors on specific health conditions through the use of binary and ordinal logistic regressions, for which I used PASW Statistics 18 software. Through these tests, I determined the relative probabilities that members of a specific group will experience a given health condition.[108] Table 1, found at the end of this section, provides a list of all independent and dependent variables examined in this analysis. The standard group for each sociodemographic characteristic, against which all other groups within that variable were compared, either represents the majority of respondents or illustrates the effect of increases in a relatively continuous variable, such as age or years of education. By comparing various groups to a standard, this method allowed for the identification of the sociodemographic groups of individuals most likely to suffer a particular health condition.

In order to determine whether the previously identified health target groups may benefit from engaging in active transportation, I have investigated the impacts of the same sociodemographic factors on the probability of engaging in at least thirty minutes of physical activity per day using an ordinal logistic regression. Statistical analysis focuses on the frequency with which members of each sociodemographic group are most likely to exercise for at least half an hour per day, which could be less than once per week, one to two days per week, three days per week, more than three days per week, or none.[109]

An analysis of current methods of commuting offers an indirect means to examine the potential for a bike-share program to increase active transportation by inspiring a modal shift, and thus to contribute to the public health of Philadelphia County. The 2010 HHS classified respondents according to the mode of transportation that they utilized in their commute to work the previous week. Due to small

sample sizes, taxi, motorcycle, ferry, and "other" have been excluded from this analysis, leaving only automobile, public transit, bicycle, "work at home", and "did not work." A separate binary regression compared each mode to an aggregation of all other modes, and therefore determined which sociodemographic groups were more likely to use that mode than any other. This analysis was conducted with the expectation that walkers and transit riders are more likely to become bike-share users than automobile drivers and passengers, and those who work from home or do not work.

Table 1. Independent and dependent variables used in the analysis of sociodemographic health disparities in Philadelphia.

Independent Variables		Dependent Variables
Sex		Health Conditions
Reference:	Male	Risk of Diabetes
Comparative:	Female	Risk of HBP
Age		Risk of Mental Illness
Reference:	18-39	Risk of Obesity
Comparative:	40-49 50-59 60-74	Risk of High Stress
Education		
Reference:	Post-College	Health Behaviors
Comparative:	< High School High School Graduate Some College College Graduate	Probability of Frequent Exercise Probability of Use of Public Rec Facilities Primary Mode of Transportation
Race		
Reference:	White	
Comparative:	Black Latino	
Poverty Status		
Reference:	Above 100%, 150%, 200% FPL	
Comparative:	Below 100%, 150%, 200% FPL	

RESULTS

Analysis of Geographic Health Disparities: Identifying Health Target Communities[110]

Out of the twelve communities examined, the highest aggregated densities of the health conditions examined were found, in order from highest to lowest, in Olney/Oak Lane, Upper North Philadelphia, West Philadelphia, Lower North Philadelphia, and Center City (Figure 3). The same communities had the highest densities of cases of obesity, though densities were higher in Lower North Philadelphia, Center City and Lower Northeast Philadelphia than in West Philadelphia, even though West Philadelphia had a higher aggregate density of health conditions overall (Figure 4). The analysis of asthma cases revealed a similar pattern to that of obesity, though the relative densities of asthma in Center City were higher than all communities aside from Upper North Philadelphia, which had the highest densities of all communities examined (Figure 5). The relative densities of all communities were the same for high blood pressure (Figure 6) and diabetes cases (Figure 7), with the highest in Olney/Oak Lane, followed by Upper North Philadelphia, West Philadelphia, Lower North Philadelphia, Lower Northeast Philadelphia, and Southwest Philadelphia.

The geographical analysis of physical activity rates revealed some overlap of communities with low physical activity and high rates of health conditions (Figure 8). Bridesburg/Kensington/ Richmond, Upper North Philadelphia, Lower Northeast Philadelphia, Germantown/Chestnut Hill, Olney/Oak Lane and West Philadelphia had the lowest rates of regular physical activity. Of these communities, Olney/Oak Lane, Upper North Philadelphia, West Philadelphia, and Lower Northeast Philadelphia had relatively high rates of health conditions as well (Figure 3). Roxborough/Manayunk had both the highest rates of physical activity and the lowest density of health

conditions. The relatively low population density of Roxborough/Manayunk may in part explain the low density of health conditions in that area. Although Center City and Lower North Philadelphia had somewhat high rates of health conditions compared to other communities, they also had the second and third highest rates of regular physical activity, respectively.

Analysis of Sociodemographic Health Disparities: Identifying Health Target Communities

Through statistical analysis, I identified a number of demographic groups at relatively high risk for developing health conditions that could be prevented at least in part through engagement in active transportation (Table 2). These groups, each characterized by a specific demographic variable, can be considered 'health target groups' for a project such as the proposed bike-share program. The analysis demonstrated that sex, education, race, poverty status, and age all played significant roles in determining risk for many of the health conditions examined.

The analysis of the impact of age revealed that individuals above the age of forty faced significantly higher rates of diabetes and high blood pressure than their counterparts between the ages of eighteen and thirty-nine. In addition, they were significantly more likely to have diagnosed mental health conditions and to be obese. The only exception in this case was among individuals aged sixty to seventy-four, who were not at an increased risk of having a diagnosed mental health condition and who were notably less likely to suffer from stress than those between eighteen and thirty-nine. It should be considered that this may be unique to the cohort, that is, individuals who were born between 1935 and 1950, rather than individuals between the ages of sixty and seventy-four. Overall, this analysis of age suggests that any program intended to contribute to the prevention of diabetes, high blood pressure, and mental

health conditions would be most effective if targeted at individuals under the age of forty.

Table 2. Odds ratios and 95% confidence intervals demonstrating the relative risks of developing diabetes (n = 3604), high blood pressure (n = 3599), mental health conditions (n = 3609), becoming overweight or obese (n = 3540), or suffering from stress (n = 3571) faced by various sociodemographic groups in Philadelphia, based on the 2010 Southeastern Pennsylvania Household Health Survey. Statistically significant results (p < .05) are marked with an asterisk.

	Diabetes	High BP	Mental Health	Obesity	Stress
Sex					
Male	Ref.	Ref.	Ref.	Ref.	Ref.
Female	-.229* (-.506, .093)	-.153 (-.317, .011)	.367* (.162, .572)	-.102 (-.234, .030)	.410* (.286, .535)
Age					
18-39	Ref.	Ref.	Ref.	Ref.	Ref.
40-49	1.300* (.856, 1.745)	1.295* (1.035, 1.556)	.364* (.104, .624)	.439* (.256, .662)	.143 (-.026, .313)
50-59	2.047* (1.639, 2.445)	2.052* (1.809, 2.295)	.256* (.013-.498)	.476* (.309, .643)	-.062 (-.218, .094)
60-74	2.575* (2.165, 2.986)	2.777* (2.517, 3.037)	-.333 (-.616, .050)	.380* (.200, .560)	-.844* (-1.014, -.674)
Education					
< High School	.618* (.178, 1.057)	.500* (.149, .850)	.362 (-.026, .750)	-.058 (-.339, .223)	.119 (-.149, .388)
High School Graduate	.211 (-.159, .581)	.345* (.077, .613)	0.235 (-.554, .083)	.238* (.030, .445)	-.100 (-.291, .090)
Some College	.258 (-.130, .645)	.389* (.105, .672)	-.026 (-.359, .306)	.340* (.119, .560)	.176 (-.025, .377)
College Graduate	-.235 (-.671, .201)	.209 (-.086, .505)	-.190 (-.538, .157)	-.024 (-.248, .210)	-.033 (-.235, 1.69)

Post-College		Ref.	Ref.	Ref.	Ref.	Ref.
Race						
White		Ref.	Ref.	Ref.	Ref.	Ref.
Black		.739* (.521, .958)	.813* (.647, .979)	-.644* (-.846, -.441)	.590* (.455, .725)	-.456* (-.583, -.329)
Latino		.567* (.182, .951)	.231 (-.069, .531)	-.299 (-.611, .014)	.551* (.324, .778)	-.239* (-.457, -.022)
Poverty Level						
Below FPL	100%	.023 (-.303, .349)	.276 (-.008, .560)	.172 (-.119, .464)	.001 (-.235, .237)	.235* (.005, .466)
Above FPL	100%	Ref.	Ref.	Ref.	Ref.	Ref.
Below FPL	150%	.305 (-.806, .695)	-.059 (-.379, .260)	.429* (.070, .789)	-.048 (-.314, .218)	.230 (-.024, .485)
Above FPL	150%	Ref.	Ref.	Ref.	Ref.	Ref.
Below FPL	200%	.104 (-.235, .443)	.410* (.147, .673)	.475* (.157, .794)	.298* (.081, .514)	.138 (-.067, .343)
Above FPL	200%	Ref.	Ref.	Ref.	Ref.	Ref.

The analysis of the impact of sex on risk demonstrated that men and women face similar risks overall, though for different health conditions. Men were at greater risk of developing diabetes than women, but women were more likely to develop mental health conditions and to suffer from stress. Because both sexes face similar overall risk, it is unlikely that sex should be used to identify health target groups. Rather, this analysis suggests that marketing campaigns should emphasize different health benefits for men and women in order to encourage their participation.

Education was important in determining risk for the somatic illnesses included in this analysis. Respondents who had not completed high school were more likely to develop diabetes than those with higher levels of education, and

those who had not received a college degree, regardless of specific educational attainment, were at increased risk of high blood pressure. Those who had graduated from high school, but not from college, were at an increased risk of obesity when compared to individuals who did not complete high school or who did complete college. These results suggest that all individuals who did not graduate from college should be considered as a health target group for bike-sharing. Marketers might thus consider initiating campaigns in the areas surrounding high schools, or with high concentrations of job opportunities for individuals without a college degree. Planners might consider constructing bike-share stations in areas with these types of employment opportunities as well.

The analysis of race highlighted that ethnic minorities in Philadelphia, and especially African Americans, are at increased risk for all of the somatic diseases examined, and should therefore be considered health target groups. Although respondents identifying as white were significantly more likely to suffer from stress than those identifying as either black or Latino, and black respondents were less likely to develop mental health conditions than white respondents, black and Latino respondents faced increased risks with respect to the majority of the conditions analyzed. Black respondents were more likely than whites to suffer from diabetes, high blood pressure, and obesity, while Latino respondents also experienced higher incidences of diabetes and obesity.

Poverty status was determined to be influential not only in the risk associated with some of the examined somatic illnesses, but with respect to mental illness as well. Individuals living below 100 percent of the Federal Poverty Level were more likely to become stressed than those living above it— even more likely than were those living below 150 percent and 200 percent of the FPL. Those living below 150

percent and 200 percent of the FPL were at increased risk of having a diagnosed mental health condition compared to those with higher incomes. In addition, those living below 200 percent of the FPL were also more likely to have high blood pressure and to be obese than those with incomes above this level. This analysis suggests that all those living below 200 percent of the FPL should be targeted for this program.

Sex, age, education, and race all played a significant role in determining an individual's likelihood of frequently exercising for at least thirty minutes per day (Table 3). Females, individuals between sixty and seventy-four years of age, individuals who did not complete high school, and Latinos were significantly less likely than other sociodemographic groups to regularly engage in physical activity for at least thirty minutes per day.

Table 3. Odds ratios and 95 percent confidence intervals illustrating the relative probabilities that individuals (n = 3600) of various sociodemographic groups frequently engage in exercise, based on the 2010 Southeastern Pennsylvania Household Health Survey. Each odds ratio demonstrates the probability that individuals of that characteristic will move from a given level of use to that above it. Statistically significant results (p < .05) are marked with an asterisk.

	Frequency of Exercise >30 min/day
Sex	
Male	Ref.
Female	-.159* (-.289, -.029)
Age	
18-39	Ref.
40-49	-.049 (-.224, .126)
50-59	-.116 (-.276, .044)
60-74	-.234* (-.407, -.060)

Education	
< High School	Ref.
High School Graduate	.452*
	(.229, .675)
Some College	.389*
	(.146, .631)
College Graduate	.498*
	(.242, .753)
Post-College	.583*
	(.306, .860)
Race	
White (Non-Latino)	Ref.
Black (Non-Latino)	-.115
	(-.245, .016)
Latino	-.273*
	(-.497, -.050)
Poverty Level	
Below 100% FPL	.043
	(-.192, .277)
Above 100% FPL	Ref.
Below 150% FPL	-.002
	(-.259, .255)
Above 150% FPL	Ref.
Below 200% FPL	-.077
	(-.283, .129)
Above 200% FPL	Ref.

The results of the analysis of modes of transportation used for commuting to work should be regarded with caution due to limitations in sample size. After applying the exclusion criteria discussed in the Methodology section, only 1,871 respondents were included in analysis. This sample size is considerably smaller than those used in all previous analyses, which ranged from 3,540 to 3,618, and is likely due to a lack of reporting in the initial survey. Nevertheless, sex, age, education, race, and poverty status were all found to have significant influences on modal choice (Table 4).

Females, blacks, and individuals living below 200 percent FPL were less likely to travel to work via automobile than men, whites, and individuals living above 200 percent

FPL, respectively. They were also more likely to be transit riders. On the other hand, individuals with some college education or a college degree were more likely to drive than individuals who did not graduate from high school, and all individuals who continued their education past high school were significantly less likely to ride public transit than those who had not completed high school. With respect to biking, females were less likely to bike to work than males, individuals above the age of forty were less likely to bike than individuals below the age of thirty-nine, individuals who had graduated from high school but not from college were less likely to bike than individuals who had not graduated from high school, and blacks were less likely to bike than whites. In addition, blacks were less likely to walk to work than those identifying as white, whereas those living below 200 percent FPL were more likely to walk.

Table 4. Odds ratios and 95 percent confidence intervals revealing the relative probabilities that individuals (n = 1871) from specified sociodemographic groups commuted to work via automobile, public transit, bike, walking, or either worked at home or did not work, in the week prior to their interview for the 2010 Southeastern Pennsylvania Household Health Survey. Statistically significant results (p<.05) are marked with an asterisk.

	Automobile	Public Transit	Bike	Walk	Worked At Home	Did Not Work
Sex						
Male	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Female	-.341* (-.546, -.134)	.367* (.129, .604)	-.837* (-1.270, -.104)	.133 (-.272, .539)	.550 (-.317, 1.236)	.821 (-.068, 1.711)
Age						
18-39	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
40-49	.078 (-.174, .330)	.003 (-.275, .281)	-2.283* (-3.748, -.817)	.296 (-.217, .810)	-.099 (-.960, .762)	-.004 (-.866, .857)
50-59	.051	-.068	-1.529*	.243	.740*	-.179

	(-.187, .228)	(-.335, .198)	(-2.534, -.535)	(-.243, .728)	(.049, 1.432)	(-1.024, .667)
60-74	.168 (-.165, .502)	-.188 (-.571, .195)	-1.574* (-3.058, -.089)	.346 (-.264, .957)	.213 (-.857, 1.282)	-.161 (-1.331, 1.008)
Education						
< High School	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
High School Graduate	.380 (-.095, .856)	-.413 (-.892, .066)	-1.972* (-.3606, -.337)	.084 (-.850, 1.018)	N/A	.548 (-1.517, 2.613)
Some College	.804* (.307, 1.300)	-.748* -1.253, -.243)	-3,029* (-5.408, -.649)	-.122 (-1.121, .876)	N/A	-.398 (-2.650, 1.854)
College Graduate	.620* (.121, 1.120)	-1.008* (-1.527, -.489)	-.664 (-2.156, .829)	.090 (-.905, 1.086)	N/A	.277 (-1.886, 2.440)
Post-College	.489 (-.031, 1.009)	-.967* (-1.518, -.417)	-.776 (-2.370, .819)	.637 (-.363, 1.637)	N/A	.730 (-1.440, 2.900)
Race						
White	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Black	-.207* (-.411, -.003)	.820* (.589, 1.050)	-1.207* (-2.234, -.180)	-1.696* (-2.211, -1.182)	-.438 (-1.050, .174)	.222 (-.482, .927)
Latino	.087 (-.272, .445)	.240 (-.449, .508)	-.287 (-1.520, .946)	-.331 (-.956, .294)	-.488 (-1.742, .767)	-1.204 (-3.278, .870)
Poverty Level						
Below 100% FPL	-.201 (-.667, .264)	.029 (-.449, .508)	-.369 (-3.221, 2.483)	.518 (-.316, 1.352)	.998 (-.405, .174)	-1.018 (-2.687, .650)
Above 100% FPL	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Below 150% FPL	.070 (-.387, .526)	-.107 (-.583, .369)	-.346 (-2.833, 2.140)	-.065 (-.911, .782)	-.085 (-1.620, 1.451)	.561 (-.904, 2.026)
Above 150% FPL	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

CONCLUSIONS AND POLICY IMPLICATIONS

My earlier literature review suggests that a bike-share program implemented in Philadelphia could indeed be considered a public health initiative. However, my analysis of the sociodemographic and geographic distributions of health needs and behaviors implies that the program's planners must take additional steps to ensure that those who are most likely to develop the health conditions against which biking can offer protection have access to the program. In this final section, I will offer a short discussion of some of the gaps between the public health needs of Philadelphia and the solutions offered by the proposed bike-share program. I do so with the objective of providing a foundation for future discussions regarding the evolution of the program to best serve public health.

The proposed core market area is centered around Center City, which has been identified as the area most likely to support a bike share program based on the community's density of potential users (individuals aged 17-64), employment opportunities, tourist attractions, and recreational areas.[111] It also includes parts of Lower North Philadelphia and West Philadelphia. There is thus some overlap between the communities included in the proposed core market area and those with high densities of health conditions. From a public health perspective, West Philadelphia is an especially important target for the program. Out of the three communities previously mentioned, it is the only one with both a high density of health conditions and low rates of regular exercise.

In addition, in order to increase the impact of the program on public health, certain sociodemographic groups should be targeted as potential users through marketing and education campaigns, as well as infrastructure development. My analysis of the sociodemographic factors influencing individuals' risk for developing certain chronic health

conditions identified women, individuals without a college degree, blacks and Latinos, and all individuals living below 200 percent FPL as health target groups. The analysis of health behaviors suggests that women, individuals who did not graduate from high school, and Latinos are also less likely to regularly engage in physical activity, indicating that they may accrue additional benefit from participating in a bike-share program. However, this additional assertion is somewhat complicated by my analysis of the modes of transportation most often used in the commute to work or school. This analysis indicated that two of these three groups, women and individuals without a high school degree, are also more likely to take public transit than men and individuals who have completed high school. Past research has shown that transit riders are more likely than users of most other modes of transportation to achieve the recommended level of physical activity simply in their walk to and from the transit station.[112] It is thus possible that these results regarding physical activity are as much influenced by the framing and perception of the survey question as by actual behaviors.

As discussed previously, a bike-share program may provide low-income households with a more economically viable means of transportation as well as an opportunity for active transportation. Furthermore, recent research has suggested that a bike-share program may break down one of the main barriers preventing these individuals from biking. According to the 2005 National Survey of Bicyclist and Pedestrian Attitudes and Behavior, only 29 percent of individuals living below 150 percent FPL have regular access to a working bicycle.[113] In order to specifically target individuals with low incomes, developers could consider implementing a more accommodating pricing scheme, whereby individuals with lower incomes would receive some kind of discounted membership rate, or could choose to pay

the fee in smaller installments, so as to avoid the barrier of a larger upfront cost.[114]

The results of the statistical analysis on age also have implications for the design of the bike-share program. This analysis suggested that in order to be most effective as a prevention strategy, the bike-share program should primarily target individuals under the age of forty. Although the Philadelphia Bikeshare Concept Study predicts that a key constituent of this age group—namely, students—would be a prominent target group for the program, it also suggests that young professionals may be an important user group as well.[115] Beyond simply affecting the placement of bike-share stations, this may require conversations with employers regarding the possibility of providing employees with a locker room in which to shower or change after biking to work.[116]

In summary, a bike-share program in Philadelphia would provide a valuable opportunity for the city to address key health conditions through the promotion of active transportation. However, in order to maximize the effects of the program with respect to public health, it will be necessary for planners to take into consideration the inequitable distribution of health conditions across Philadelphia, both spatially and sociodemographically, as well as the potential barriers that may prevent individuals who would greatly benefit from involvement in the program from becoming members. By taking active steps to provide members of health target groups with convenient access to the bike-share program, planners will be able to both improve the overall health of the city in future years by working to prevent the development of chronic illnesses and reduce the health disparities that have caused these groups to stand apart from the rest of the city's population.

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96 "Public Health Management Corporation's Community Health Data Base (2010) Southwestern Pennsylvania Household Health Survey"

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98 As mentioned previously, many bike-share programs relying on a liability waiver for insurance purposes—including most of the existing programs in the United States—exclude users under sixteen, as opposed to eighteen, years of age (DeMaio 2003:10). The cutoff age of eighteen has been used in this case due to the organization of data in the 2010 Household Health Survey.

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108 With respect to both obesity and stress, which were measured in intervals and therefore analyzed using ordinal logistic regression, the statistical test actually provides an indication of the probability of moving up one level: that is, from a healthy weight to obese, or from a stress level of 6 to 7.

109 Public Health Management Corporation, "2010 HHS Codebook", 2011:23.

110 All geographical analyses are available in the online version of this publication, labeled as Figures 3-8..

111 Krykewycz et al., "Defining a Primary Market and Estimating Demand for Major Bicycle-Sharing Program in Philadelphia, Pennsylvania,"119.

112 Lilah M. Besser and Andrew L. Dannenberg, "Walking to Public Transit: Steps to Help Meet Physical Activity Recommendations," *American Journal of Preventive Medicine* 29 (2005): 273-280.

113 *Natonal Survey of Bicyclist and Pedestrian Attitudes and Behavior* (U.S. Department of Transportation, National Highway Traffic Safety Administration).

114 Given the reliance of third-generation bike-share programs on credit cards for user tracking and accountability, it is possible that credit card ownership might present another barrier to participation in the program. Unfortunately, I was unable to find any clear and current data illustrating the disparities of credit card ownership across income groups.

115 JzT1, Bonnette Consulting, and Delaware Valley Regional Planning Commission, *Philadelphia Bikeshare Concept Study*, 37.

116 John Pucher and Ralph Buehler, "Cycling for Everyone: Lessons from Europe," *Transportation Research Record: Journal of the Transportation Research Board* 2074 (2008): 58-65.