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Prescribe a bike: reducing income-based disparities in bike access for health promotion and active transport through primary care

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SCHOOL OF PUBLIC HEALTH

Dissertation

PRESCRIBE A BIKE:

REDUCING INCOME-BASED DISPARITIES IN BIKE ACCESS

FOR HEALTH PROMOTION AND ACTIVE TRANSPORT

THROUGH PRIMARY CARE

by

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Boston University School of Public Health, 2016

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ABSTRACT

Low-income groups have greater potential to gain from incorporating health promotion into daily living using bike-share to increase physical activity and expand transport options. The potential is unmet because of socioeconomics and access. Disproportionate uptake of bike-share by higher income individuals widens the gaps in health equity and transportation equity as bike-share use over-represents males with more resources, less need, and lower health risk. The Prescribe a Bike (RxBike) program, a key focus of this study, is a partnership between primary care providers (PCPs) at an urban safety net hospital and the city's existing income-based, subsidized bike-share membership.

Three studies using quantitative and qualitative methods were performed to: examine utilization of bike-share by Boston residents among subsidized and non-subsidized members; examine perceived attributes of the RxBike program by Boston Medical Center (BMC) PCPs; and evaluate BMC patient referrals. The overarching

conceptual model uses elements of theories from health services and organizational behavior, in a public health framework.

Analysis of Boston resident utilization at the trip-level (2012–2015) demonstrated overall ridership was increasingly by males and residents of more advantaged neighborhoods. Subsidized members had significantly higher likelihood of living in neighborhoods with socioeconomic and health disadvantage, and less gender disparity when compared to non-subsidized members. The impact was minimal because subsidized members made only 7.17% of trips. The survey of PCPs revealed mismatch between highly favorable opinion of RxBike appropriateness and lower intent to refer. Female gender and not being an urban biker predicted lower likelihood of intent to refer. Examination of open-ended survey comments mirrored quantitative data and expanded on the range of provider biking safety concerns in Boston. From 2013–2015, 27 BMC providers made only 72 referrals to RxBike. Patients referred had high cardiovascular health risk, resided in neighborhoods with extremely high levels of disadvantage, and in neighborhoods without meaningful access to bike-share kiosks.

Overall, the subsidized membership extends reach of bike-share to residents of neighborhoods with more health and socioeconomic risk than the rest of the city; RxBike has strong potential to impact this vulnerable population. The most critical matters for program success are safety and neighborhood access.

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LIST OF ABBREVIATIONS

ACA ....Affordable Care Act

ACS... American Community Survey

AIM...Adult internal medicine

BMC.. Boston Medical Center

BMI .... Body mass index

BPHC .... Boston Public Health Commission

BRFSS .... Behavioral Risk Factor Surveillance Survey

BU .... Boston University

BUMC... Boston University Medical Center

CDC .... Centers for Disease Prevention and Control

CDW .... Clinical Data Warehouse

CPS ....Consumer Product Safety Commission

DOI .... Diffusion of Innovation

ED .... Emergency department

EFA .... Exploratory factor analysis

GIM.. General Internal Medicine

HIP .... Health Impact Pyramid

HIPAA .... Health Insurance Portability and Accountability Act

HP2020 .... HealthyPeople 2020

IMR .... Infant mortality rate

IRB .... Institutional Review Board

ISO .... International Standards Organization

ITDP...Institute for Transportation Development and Policy

MA DPH .... Massachusetts Department of Public Health

MTI ....Mineta Transportation Institute

NEISS-AIP................National Electronic Injury Surveillance System- All Injury Program

NHTS ....National Highway Traffic Safety Administration

NTSA ....National Highway Traffic Safety Administration

NP ....Nurse practitioner

PAM...Pediatric and adolescent medicine

PAs...Perceived attributes

PBSP ....Public bike-share program

PCP .... Primary care provider

PPACA... Patient Protection and Affordable Care Act

REU.. Research Evaluation Unit

RxBike .... Prescribe a Bike

SDH ....Social determinants of health

SEM ....Socio-ecologic Model

SES..Socioeconomic status

TBI .... Traumatic brain injury

CHAPTER ONE

Brief Literature Review

Public health perspective

The relationship between physical activity and improved health outcomes is well known. There are clear and strong associations between cerebrovascular diseases, type II diabetes, depression, obesity, life expectancy, and physical activity. It is also established that most American adults do not get enough exercise; the default life-style is sedentary when at home and at work. The resultant increase in direct medical costs, lost productivity, and decrements in health-related quality of life create a population-level public health crisis.[1–4]

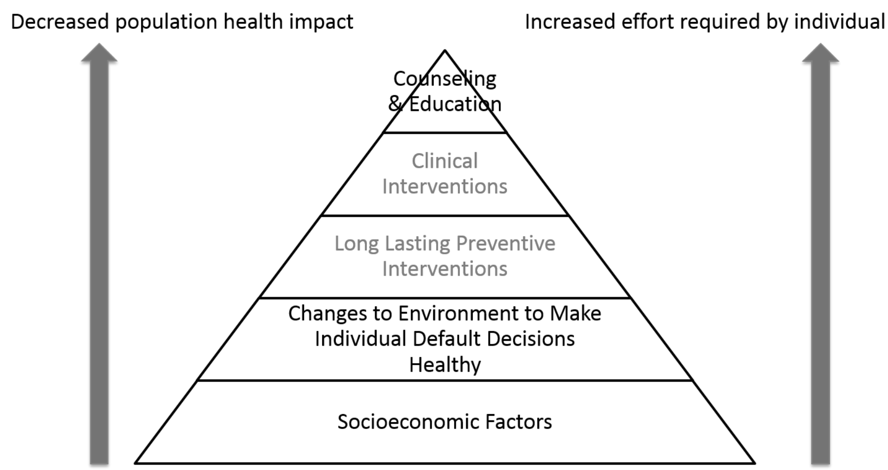
In 2008 the United States Office of Disease Prevention and Health Promotion issued the first evidence-based national guides for physical activity. These guidelines serve as Leading Health Indicators for Healthy People 2020 (HP2020).[5] The targets for non-elderly adults (ages 19 to 64 years) are at least "150 minutes (2 hours and 30 minutes) a week of moderate-intensity, or 75 minutes (1 hour and 15 minutes) a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity. "Examples given are brisk walking, jogging, biking, dance and swimming. The guidelines serve as a threshold. The authors acknowledge the biological gradient between exercise and health promotion, and state that sub-threshold levels of activity are preferable to inactivity.[4]

In 2014 the CDC released a status report on physical activity based on the 2011 Behavioral Risk Factor Surveillance Survey (BRFSS).[3] BRFSS is a cross-sectional, telephone survey of non-institutionalized adults conducted by each state that provides a systematic means of data collection to track prevalence of risk behaviors, preventive health behaviors, and health status. BRFFS data are also used to set health goals and monitor progress of public health programs, including those relating to HP 2020 initiatives. In the BRFSS, physical activity is assessed by asking respondents to identify whether they participate in leisure time activities (i.e. running, calisthenics, golf, gardening, or walking for exercise). Frequency and intensity are then assessed for those reporting activity. [6,7]

Results of the 2011 BRFSS indicated that, nationally, one quarter of adults reported no physical activity during leisure time (state range 18.9–35.1%). Only 52% of adults reported meeting the 150-minute threshold for physical activity (state range 42.0–61.8%). Less than half of that group (20.6%) met the benchmarks for both aerobic and muscle strengthening guidelines. Data from Massachusetts revealed only slightly improved population performance. Approximately 23% of Massachusetts' respondents reported not having leisure time for physical activity; 56.3% met the 150-minute aerobic activity threshold.[3]

Friedan's five-tier Health Impact Pyramid (HIP) provides a framework to examine the spectrum of interventions used to improve health (Figure One). The pyramid rests on the socioeconomic determinants of health, as income, education and zip code may be better predictors of health than use of medical services.[8] Interventions to change the socioeconomic structure of society have the greatest promise to improve health, but the political barriers are often insurmountable.

Figure 1.1: Health Impact Pyramid[9]



Public health approaches to improving population-level health often focus on the second tier by changing the context to make health-promoting behavior the default choice. These interventions reach a broad audience without requiring individual effort.[9] Tier two strategies used to promote physical activity include educational campaigns, mandating physical education in schools, and modifications to the built environment (i.e. walkable cities, playgrounds).

Within the US, income-based disparities exist for physical activity. Income is a multi-dimensional variable, capturing both financial capital and neighborhood resources; and is associated with many of the other social determinants known to impact health and well-being. Low-income populations have higher obesity rates, and shorter lives.[8,10] An increase in physical activity should have a protective effect for this population. Unfortunately low-income persons have economic barriers to choosing a physically active lifestyle for reasons including neighborhood safety, availability of outdoor recreational space, poor walkability of community, cost to join a health club, opportunity cost of purchasing child care, fees for community recreation activities, and baseline lower health status than their higher income counterparts. Targeted public health and medical care strategies to increase physical activity must address the income-related barriers persons to improve health equity.[11–14]

Health promotion in medical care

It should not be surprising that the processes of traditional medical care continue to have a limited impact on population health. Starting from the base, each tier of the PIH reaches a progressively smaller section of the population and requires an increasing amount of effort from the individual to be successful. Medical care is at the upper tiers of the HIP. The apex, or fifth tier, represents individual-level health education and counseling.[9] Health promoting behavior requires persistent behavioral change by the patient. The success of health promotion is prevention of disease occurrence (primary prevention) or prevention of complications from existing disease (secondary prevention).[15(chap1)] Prevention is therefore a non-event; the benefits may not be evident for decades.[16]

The discordance between the availability of effective educational interventions for health promotion and actual clinical practice is a known phenomenon in health services.[17] Primary care providers (PCPs) have baseline competing demands for patient volume, arduous documentation, and clinical care.[18] There is an opportunity cost to incorporating behavioral counseling into the standard PCP visit. Providers may not believe that time spent in counseling would have an effect on patient behavior. Without tangible evidence of success, providers lack positive reinforcement to prioritize behavioral counseling for health promotion.[19] Provider reluctance to prioritize counseling for health promotion may be due to the mixed evidence base on the success of these interventions. Although two recent systematic reviews on primary care interventions for physical activity demonstrated positive provider attitudes and a favorable effect on patient-reported levels of activity, multiple barriers were identified to implementation.[20,21]

There are several other explanations of why PCPs do not engage in more health promotion with patients.[17] Use of the bio-medical model for physician training emphasizes diagnosis and treatment of clinical conditions over prevention and lifestyle management. [17,22] Traditional models for reimbursing primary care generally do not incentivize physician time spent in counseling.[23(chap4)] The patient-level outcomes from preventive or health promoting activities are difficult to capture or to attribute to individual elements clinical care.[24]

On the other hand, there are multiple arguments to support the appropriateness of PCP as counsel for health behavior specific to physical activity.[17] The ACA expansion of health insurance will cover more of the population; the newly insured will have an increased likelihood of accessing a PCP as a usual source of care.[18,25] The visit between PCP and patient is a private encounter, which allows the message to be individualized. The relationship between PCP and patient is intended to be repetitive and longitudinal. This is a good fit for behavioral counseling as effective change requires reinforcement, reassessment and readjustment. [26]

In theories of health behavior, a discrete encounter at a medical visit may be viewed as educative and as a cue to action. If a patient is ready to adopt a health behavior or to contemplate change then the suggestion of a PCP could be the trigger that activates the patient. Provider counsel could also serve as a primer, leaving the patient more susceptible or likely to consider change in the future.[27–29] The payoff for an individual patient to make meaningful change may be low, but across the population there is the potential for significant impact if effective education were to be provided on a consistent basis.[9]

Active transport in the United States

Low-income persons also have barriers to efficient modes of transportation. Car ownership is expensive. Public transportation does not penetrate all neighborhoods and schedules may not accommodate non-traditional working hours. Public transportation may also be a financial hardship as the regressive fare structure is a proportionately larger percentage of income as income declines.[30–32] One strategy for increasing physical activity in this at-risk group is to link health with everyday life[8] via active transport. Active transport is the use of walking, cycling or other non-motorized means for non-recreational travel. Bicycling as a form of exercise and active transport has been shown to have population-level benefits on health status.[33] Barriers to biking as active transport include the built environment (access to safe routes) and lack of resources (purchase, storage, and maintenance of a bicycle).[34]

The National Household Travel Survey (NHTS) is a periodic survey on transportation and travel behavior conducted at the individual and household levels to inform transportation policy and planning. The most recent years of NHTS data collection are 2001 and 2009.[35] An analysis of NHTS data revealed that in 2009 the average adult took 185.8 trips on foot and 14.2 trips by bike. This was equivalent to 37.7 hours of travel on foot and 4.6 hours on bike. The analysis revealed statistically significant increases in the frequency, duration and distance walked from 2001 and 2009. Increases in biking were not proportional to the changes in walking. The change in proportion of trips from biking increased from 0.9 to 1.0%; statistically significant annual increases in biking were seen in frequency and distance. More than half of the bike trips were classified as utilitarian in purpose, as opposed to recreational. Less than one percent of people met the physical activity threshold of 30 minutes per day through biking. The cohort cycling 30 minutes per day was disproportionally male, employed, had higher income, and biked more on weekends. Prevalence by educational attainment demonstrated non-linear associations. The group with a university degree had the highest prevalence (1.3%) followed by those with less than a high school education (0.9%); persons with a high school education had the lowest rates (0.6%).[36] It is important to note that the 2009 NHTS has many limitations; it is self-report, uses only land-lines, and the marked decrease in response rate from 41% in 2001 to 19% in 2009 calls into question the validity of comparison between years.[36]

In 2014 the US Census Bureau published an overview of walking and cycling for commuters comparing the 2000 Census to the most recent five years of the American Community Survey (ACS) (2008–2012). The ACS is an annual survey conducted by the US Census Bureau to provide timely information to federal, state and local governments to allocate funds related to education, public health and infrastructure. ACS uses a stratified, random sample of about 3 million households, representative of the population.

ACS collects data on socio-demographics, housing, and economic characteristics of the US population.[37,38]

This published analysis examined walking and biking by community, demographics, income and characteristics of the commute between home and work for persons aged 16 and above.[29,30] On a national basis 2.5% of the population walked to work and 0.6% commuted by bicycle. From the baseline of 2000 to the 2008–2012 time period, the number of bicycle commuters increased 61% to 786,000. The highest rates of cycling to work were in the West. The Southern states had the lowest rates of walking and cycling. Rates of active transport for commuting were higher in urban areas. The cities with increases in biking were more likely to have a decrease in walking. This is consistent with existing literature base showing an increase in biking is often a modal shift from other active transport means.[36,39,40]

Characteristics of those most likely to commute by bicycle were younger age, male, Latino, did not own motor vehicles, had short commute distance, had lower incomes, lived in cities with colleges, and lived in households without children. Income had a primarily inverse relationship with rates of commuter cycling. The highest rates were for those with household incomes of less than $10,000 per year until a slight increase at the tail to 0.5% for those with incomes greater than $150,000. Education was shown to have a U-shaped relationship with commuter bicycling. Those with graduate or professional degrees had the highest reported prevalence (0.9%). The rates decreased with declining education (flatten at 0.3%) until an increase for those with less than a high school education (0.7%).[37] ACS has sound methodology and response is mandated by law.[38] A disadvantage of this dataset is the exclusion of non-work commute bicycling. Table A in the Appendices provides additional information on the advantages and limitations of NHTS and ACS as data sources on biking injuries.

Gender

Gender is a consistent theme in the biking literature. Biking prevalence in the US is significantly lower in females than males, especially for commuting.[36,39] Numerous factors have been identified to explain this difference; a principal reason is safety. Safety concerns are rational as biking is the highest risk mode of transportation; females are generally more risk averse than males. Evaluation of risk against benefit and perceived susceptibility to a negative outcome are key elements to an individual's decision to engage in a health behavior.[29] Edmonds et al used the socio ecologic model to explain the decreased prevalence in biking for females in a multi-city survey. Females endorsed lower levels of comfort biking, more negative perceptions of the practice of road sharing by cars, and greater preference for infrastructure changes. The gender divide in biking prevalence is not as wide in cities with more developed bike infrastructure and stronger biking culture. The authors conclude that changes to the built environment conducive to biking would improve women's safety perceptions and increase biking prevalence.[41]
In a time trade-off study of bike commuters, respondents of both genders would increase commute time to use separated bike paths and roads without parked cars. Women would trade off longer periods of time and placed increased value on lighting, road conditions, and paved shoulders on roadways. [42]

In countries with overall increased biking prevalence, better developed biking infrastructure, and less of a car-centric lifestyle, females bike at equivalent rates to male counterparts.

In the field of urban planning, a distinction is sometimes made between the objective and subjective built environments. Ma et al. documents how subjective perceptions of the built environment are often discordant with the measurable attributes of the physical biking environment. Women often had more negative ratings of the same physical space for biking. The authors highlight the importance of understanding gender differences in perceptions of infrastructure. Changing the infrastructure will not increase rates of biking for those with safety concerns unless these changes are recognized as improvements because it is the subjecting built environment that directly influences biking behavior. The challenge is to reach those not currently biking because positive experience with improved infrastructure is self-reinforcing. [43]

Other factors to explain lower biking prevalence in women are related to reasons for using transportation, household responsibilities, and practical concerns. Men are more likely to work outside the home and therefore have more opportunity for bike commuting. Women are more likely to be transporting children and goods (shopping) when in transit. Women may also have more limitations from work attire, making biking and helmet use a less desirable option.[41,42]

Cycling related mortality and morbidity

From a public health perspective, the population-level health benefits of bicycling as a physical activity must be weighed against the risk of traffic injury and death. A review of the health effects of cycling would be incomplete without discussion of the potential negative health effects of biking, which include injury, death, and morbidity from exposure to poor quality air.

The absolute number of deaths from motor vehicle crashes is obviously higher than cycling deaths given the vastly disproportional prevalence between modes of transport. Results from the US and European countries describe increased relative risks to pedestrians and bicyclists compared to transport by car or bus.[44] It is difficult to estimate relative injury and death risks among types of transportation, but it is not unreasonable to be concerned that a modal shift from car to bicycle transport could increase rates of persons injured or killed in traffic crashes.[45]

The Center for Statistics and Analysis of the National Highway Traffic Safety Administration (NTSA) publishes reports on injuries and death related to transportation from data reported by each state. In 2013, 743 cyclists were killed in crashes with motor vehicles; this is a 19% increase from 2010. Six fatalities were reported in Massachusetts. An examination of fatalities per million population revealed a national rate of 2.35, with highest rates in Florida and Arizona (6.80 and 3.68 per million respectively). The Massachusetts rate was 0.9 per million; down from 2.26 in 2012.[46,47]

As with all unintentional injuries, males were the most likely to be injured or killed (seven-fold increase from females). Younger cyclists were more likely to be injured (average age 32 years); older cyclists were more likely to be killed (average age 44 years). Further analysis of the fatal crashes reveals some interesting associations. Most deaths occurred in urban areas (68%), more than half were between the hours of 3 PM and midnight, and fatal crashes were most likely to be outside of an intersection (57%

non-intersection and 34% intersection, 9% other). Alcohol use based on blood alcohol concentration for both the cyclists and vehicle drivers was associated with about one third of the fatal crashes.[47]

The US Consumer Product Safety Commission (CPSC) conducts surveillance of bicycle-related injuries based on emergency department (ED) utilization via the National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP). NEISS-AIP is probability sample of hospitals; population estimates are based on estimates from the US Census Bureau.[48,49] Diagnosis was used as a measure of severity.[50] A 2013 analysis of NEISS-AIP data for bicycle related injuries between 2001 to 2008 reported bicycle injuries as the second most prevalent sports related injury. Demographic similarities are seen with the 2012 NTSB data. The majority of injured cyclists were male. For adults, the highest injury rates were in the 15–24 year age group.[50]

The unique contribution of NEISS-API is the clinical data on injuries. Only 4% of patients required hospitalization. For adults (defined as 15–64 years of age) injuries to the upper trunk, face and head were the most prevalent. One-third of the injuries to the head were superficial; almost 67% of the head injured were diagnosed with traumatic brain injury (TBI). [50]

The benefits of NEISS-AIP over NTSB are collection of data from off-road injuries (42% of the encounters) and information on extent of injury. Neither dataset offers a true measure of incidence of bicycle injuries. Many injured cyclists do not come to the attention of authorities or emergency room staff. The datasets provide a count of fatal injuries and more granular information on the subset of non-fatal injuries serious enough to require evaluation by emergency room personnel. Neither data source collects information on helmet usage. [46,50] See Table in tithe Appendices for further oops information on the advantages and limitations of NEISS-AIP and NTSB as data sources on biking injuries.

A final health concern for bicyclists is the negative health effects associated with exposure to air pollution from motorized vehicles. This is a reasonable concern as population based studies have shown higher rate of bicycle commuting in urban areas where there is likely to be higher vehicles density. However, there are no studies available to quantify the risk. Exposure to air pollution varies by location, volume of cars, fuel used in motor vehicles, time of day, and weather. Health effects are also expected to vary by duration of exposure (time), frequency of exposure to these differential levels of pollution, intensity of exercise, and baseline health status. Generalizations are based on clinical effects of exposure to pollutants from controlled experiments and excess death rates attributed to air pollution. Estimates of health effects are not precise, but there are enough data to infer there is health risk.[44]

Bike-share

Shared mobility is the idea that sharing vehicles to maximize use will increase access to transportation and reduce costs for individuals. The most common forms of shared mobility in the US are ride share (carpool), on-demand vehicles (Zipcar™), and bike-share.[31] Bike-share is defined as the on-demand use of bicycles in a network of docking structures with an information technology (IT) framework for one-way or round trip rides of under 30 minutes.[51,52] Benefits associated with bike-share include facilitating mobility at a lower cost to the user, decreasing traffic, decreasing use of fossil fuels and resultant emissions, and improved health. Bicycle ownership requires the purchase of a bicycle, a secure place for storage, theft prevention, bike maintenance, and the need to cycle round-trip. Bike-share eliminates these barriers with access for one-way trips available at multiple locations.[51]

Shared cycling is not a new idea. First generation systems emerged in in 1965 with the Witte Fietsen (White Bikes) in Amsterdam. There was no infrastructure for tracking utilization or preventing bicycle theft. The program quickly failed. In 1990s the second-generation models emerged. The systems required coin deposit for use. Theft remained a problem since the system lacked a means to hold users accountable for returning units.[52]

Today's third generation systems use advanced technology to avoid the problems of past initiatives. In 2005 Velo'v™ launched in Lyon, France, as the first large technology-based system. Over the next several years, cities across Europe developed programs incorporating electronically locking racks, swipe card or fob access, central tracking, and smart phone applications. At the start of 2013, thirteen IT-based public bike-share programs operated in the US; by the end of the year, 37 programs were active on at least a seasonal basis.[51,52]

The emergence of these third generation programs increased bicycle access for the population, but an unintended consequence may have been decreased access for low-income groups. In previous programs the fees were based on individual episodes at point of service. Today's systems require users establish accounts to access the system.

Generally speaking this translates into needing a credit card or debit card for deposit, and an electronic means of payment for overages and replacement of stolen bikes.[53] Across the United States, bike-share enrollment rates among low-income persons have been low. Primary reasons identified for low enrollment are: cost of initial enrollment; lack of credit card required for ongoing use; and absence of bike stations in low-income neighborhoods.[34,53]

In 2014 the Mineta Transportation Institute (MTI) released a comprehensive report on bike-share expansion in North America (US, Canada, Mexico). Programs were categorized by program ownership and for-profit status. Primary sources of revenue were membership fees, usage fees, sponsorships, public subsidies, and grants. Twenty-two US programs provided information for the 2012 season. More than 760,000 users (unique user on a per-program basis) rode 7,549 bikes from 800 stations. On a national basis, users are predominantly categorized as casual (94.5%), which means short-term sign-ups between 1 and 30 days.[51] Median US membership fees are $65. Kiosks with the highest demand are in either tourist locations or in dense mixed use areas (residential and business) close to public transportation. The cost to install and supply bikes to a kiosk is $45,000 ($6,000 per bike).[51]

MTI also conducted a member survey from five programs in North America. The survey included two US programs: Nice Ride Minnesota™ in Minneapolis-St. Paul (N= 620) and GREENBike™ in Salt-Lake City (N=72). When asked why they chose bike-share over public transportation the most common response was “faster travel and lower cost”.[51] In both Salt Lake City and Minneapolis-St. Paul, almost half of the members reported using bike-share at least weekly (44% and 47% respectively). A modal shift was demonstrated as six out of ten users reported driving a personal vehicle less frequently as a result of bike-share. [51]

MTI also performed an on-street survey in Boston (N=191). Bike-share users were passively recruited at the Hubway kiosks through scanning of QR code or use of posted URL. Most respondents were members (72%). The primary reason for using bike-share was commute to work. Commuting via bike-share substituted for subway (32%) and walking (31%).[51] There are obvious biases in the subject recruitment, but the kiosk-based survey did have the unique advantage of capturing users outside of a membership.

Harms and benefits of bike-share

A recent systematic review on the health effects of biking found a consistent positive response between biking and health with evidence of a dose-response effect. Even short rides (brief commuter trips) were shown to improve cardiovascular fitness. An inverse relationship was demonstrated between amount of biking and negative health outcomes: all-cause mortality, cardio-vascular disease and colon cancer.[33] A second systematic review specific to the impact of active transport on physical activity and body weight failed to show strong support for an association with activity or body weight. Odds ratios for the association showed consistent inverse relationships between active transport and the chosen adverse outcomes, but the confidence intervals were wide and almost half did not show statistical significance. The authors do note the limitation of the evidence base as study designs were predominantly cross sectional; measurements of key variables were crude using predominantly unvalidated measures of self-report;

populations were heterogeneous; and the small studies may have been underpowered.[54]

In addition to the direct, individual benefit, there are positive, health externalities to society from increasing levels of active transport. An increase in biking has the potential to decrease fossil fuel use and resultant harmful emissions.[54] This may be especially important in cities with high levels of atmospheric fine particulate matter.[55–57] Two recent studies are specific to injury rates and bike-share. An analysis was performed using the London bike-share utilization data, injury surveillance data, levels of particulate matter in the air, and physical activity to model the health impact on system users. The authors concluded that accurate determination of net benefit required examining the positive (health benefit) and negative (pollution and crashes) effects by both gender and age. Men received much higher net benefit as females had a higher observed rate of fatal crashes. As the age of bike-share users increased, the rate of injury and death increased; this was attributed to age related frailty. Older males had the greatest benefit, as these negative effects were offset by the greater health gain due to baseline cardiovascular risk. Bike-share cyclists had lower rates of fatal and non-fatal injury than cyclists not using bike-share. [58]

An ecologic study in The American Journal of Public Health examined the association between the operation of new bike-share programs and cyclist injuries using an interrupted time series design.[59] Each of the five cities with a public bike-share program was matched with a control city based on population size and climate. The independent variable was the opening of a bike-share program in the study city. Trauma center records for bicycle-related injuries were analyzed for two years before bike-share opening and or one year after. The authors reported that in the bike-share cities the proportion of head injuries demonstrated a statistically significant increase from 42.3% to 50.1%. The proportion of head injuries did not change in the control cities over the same period. The authors stated: “although PBSPs (public bike-share programs) may promote healthy and environmentally conscious lifestyles, this study suggests that, at the city level, PBSP implementation is associated with increased risk of bicycle-related head injuries.” It is important to point out several limitations of this study and discrepancies between results and conclusions.[60,61] There is no way to determine on an absolute or relative level how many of the head injured were injured using bike-share. About one in five of the head injured in the bike-share cities were less than 15 years of age; these are unlikely bike-share users as the studied programs had minimum age requirements of 14–16 years. The count or absolute number of head injuries and non-head injuries actually decreased in the bike-share cities after the bike-share programs were launched by 28%; the decrease in the control cities was under three percent. Study critics suggest that opening bike-share programs actually made biking safer. Bike-share cities made infrastructure changes to improve safety for the program launch. Also, an increase in overall riders may have resulted in improved motor vehicle operator vigilance.[60,62]

A common refrain in discussing bike-share is helmet usage. Observational studies have shown proportionately lower helmet usage rates in bike-share users than in people on non-bike-share bicycles in Boston, Washington DC, and New York City.[63–65] In the previously discussed MTI member survey, less than 40% of the US respondents reported always wearing a helmet n bike share. Seventeen percent of them reported both owning a helmet and never wearing a helmet on bike share.[51]

Legal mandates have been proposed in the form of helmet laws. The premise of these regulations is that requiring all cyclists to wear a helmet will change cyclist behavior towards helmet use and thus decrease injury. At this time there is no federal or state law requiring helmet use for persons of all ages. Evidence for a decrease in adult injury rates after imposing mandates are mixed, which may be due to limitations in study design.[51,62]

Bike helmet mandates have several disadvantages from the public health and policy perspectives.[62] The potential unintended consequence of helmet mandates policy is to decrease in cycling rates. An advantage of bike-share over riding a private bicycle is the ability for spontaneous use. Requiring a helmet can discourage bike-share use, which means a tradeoff of head injury risk with the individual and community health benefits previously mentioned. The inconvenience of carrying around a helmet may be perceived as not worth the safety benefit. The predicted feasibility of enforcement is low.[51]
One year before the opening of Citi-Bikes in New York City Mayor Bloomberg opposed two proposed helmet mandates that would expand mandatory helmet use above the age of thirteen years. The rationale provided for his lack of support was a concern for decreasing cycling rates.[66]

A strategy for bike-share would be to implement means to rent helmets via kiosk in tandem with the bike-share program. Implementation of helmet dispensing systems has been difficult for technical reasons, including concerns about infection control.[51,67] Other initiatives to increase helmet use are in place: hotels are offering loaner helmets to guests, some municipalities offer discounted helmets.[68 69]

Lower rates of injury on bike-share is counter-intuitive to the known lower rates of helmet use. Several rationales have been proposed, including the bike-share bicycles (heavier, speed limited by gear ratio, lower center of gravity and mounted reflectors) and the exclusion of children in US bike-share (usual age requirement is 14 to 16 years).[51,58,60]

Income-based equity in bike-share

As previously discussed, low-income groups have unmet needs both physical activity options and affordable transit. Biking has the potential to integrate physical activity with low-cost transportation. The obstacles to bike ownership are related to resources; barriers include price of purchase, need for safe storage space, and maintenance costs. Bike-share eliminates the need for storage and maintenance, but uptake of bike share in low-income populations has been low. This is disappointing as recent survey data demonstrated that income had an inverse relationship with motor vehicle use, and that those with the lowest incomes bike for both recreation and transport more than any other income group.[70] As a confirmation of need, ACS data revealed increased prevalence of bike commuting for those in the lowest income brackets.[34,51,53]

In the MTI study the personal characteristics of the US bike-share members surveyed did not mirror the population of those cities. Survey respondents were disproportionately Caucasian and more likely to have incomes above $50,000 when compared to the cities' populations. However, external validity of these within city comparison is questionable, as the report did not compare characteristics of respondents to survey non-respondent members. Generalizability to bike-share members across the US is unknown.[51]

In December 2014 the Institute for Transportation and Development Policy (ITDP) published a report specific to income based inequities and strategies to increase access across shared mobility modes. Table One provides a summary of the barriers to bike-share identified in the report at the level of the individual and of the bike-share vendor. At the foundation of each barrier lies income as the fundamental cause of disparate access to bike-share.

Table 1.1: Barriers for Equitable Bike-share Access from ITDP[31]

Individuals	Vendors
<u>Structural</u> Lack of station placement in low-income neighborhoods Need for technology to enroll <u>Financial</u> Enrollment fee Account hold for deposit Need for credit card or bank account <u>Informational/Cultural</u> Not aware of program due to lack of neighborhood stations and lack of targeted marketing Difficulty understanding program and enrolling if not English proficient	Capital cost of station installation. Station placement based on projected demand (income based, tourist sites, mixed business-residential areas) Perceived liability for damage and theft at stations

On the individual level, low-income persons lack the financial capital and resources to initiate and maintain membership. The membership fee for bike-share may be cost-prohibitive. The need for a credit or bank account is an ongoing barrier for bike-share as lower-income persons are more likely to be unbanked. Unbanked is defined as lacking an account at a federally insured institution (credit card, checking account, savings account). The account is necessary for ongoing usage fees, and some programs place a financial hold on the account as a deposit for lost or damaged bicycles. In a 2013 study performed by the US Census Bureau one in thirteen US households were unbanked, which is nearly 17 million adults. Prepaid debit cards may be a strategy as nearly one quarter of the unbanked households had used a prepaid card in the past twelve months.[71] Not all bike-share programs accept pre-paid debit cards. Current models of bike-share also require access to technology. Enrollment is on-line. Access to a smart phone is not necessary for ongoing use, but is an enabling resource. Without this technology a member may have to check several stations to locate an available bike and return dock.[72]

Consistent with fundamental cause theory, income is a marker for neighborhood resources.[73,74] Preferential station placement in higher income neighborhood means that residents of low-income communities can't use bike-share for full commutes, decreases likelihood of program awareness, and decreases probability of local membership outreach efforts. Persons without English language proficiency have the additional challenges with both knowledge of program and ability to enroll independently.[31,34,51]

Barriers at the vendor level are also related to participant resource inequity on the neighborhood level. Bike-share is a business and even not-for-profit the programs depend on revenue from enrollment and usage to maintain operations. Vendors will not want to invest in stations at which they do not anticipate demand, or in neighborhoods where there is concern for equipment loss. Without subsidization or regulation, bike-share programs will not be motivated to equally distribute stations across neighborhoods. [31,75] The consequence of the structural, financial, cultural and vendor barriers is differential access to bike-share based on income. This further increases income-based disparities in options for physical activity. The downstream effect is seen in health disparities.

Local context and the innovation

Boston has a population of nearly 650,000. The US Census Bureau estimates that 21.6% of all residents are living in poverty; this is nearly double the poverty rate for Massachusetts. It is estimated that low-wage workers in Boston are more likely to depend on public transportation to commute to work than high-wage Bostonians (40% versus 30%).[76] Selected sociodemographic and health indicators for Boston are presented in Table Two to describe the context for the innovation.

Table 1.2: Sociodemographics and health indicators for Boston and Massachusetts (2009–2014)[7,77–80]

	Boston	Massachusetts
Population	645,966	6,708,874
Non Elderly-Adults Living in Poverty	19.9%	10.7%
Children Living in Poverty	21.8%	14.9%
Per Capita income	$33,963	$35,763
Home Ownership	34.1%	62.7%
Language Other than English Spoken at Home	35.8%	21.9%
Report not Having Leisure Time for Physical Activity	31.8%	23.5%
Prevalence of Diabetes Diagnosis	7.4%	8.3%
Obesity	21.1%	22.7%
Commute to Work via Public Transportation**	33.3%	9.3%
SNAP Recipients within 12 months	18.2%	11.7%
At Least a High School Equivalency Degree	85.0%	89.4%

*age-adjusted rate per 100,000 residents ** of those employed

Boston has been consistently rated as one of the more bikable cities in the US. Scores are based on terrain, prevalence of bike commuting, availability of racks, bike lanes and other infrastructure considered to be bicyclist-friendly.[81–83] ACS data placed Boston at 14th place for frequency of bicycle committing in large cities (2008–2012).[39] Updated data estimate the prevalence of bike commuting in Boston at 1.9% for 2010–2014.[80] The city goal is to have ten percent of all trips in Boston made by bike before

2020.[84]

The city has taken a comprehensive approach to increasing biking rates across the population with concurrent infrastructure changes to improve safety. Initiatives include adding bike paths, improving signage, installing bike parking racks, safety awareness campaigns, distribution of used bicycles, and instructional classes.

The New Balance Hubway™ (Hubway) bike-share program began in Boston in 2011 through the city agency Boston Bikes. Hubway has since expanded to three other municipalities. An annual membership allows an unlimited number of trips, and riders do not pay usage fees for trips up to 30 minutes.

Boston Bikes also conducts outreach specific to underrepresented populations. Uptake of bike-share membership in the low-income population in Boston is estimated at 10%.

While this figure is higher than other urban bike-share programs, the City is committed to an even greater degree of inclusivity. As the system expands bike stations are reaching into previously unserved, low-income areas. The city's subsidized membership removes majority of financial barriers to membership. The annual membership fee of $85 has been reduced to $5, and may be waived entirely. If the enrollee does not have a credit card or pre-paid debit card, the City will assume financial risk for additional charges. Subsidized members have an extended time period for individual trips which decreases likelihood of accruing usage fees.[53,75 85,86]

Boston Medical Center (BMC) is a not-for-profit, urban, teaching hospital and the largest safety-net hospital in New England. The mission of BMC is to provide a comprehensive array of medical care services consistent with the needs of its community to ensure access and improve health outcomes. Seventy-three percent of patients are members of underserved populations, often reliant on Medicaid and other safety-net programs.[87,88]

BMC and the City of Boston are partnering to provide the first program to improve health equity of residents by addressing income-based barriers to physical activity in bike-share. Prescribe a Bike (RxBike) is an innovative approach for low-income patents combining access to bike-share membership with the power of a primary care referral. RxBike allows medical providers to write patients a "prescription" for a subsidized Hubway membership that can be redeemed on site. The patient referral process is simple, and uses a template embedded in the electronic health record.

RxBike is a promising public health and health services intervention to address physical inactivity, disparities in bike access, and need for affordable transportation. This comprehensive intervention incorporates elements at three tiers of the HIP: socioeconomic factors (subsidized membership), changing the environmental context (program expansions into low-income neighborhoods, and provision of a bike helmet with the subsidized membership), and individual counseling (provider referral to RxBike at primary care visit).[9]

Problem Statement

Preventing diseases associated with physical inactivity and secondary prevention for those with existing health problems is a priority for both public health and clinical medicine. Low-income groups are most in need given the pre-existing health disparities based on social determinants. Active transport via biking has the potential to increase physical activity while providing low-cost transportation. Low-income individuals have greater health risk and accordingly have more to gain from incorporating physical activity into daily living.

Low-income persons have higher rates of bicycle commuting, but may have limited resources for bicycle ownership. Shared ownership of bicycles via bike-share should be an especially attractive option for this group as the upfront costs are less, there is no need for storage, and bike-share is maintenance-free. As with many technologic interventions, the emergence of IT-based bike-share systems has disproportionally benefitted those with less health risk as enrollment is higher in individuals with higher incomes. This phenomenon has been referred to as a mismatch between access and risk, and is not unique to bike-share.[89] The result in the case of bike share is an increase in uptake by higher income individuals, which serves to widen the income gaps for both health equity and transportation equity. If health begins where individuals live and work then it should be a priority to create and evaluate "sustainable solutions at the intersection of health and daily life" to reduce disparities.[8] RxBike is one possible strategy.

While the City can remove financial barriers to access and RxBike can facilitate enrollment, program referral is only the first step towards equitable, realized access. Examination of the predisposing characteristics of existing subsidized, Boston, Hubway members is needed to target individuals most likely to be interested, and to identify disparities within the subsidized members. The first part of this project will analyze these records.

RxBike is has the unique feature of incorporating a non-traditional, public health service in a traditional medical care setting. A familiar refrain in health services research is the failure of medical care providers and the larger health care system to adopt evidence based practices.[90] The implementation of novel innovations such as RxBike may be more of a challenge as there is no evidence base to support program efficacy. The population-level health benefit cannot be assumed to be a valid predictor of individual patient risk. This leaves the provider with equipoise as to the safety and health benefits of the program. It is necessary to better understand the perceptions of primary care providers to tailor the design of an effective strategy to encourage provider referral to RxBike. The second part of this project will examine the perspective of these primary care providers.

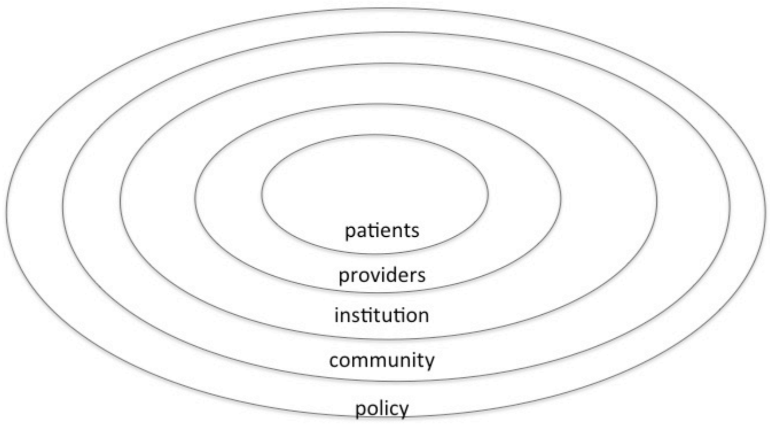
RxBike is primary care intervention using local health policy to reduce income-based disparities for biking as active transport and health promotion. The challenge for health services is to determine the efficacy of both the clinical intervention and the implementation efforts in order to improve provider uptake, reduce access disparities, and improve health. This third part of this project will evaluate program implementation at BMC.

Theoretical Context & Framework

Project framework

A socio-ecologic model (SEM) of health behavior will be used as the project framework (Figure 1.2); SEM integrates the community interventions for health promotion at the base of the public health pyramid with clinical medicine at the level of the individual. Each ring of the concentric circles represents a different aspect of the multiple environments influencing health behavior.[91] This patient-centered perspective examines individuals' personal attributes within the cumulative, interrelated health promoting influences of relationships with medical providers, the environment at BMC, and bike equity policies from the city of Boston.

Figure 1.2: Socio-Ecologic Framework for Project

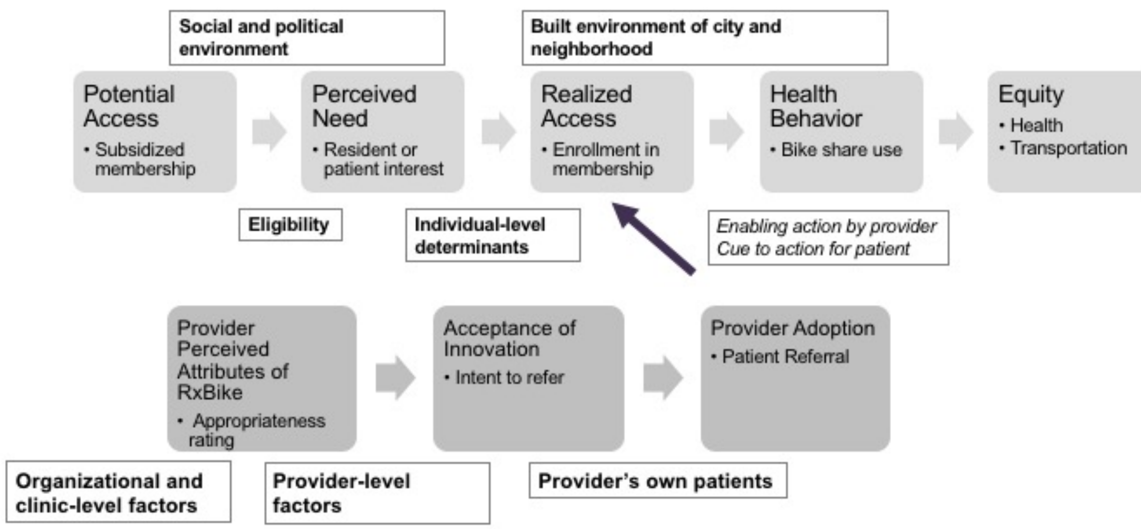


Patient-level factors are at the core and nested within the direct influence of the interpersonal level of patient-provider relationships. Counseling patients about physical activity and referring to RxBike is the clinical intervention at the provider level at the top of the public health pyramid. Primary care providers act within the joint contexts of relationship with patients and the structure of the larger institution of BMC. Through it's infrastructure, policies, communication channels, and resources, BMC provides the institutional environment for patient care. The two outermost rings represent the public health interventions at the base tiers of the public health pyramid. The community of Boston surrounds the institution and the built environment of Boston affects the patient-level decision about bicycle use. The final level is policy, which is the city policy to fund the subsidized membership for low-income residents.

Conceptual Model

Two health services theories will be embedded within the SEM framework to create the overall conceptual model for this dissertation. This model is depicted in Figure Three. The population-level goal of the RxBike intervention is the adoption of biking as a form of health promotion to improve health equity and transportation equity. The three studies described below focus on intermediate outcomes, as depicted below.

Figure 1.3: Conceptual model for project (full-page version in appendix)



In the first study, the Andersen Behavioral Model of Health Service Use[92] will be used to examine the relationship of patient level characteristics to program access. All low-income Bostonians have potential access to the subsidized membership. Enrollment in the subsidized membership is the measurable outcome that will serve as an intermediate proxy for equitable access to bike-share at the level of the city of Boston. The distal outcome will be program utilization (biking). This first study is not specific to BMC because a broader snapshot of Boston's subsidized bike-share members is necessary to understand the perceived and realized need related to membership. In the second study, Everett Rogers' Diffusion of Innovation theory[93] (DOI) will provide the foundation to understand clinician uptake of the program within the social environments of the individual primary care clinics and BMC. The primary care providers are the targets of the RxBike implementation efforts at BMC. Consistent with DOI theory, the provider-level perceived attributes of the innovation will be examined as the outcome of study two. The third study will examine the implementation of the RxBike innovation at BMC. Implementation will be evaluated using the intermediate measures of the provider process of patient referral as enabling access and the successful enrollment of patients in the program as realized access.

Policy and community environments

The City's strategies to reduce disparities in bike access aim to change the default options for transport without limitation by income or place within Boston. Changes within the community are the structural modifications to encourage safe biking for all residents.[9] The funding of the subsidized membership is a policy initiative to remove the financial barrier to actualized use for persons of low-income.

Institutional environment

RxBike truly is a partnership of two institutions: BMC and the City of Boston. Boston Bikes is the first governmental agency to partner with a health care institution to expand uptake of subsidized membership through primary care. SEM classifies the role of BMC as an intermediary between the community-level intervention and patient-provider encounters.[91] BMC is an ideal setting to launch the RxBike program as the institution has a long record of creating, implementing, and disseminating innovative programs within the realm of traditional medical care to reduce health inequity based on social determinants.[94–96 94–97]Program success benefits both institutions as positive publicity from the lay media and academia are key to maintaining a strategy as prime mover in their own external environments.

In DOI, Rogers defines diffusion as “the process in which an innovation is communicated through certain channels [93]over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas" (p. 5–6). To Rogers, DOI is a universal process, and not specific to a specific field, type of innovation, or adopter category.

Providers and the innovation

Ideally all provider decisions about patient care would be based upon consideration of each option for an individual patient. This is not a realistic expectation given the complexities of clinical medicine, patient heterogeneity, and time constraints. Resultant assessments about the consequences of actions may be simplified and based in the context of competing demands at the patient encounter. This bounded or limited rationality in provider decision-making leads to choices based on familiarity and availability. These cognitive biases are obstacles to the successful diffusion of an innovation. The process of social change is driven by the decision to accept or reject an innovation, as well as the consequences of those decisions.[93]

Innovation attributes are not absolute. Each provider’s decision to refer to RxBike will depend on that provider’s knowledge, beliefs, and experiences in many areas: primary care, physical activity, biking, safety of city biking, bike-share, and the provider's perception of the appropriateness of the innovation for individual patients. Perceived attributes of the innovation include relative advantage, trialability, complexity, and observed effects. Rogers estimates that perceived attributes are responsible for at least half of the variation observed in innovation adoption rates. Additional constructs for intervention source, strength and quality of evidence are important additions framing the RxBike innovation.[98] Opportunity cost and workflow changes needed for patient referral may serve as barriers.[93]

Diffusion of innovation

In DOI theory the innovation-decision process is "the process through which an individual (or other decision-making unit" passes from first knowledge of an innovation, to the formation of an attitude towards the innovation, to a decision to adopt or reject, to implementation and use of a new idea, and finally a confirmation of this decision."[93] Using the nomenclature of Rogers, the institutional decision to adopt or allow RxBike at BMC is an authority decision. BMC as an institution did not recommend or mandate program use.[93]

The decision to refer a patient is optional and dependent on the individual provider. Rogers describes a five-step decision making process: knowledge, persuasion, decision, adoption, and confirmation.[93] During the persuasion stage, the provider forms an attitude about RxBike, which could be positive or negative. Once an overall decision is made about the degree of advantage or disadvantage of the overall RxBike program, the next phase of decision-making is at the level of individual patient encounters.[93]

Primary care providers are concerned with the direct benefit of an intervention to individual patient in the room. Without the time or ability to make a fully informed decision the provider may err on the side of patient safety and not refer the patient. Adoption is the one-time act of making a patient referral; referral serves as the mechanism for patient access. Confirmation should occur after each referral between the levels of provider and patient, but will be greatly delayed given lag time between the health promoting act (use of the bike) and effect (health effect) of this preventive intervention.[16] It is important to note that adoption is a patient-level, discrete event. The decision process is recursive because initial provider adoption of RxBike does not ensure continued use.

Individual patients

The end outcome of RxBike is to improve health by facilitating access to bike-share for low-income populations; the distal goal is health benefit. The intermediate outcome of the RxBike innovation is patient enrollment.

Boston has higher uptake of low-income enrollment than other cities, but enrollment remains significantly disproportionate to the proportion of eligible low-income residents. The Andersen Behavioral Model of Health Service Use will be used to examine factors associated with realized access for this population. [92,99] Predisposing characteristics and enabling resources of individual enrollees will be the foci of analysis. Consistent with the SEM, the enabling potential of the multiple levels of environmental influences hinge on degree of congruence with individual need.[91] Community level strategies to increase bike-share equity and BMC's institutional adoption of the RxBike program are environmental enabling factors. Potential access to bike-share is evidenced by the City's subsidized membership, location of new stations and modifications of the built environment. It is hypothesized that provider referral may be the leverage point or trigger to activate patient's perceived need.[29,91] Realized access to bike-share requires effort by the patient to enroll in the program and use the bikes. Access is inequitable when there are disparities in realized access based on patient factors, as well as the community and societal environments. One project goal is to identify mutable environmental and other enabling factors to guide subsequent initiatives to improve uptake and reduce disparities.

Evaluating the implementation

The aim of program evaluation is to examine effectiveness, progress towards goals, feasibility of intervention, fidelity of implementation, efficient use of resources, unanticipated outcomes, and areas for improvement for the innovation and implementation.[100] Targets of the current implementation are clinical providers within the primary care clinics at BMC. The goal and measurable outcome of implementation is the proximal process of referral to RxBike by a primary care provider. A secondary outcome is realized access to membership as evidenced by enrollment of referred patients. The end product of the RxBike evaluation will be feedback to improve the program.

CHAPTER TWO

Access to a Subsidized Bike-Share Program for Low-income Residents in the City of Boston

Study Description

Summary

The Hubway bicycle sharing system in Boston was launched in 2011. In addition to standard memberships for users of the system, Boston offers subsidized Hubway memberships for low-income residents. However, subsidies may not be sufficient to facilitate access. The literature has shown that the barriers to bike share for low-income persons extend beyond the personal financial capital and necessary bank account to secure membership. The other known barriers are related to lack of neighborhood resources. The impact of place on bike share is evidenced by lack of stations in low-income neighborhoods, lack of membership marketing in these geographic areas, and decreased likelihood of the infrastructure changes to encourage biking as seen in higher income neighborhoods. A second known inequity in bike share is gender. Underrepresentation of females has been noted in membership and utilization. It is unknown if these differences are mirrored in the low-income population.

At the policy level, the subsidized memberships are designed to promote income-based equitable access to bike-share. At the individual level, access to bike-share for low-income persons would promote health, and offer an option for low-cost transportation. In order to understand whether the City's goals are being met, it is important to examine the subsidized population enrolled in Hubway, in terms of both individual characteristics and

associations with place.

Research question(s)

What are the socio-demographic characteristics of Boston residents in the subsidized Hubway membership? How do these members compare to the non-subsidized Boston members in terms of gender, neighborhood, and utilization?

Specific aims and hypotheses

Objective 1: To describe bike-share members living in Boston in terms of gender, neighborhood, and membership type at the trip-level.

There is no testable hypothesis for this objective. *

Objective 2: To examine the differences in gender, neighborhood, and utilization between the subsidized and nonsubsidized members.

H_{A2}: There will be differences in utilization by gender between membership types.

H_{A2}: There will be differences in utilization by neighborhood between membership types.

Objective 3: To examine the difference in sociodemographic and health indicators as markers of neighborhood disadvantage between membership types.

H_{A1}: There will be differences in sociodemographic and health indicators for neighborhoods of riders by membership type.

*Objective 1 is exploratory and may generate hypotheses for future work in this area.

Data source(s)

1) The Director of Boston Bikes has provided deidentified trip-level data for the all Hubway rides for January 2011 through October 31, 2015

2) Data on neighborhood population, socioeconomic markers, health indicators, and racial/ethnic composition at the neighborhood level were provided by the Research and Evaluation Unit of the Boston Public Health Commission (BPHC). BPHC data sources were the US Census (2010), the American Community Survey (ACS; 2008–2012), The Massachusetts Center for Health Information and Analysis (2012), Boston's Behavioral Risk Factor Surveillance Survey (BRFFS; 2013), and the Massachusetts Department of Public Health (MA DPH; 2008–2013). See Appendix B14 for technical notes.

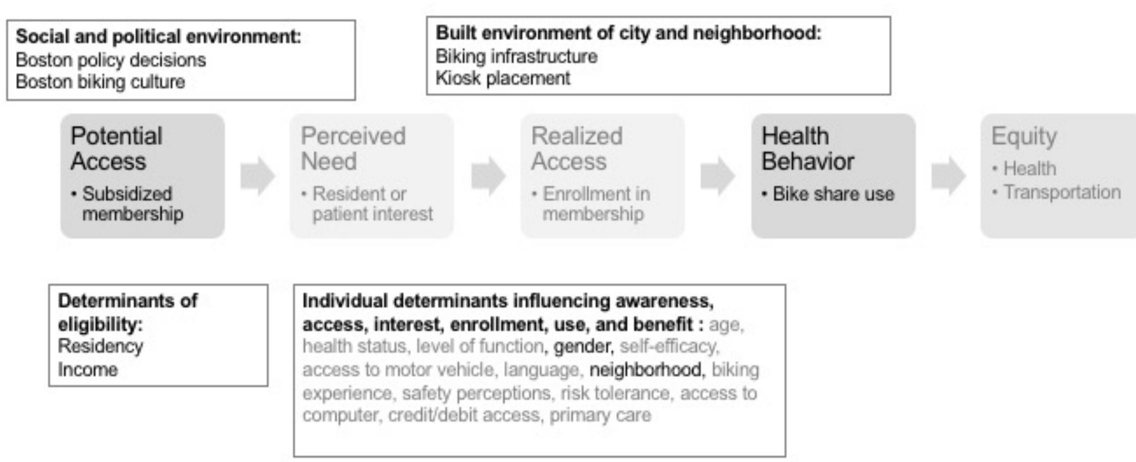
The BUMC IRB determined this study to be non-human subjects research.

Design and Methods

This observational study will examine the relationships among gender, neighborhood characteristics, Hubway enrollment, membership type, and utilization using secondary dataset analysis.

Relationship to Conceptual Model: See the figure below for a depiction of the linkage between this study and the overall project conceptual model. The full model is available in the Appendix A2. The subsidized bike share membership may be considered a form of *potential access* to bike share for low-income Bostonians. The changes Boston has made to streets and signage to promote biking are communitywide, thus considered *enabling factors*. Placement of bike kiosks in low-income neighborhood will facilitate resident access to the program. Other determinants of the residents' decisions to enroll will be based on *personal characteristics* and *individual enabling resources*. Enrollment is a marker of *realized access*. The measurable outcome is bike-share *utilization*. The unmeasurable person-centered end outcomes are health and transportation equity.

Figure 2.1: How Study One Relates to the Conceptual Model for the Overall Project and Study Outcomes



Variable Specification: See Table 2.1 for description of constructs, variables, measures and data sources for study one.

Table 2.1 Variable Specification for Study One

Construct	Variable	Measure	Data Source
Population-Level Explanatory Variables			
Member characteristics	Patient characteristics, membership type, and patterns of use	Resident enrollment, gender, zip code, trip length, year of trip	Boston Bikes data
Neighborhood resources (Place)	Community-level social determinants of health, potential access to biked	Sociodemographic and health indicators for neighborhood	BPHC
Population-Level Outcome Variables			
Realized access	Enrollment	Membership by year	Boston Bikes data
Health behavior	Utilization	Patters of use (number of trips, duration of trips)	Boston Bikes data

Analysis

Data were provided in Microsoft Excel files and imported into SAS™ (Cary, NC; version 9.4) for analysis. Significance testing was performed using two-sided statistical tests with an a priori α level set at 0.05. The analysis was primarily descriptive. Continuous variables were examined for distributional properties (box and whisker plot, normality, extreme observations, missing data) as well as measures of central tendency and variability (mean with 95% confidence interval, median, standard deviation, range, quartiles). Categorical and ordinal variables were described graphically and with frequencies (bar chart or histogram respectively, count, proportions). Subjects were linked to neighborhoods using the BPHC's zip-code crosswalk.[101] The study population was then described and compared by membership type in terms of member demographics, socio-demographics of home zip code, and patterns of utilization.

Each neighborhood was compared to the entirety of Boston by indicator. This method yielded conservative estimates of differences as each neighborhood was also included in the Boston comparator statistic. *Relative advantage* refers to a neighborhood with more favorable socioeconomic and health indicators than the entire city as evidenced by lower rates of negative events and lower proportion of residents with markers of low socioeconomic status. Trends in neighborhood health advantage were examined using the proportion of rides by residents of neighborhoods in top performing quartiles (lowest rates) for preterm birth, diabetes mortality, and diabetes hospitalizations from 2012 to 2015. For the other measures in health, BPHC had classified each neighborhood as performing better (more favorable) than Boston, same as Boston, or worse than Boston. Race was examined by classifying each neighborhood has having disproportionate racial/ethnic composition (< 50% or >150%) compared to total Boston population.

Bivariate description and analysis were performed to examine rider differences between membership types by gender and neighborhood. Inferential statistics were performed using the χ^2 test for homogeneity across groups.

Sample size and power: Power calculations were not performed as the dataset contained all rides for Boston members from Hubway launch through October 31, 2015.

Results

The initial dataset consisted of 3,652,299 trips; 990,008 trips were excluded as one of the following: casual trip, rider zip code outside of Boston, rider zip code in Boston not linkable to a neighborhood, and missing gender (details in Figure 2.2). Examination of data identified subsidized member rides beginning in 2012; 2011 rides were therefore excluded. Rides greater than two hours, and rides under three minutes with same station for departure and arrival were excluded. The Boston data set contained 1,256,385 rides. Unless otherwise noted, this is the dataset used for analysis. Rides through October 31, 2015 are referred to as 2015. It should be noted that the Government Center stop was not included in the data, as it was not included in the initial dataset provided by Boston Bikes.

Figure 2.2 Creation of dataset for analysis

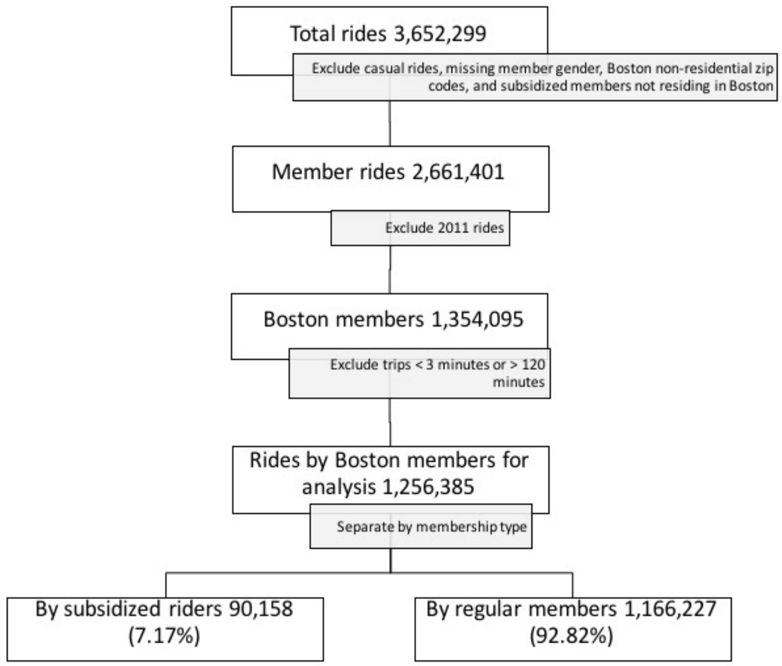


Table 2.2 presents select statistics on the non-unique members making the 1,256,385 rides. The majority of riders were non-subsidized (regular) members (92.82%). Riders were disproportionately male (73.28%). The number of trips increased from 2012 to 2014, then decreased for 2015. Riders were not evenly distributed among neighborhood of residence, nor were they distributed proportional to neighborhood population. Comparison of utilization by population count is not informative as the metric is confounded by disparate bike kiosk (station) among neighborhoods, and kiosk expansion across the study period. Residents of three neighborhoods - Back Bay, South End, and Fenway – each took more than 250,000 trips. The fewest trips were by residents of West Roxbury (n= 39,800), Hyde Park (n = 1,922), and Mattapan (n = 310). The majority of trips (97.66%) were at or under 30 minutes duration. Additional description of trips and visual comparison of utilization by population are in appendix B1-2.

Table 2.2 Trip-level description of riders (n=1,256,385)

	Frequency	Percent
Membership type		
regular member	1,166,227	92.82
subsidized member	90,158	7.18
Gender		
female	340,944	27.14
male	915,441	72.86
Year of trip		
2012	216,673	17.25
2013	307,536	24.48
2014	399,251	31.78
2015	332,925	26.50

Subsidized members

As shown in Table 2.3, the proportion of subsidized member rides increased from 4.9% in 2012 to 8.13% in 2014; and decreased to 7.59% in 2015. There was an overall trend identified on proportion of subsidized members across years (CMHχ^2 1451.5512, df=1, p<.0001).

Table 2.3 Proportion of trips by membership each year (n=1,256,385)

	% Subsidized	% Regular	Total Trips (#)
2012	4.90	95.10	216,673
2013	7.09	92.91	307,536
2014	8.13	91.87	399,251
2015	7.59	92.41	332,925
Total #	90,158	1,166,227	1,256,385
%	7.18%	92.82%	

Distribution of rider neighborhoods by membership type demonstrated the subsidized membership improved participation in neighborhoods with low penetration of the regular membership. Roxbury and North Dorchester are notable because rides by these residents were three- and five-fold higher for subsidized members than for regular members. Results are presented in Appendix B3.

Gender equity

Across the membership, 27.14% trips were by females with mild fluctuations between years. An overall association was found between year and proportion of female riders, but this was not significant as a trend. Results are in Appendix B4.

The gender breakdown of trips showed that female ridership was highest in 2012 for both membership types. Proportion of female trips was consistently higher within the subsidized membership (33.08% for subsidized members versus 26.68% for regular members). The odds of a female rider were 1.3652 times higher for the subsidized members than for the regular members; results are in Table 2.4.

Table 2.4 Proportion of rides by females within membership type by year and odds that trip was by a female for subsidized versus regular members (n=1,256,385)

	% Female rides within membership				
Year	**Subsidized membership**	**Regular membership**	**Odds Ratio**	**95% Confidence Interval**	
2012	34.35	27.05	1.4114	1.3544	1.4708
2013	32.46	26.07	1.3631	1.3234	1.4040
2014	34.07	26.95	1.4009	1.3676	1.4350
2015	31.81	26.67	1.2827	1.2477	1.3187
Total	33.08	26.68	1.3688	1.3392	1.3786
#	90,158	1,166,227			

Gender distribution was not consistent across neighborhoods. Male members were responsible for more than 82% of trips for North Dorchester, South Dorchester, and West Roxbury combined. Females made more trips than males only among residents of Mattapan. Results are presented in Appendix B5.

There was evidence that subsidized membership improved female equity within certain neighborhoods, although the absolute impact was low given the lower number of subsidized rides.

Appendix B6-7 describes the heterogeneity of gender distribution among neighborhoods by membership type. In five neighborhoods, odds of a female trip were more than twice as high for subsidized females than for regular females.

Trip Duration

The distribution for trip time in minutes was markedly non-normal with positive skew, kurtosis, a mean of 11.73788 (standard deviation 7.92696) and median of 9.7853 (see Appendix B8-9). As seen below in Table 2.5, there was a positive trend seen in trip time across years. The median increased from 9.10 minutes in 2012 to 10.25 minutes in 2015; a parallel increase was seen in the percent of trips over 15 minutes and length of trip at the 95th percentile. Variance was found for trip time in minutes among groups. The longest trips were by subsidized females, followed by subsidized males, regular females, and regular males.

Table 2.5 Description of trip duration in minutes by membership type and year

	Total trips	**Median time in minutes**	**IQR in minutes**		**% > 15 minutes**
Subsidized female	29,826	11.47	7.38	18.12	34.81
Subsidized male	60,332	11.22	6.73	18.47	35.01
Regular female	311,118	10.85	7.25	16.11	29.14
Regular male	855,109	9.30	6.14	14.10	21.77
2012	216,673	9.10	6.14	13.84	20.98
2013	307,536	9.49	6.26	14.43	22.96
2014	399,251	10.03	6.55	15.23	25.82
2015	332,925	10.25	6.71	15.48	26.77
All	1,256,385	9.79	6.44	14.87	24.54

Explanatory model for trip time

The next step was to take a more detailed investigation of differences in trip time by group. Given the non-normality of the trip time variable, the decision was made to create a categorical variable. Across all rides, 75.46% were less than 15 minutes, 22.0% were 15–30 minutes, 2.07% were 30 to 60 minutes, and < 1 % were greater than 1 hour; see Appendix B10 for breakdown of trip time. In the unadjusted analyses, females had a higher proportion of longer trips (29.64 versus 22.44 %); and the odds of a longer trip being made by female member were 1.4394 times the odds of the longer trip by a male member. Subsidized members had a greater proportion of trips for over 15 minutes as compared to the regular members (34.94 versus 23.73%). The effect for membership type was stronger than for gender; a ride greater than 15 minutes had 1.7259 times the odds of being by a subsidized versus a regular member. The percent of trips greater than 15 minutes increased annually from 20.98% in 2012 to 26.77% in 2015; the trend was statistically significant. Results of these unadjusted analyses are in Appendix B11-12. Logistic regression was used to determine if trip time could be predicted from the available variables of gender, membership type, and year. The outcome variable was trip time longer than 15 minutes. The model was statistically significant, but had poor predictive ability and was not able to discriminate between the outcomes. Model description and technical summary are in Appendix B13.

Neighborhood equity

Neighborhood risk and resources were captured using BPHC indicators for socioeconomics, health, and demographics; see Appendix B14 for data sources and technical detail. The socioeconomic and health indicators were highly correlated and demonstrated good internal consistency reliability (Cronbach alpha 0.9101); these results are in Appendix B15.

A snapshot of Boston for these indicators is in Appendix B16. At the household level, half of Boston housing units occupied by renters were classified as having a financially burdensome rent, one in five residents lived at an income below poverty level, one in six adults aged 25 and above did not have a high school diploma, one in nine households were classified as linguistically isolated, and the unemployment rate was 10.3%.

From the perspective of demographic diversity, Boston is a minority-majority community; 47.01% of residents identified as white non-Hispanic, 22.36% as Black non-Hispanic, and 17.47% as Hispanic/Latino of any race (will refer to this group as Latino). The demographic analysis used only these three racial/ethnic groupings. See Appendix Figure B17 for a chart of the complete racial/ethnic composition of Boston from the 2010 Census.

For most health indicators, the highest rates of adverse outcomes were in Blacks, followed by Latinos, and then Whites. Mental health hospitalizations showed an opposite trajectory with 9.9 hospitalizations per 1,000 for Whites, 8.3 per 1,000 for Blacks, and 5.3 per 1,000 for Latinos; rates of suicide and unintentional overdose were two-fold higher for Whites than either other group. Blacks had significantly higher rates of homicide and emergency department visits for gunshots and stabbings. A Latino advantage was seen for mortality rates and life expectancy (Latino life expectancy of 86.4

years, 79.5 years for Whites, and 77.0 years for Blacks).

Health risk and behavior were examined but these indicators did not distinguish among Boston neighborhoods because of wide 95% confidence intervals and insufficient data for reporting in smaller neighborhoods.

Socioeconomic determinants of health

Compared to the entire city, riders lived in neighborhoods with lower unemployment, lower rent burden, less linguistic isolation, and fewer residents without a high school diploma; in contrast, 56.21% of riders lived in neighborhoods with relatively high poverty (Appendix B18). Across the four-year time period (2012–2015) the proportion trips by residents of advantaged neighborhoods rose for linguistic isolation, unemployment, and rental burden. The percentage of riders from advantaged neighborhoods decreased only for income below poverty level. These results are presented in Table 2.6 and Appendix B19.

Table 2.6 Trend in rides from members of socioeconomically advantaged neighborhoods (n=1,256,385)

Indicator of advantage	2012	2013	2014	2015
Fewer households with linguistic isolation	37.53	41.00	41.94	44.07
Fewer residents without HS diploma	60.20	63.60	62.00	61.58
Fewer unemployed residents	43.14	48.14	47.73	48.74
Fewer residents in poverty	32.84	31.08	27.18	26.57
Fewer housing units with rent burden	37.23	40.87	41.58	43.65

The proportion of trips by subsidized riders from neighborhoods with neighborhood disadvantage was compared to neighborhoods of the regular riders for each indicator. The subsidized membership had greater penetrance into disadvantaged neighborhoods for all indicators. The odds of a subsidized rider living in a disadvantaged neighborhood were highest for low education and unemployment (odds 2.05 and 3.75

times higher). See Table 2.7 for results with 95% confidence intervals.

Table 2.7 Comparison of neighborhood socioeconomic disadvantage between membership type (n=1,256,385)

Indicator of disadvantage	**% subsidized**	**% regular**	**Odds ratio**	**95% CI**	
Linguistically isolated households	31.45	21.73	1.6529	1.6287	1.6774
Population with less than a high school diploma	15.30	8.09	2.0524	2.0131	2.0924
Unemployment rate	15.80	4.76	3.7535	3.6798	3.8286
Income below poverty level	69.65	55.17	1.8647	1.8376	1.8923
Housing units with rent burden	33.37	27.25	1.3373	1.3181	1.3567
Total (#)	90,158	1,166,227			

Health indicators

Riders lived in neighborhoods with fewer admissions and deaths from chronic disease, and lower incidence of adverse birth outcomes compared to the entirety of Boston. Results for changes in proportion of riders from advantaged neighborhoods across the study period were mixed. See Table 2.8 and Appendix B20 for results and χ^2 testing.

Table 2.8 Trend in rides from members of neighborhoods with health advantage (n=1,256,385*)

Indicator of advantage	**2012**	**2013**	**2014**	**2015**
Lower preterm birth weight	12.86	15.13	18.80	18.99
Lower diabetes mortality rate	9.19	10.97	12.08	11.13
Lower diabetes hospitalization rate	55.82	53.68	48.81	45.97
Lower mental health hospitalization rate	64.25	65.39	67.28	66.61
Lower chronic illness mortality rate	64.68	62.08	65.63	65.38
Lower chronic illness hospitalization rate	74.94	73.78	73.73	68.55
Lower birth adverse outcome rate*	53.49	54.59	51.78	46.25
Lower homicide rate**	18.67	21.87	21.23	18.78

**Sample size 1,252,510; ** sample size 637,015*

Subsidized membership was examined for associations with living in neighborhoods with health disadvantage. Neighborhood disadvantage was demonstrated for all but one indicator; results are presented in Table 2.10. Subsidized riders had 2.7 to 3.7 times the odds of living in a neighborhood in the lowest quartile (highest rates) for preterm birth, diabetes hospitalizations and diabetes mortality (10–15% of subsidized riders versus 3–5% of regular riders). Subsidized riders resided in neighborhoods with more hospitalizations for mental health, worse outcomes for chronic disease, and higher homicide rates.

Table 2.10 Comparison of neighborhood disadvantage by membership type for health indicators

Health indicator of disadvantage	% subsidized	% regular	Odds Ratio	95% CI	
Bottom quartile for preterm birth	10.43	3.71	3.0248	2.9547	3.0964
Bottom quartile for diabetes mortality	10.43	3.71	3.0248	2.9547	3.0964
Bottom quartile for diabetes hospitalizations	15.50	4.76	3.6724	3.5998	3.7464
More mental health admits	64.88	54.58	1.537	1.5154	1.5589
More chronic disease mortality	14.51	8.99	1.7186	1.6853	1.7526
More chronic disease hospitalizations	16.20	4.89	3.7615	3.6885	3.836
More negative birth outcomes*	23.58	24.07	1.0277	1.0114	1.0442
More than 1.5x homicide rate**	23.09	9.65	2.8122	2.7546	2.8709
Total (#)	90,158	1,166,227			

**Total sample size 1,252,510; ** sample size 637,015 n for subsidized = 61,663 n =575,352 non subsidized*

Racial/ethnic composition

The final set of indicators was for self-reported racial/ethnic composition for neighborhood of rider relative to the entirety of Boston. Riders resided in neighborhoods with lower proportion of Black residents (neighborhood of rider for 70.67% of riders), average to high proportion of Whites (94.45% riders), and were generally not from neighborhoods with high proportion of Latino residents.

Table 2.11 Trend in race/ethnicity for rider neighborhoods of residence (n=1,256,385)

	2012	2013	2014	2015
Higher proportion of Whites	35.96	39.22	37.78	39.42
Lower proportion of Blacks	67.89	72.70	71.35	69.77
Lower proportion of Latinos	31.08	29.40	25.22	24.98

These results are presented in Table 2.11 and Appendix B21. Over the four years, there was a slight increase in proportion of rides by residents of neighborhoods with a higher proportion of Whites and a lower proportion of Blacks; both trends were statistically significant. Representation from neighborhoods with a higher proportion of Latinos increased over the four-year period; crosstab is in Appendix B22.

Subsidized riders had 3.7 times the odds of residing in a neighborhood with racial/ethnic patterns consistent with health inequities- disproportionately high Black population and a disproportionately low White population. Riders were also twice as likely to come from neighborhoods with higher proportions of Latinos.

Table 2.12 Disproportionate racial and ethnic composition of neighborhoods of riders by membership type compared to entire city

Relative proportion of race/ethnicity	% subsidized	% regular	Odds Ratio	95% LCI	95% UCI
Lower proportion of Whites	15.80	4.76	3.7535	3.6798	3.8286
Higher proportion of Blacks	16.20	4.89	3.7615	3.6885	3.836
Higher proportion of Latinos	13.98	6.41	2.3728	2.3253	2.4213

Discussion

Examination of Hubway utilization demonstrated that Boston riders lived in neighborhoods with socioeconomic and health advantage compared to the total population of Boston. Riders also lived in neighborhoods with a racial composition consistent with better health outcomes. One of the few exceptions is higher rates of mental health hospitalization, which may be more of a marker of improved access to mental health services as opposed to a proxy for poor mental health. It is not surprising to see the associations of socioeconomic[51,102] and health advantage with bike sharing utilization.

Over the four years of ridership a pattern was seen of increasing ridership by residents of advantaged neighborhoods. These trends may correlate with station expansion preferentially in advantaged neighborhoods. These findings are unfortunate, as residents of the more disadvantaged neighborhoods should have relatively more to gain from the health impact biking and the expansion of affordable transportation options.

Subsidized membership increases gender equity as subsidized riders are more likely to be female. Subsidized members also have slightly longer trip times, which supports the membership provision to allow 60 minute rides before applying overage charges. More subsidized riders come from underserved neighborhoods based on the social determinants of health and health outcomes. The impact on the overall membership is minimal as subsidized members made only 7.18% of the rides. The subsidized membership gives Hubway penetrance into Boston neighborhoods with socioeconomic and health disadvantage. As previously mentioned, there are both individual cost barriers to membership and neighborhood-specific barriers to bike-share for low income persons. This speaks to the previously mentioned theory of fundamental cause as subsidized members have less in the way of personal resources, live in disadvantaged neighborhoods, and have less access to bike kiosks where they live.

This study evaluated trip level bike-share utilization. Utilization is a fitting outcome because membership statistics would only capture realized access; the act of signing up to be a member does not in itself confer health benefit. There are four important limitations to this study. Utilization is confounded by distribution of bike kiosks, which are not proportional across neighborhoods and changed over the course of the study period.[103] The 2015 data did not include November and December; the addition of these months would be unlikely to have a significant impact because the weather became less conducive to casual biking and the bike kiosks within Boston were removed by December.[104] The analysis was on a macro level by rider neighborhood. This may have decreased ability to identify both temporal changes and differences between rider types within the neighborhoods with higher degree of heterogeneity for health, socioeconomics, and racial/ethnic composition. Lastly, it is worth noting that while all members had income below 250–400% FPL (eligibility varied), there were likely members with similarly low incomes in the regular membership because there is no income screening for membership through the Hubway enrollment portal.

The subsidized membership initiative has demonstrated success at reaching residents from neighborhoods with socioeconomic and health disadvantage. It is reasonable to hypothesize that bike-share use resulted in an expansion of affordable transportation options for the subsidized members.[105] This study does demonstrate the potential for the subsidized membership to improve both health and transportation equity for low-income Bostonians. The population-level impact will not be meaningful unless subsidized membership enrollment increases, and the bike-share network is expanded into disadvantaged neighborhoods.

CHAPTER THREE

Predictors of Primary Care Provider Uptake of Bike-Share Referrals for Low-Income Patients in an Urban Teaching Hospital

Study Description

Summary

The subsidized membership within the Hubway system is a program for low-income Boston residents via Boston Bikes. Membership fee is $5.00, a helmet is provided, and riders do not accrue usage charges for rides under 60 minutes. The City of Boston and Boston Medical Center (BMC) have partnered to expand access to this existing subsidized bike-share membership. The Prescribe a Bike (RxBike) program allows healthcare providers at BMC to print a “prescription” or referral for this program, which can be redeemed on-site. Despite hospital-wide social marketing to providers and clinic-based information sessions, initial patient enrollment in RxBike was low. In order to understand the perspective of the providers regarding RxBike, is it necessary to examine their knowledge, attitudes and experiences related to urban biking and bike-share.

Research question(s)

How do provider characteristics and provider biking relate to opinions on bike safety, beliefs about their patients’ suitability for bike-share, and perceptions about the RxBike program? Are there identifiable predictors for positive, provider perceived attributes of the RxBike innovation and willingness to refer?

Specific aims and hypotheses

Objective 1: To examine primary care provider experiences and perceptions about biking in general and urban biking in particular.

There is no testable hypothesis for this objective.*

Objective 2: To examine the association between provider demographics and practice characteristics with perceptions of urban biking.

H_A: There will be associations identified between provider characteristics and perceptions of urban biking

Objective 3: To examine the association between provider biking and providers' perception of their own of patients' biking.

H_A: Providers with more positive perceptions of biking safety and current experience with urban biking will have differential estimations of own patients' biking.

Objective 4: To examine provider perceived attributes of the RxBike program

There is no testable hypothesis for this objective.*

Objective 5: To examine predictors of positive perceived attributes of RxBike and associations with provider willingness to refer to RxBike.

H_A: Providers with more positive perceptions of biking safety and current experience with urban biking will report more positive perceived attributes of the innovation, and indicate increased willingness to refer patients to RxBike.

*Objectives 1 and 4 are exploratory and may generate hypotheses for future work in this area

Data Source(s)

Primary data collection from an IRB-exempt, anonymous web-based survey of primary care providers at BMC in General Internal Medicine, Pediatric/Adolescent, Family Medicine, and HIV Primary Care practices.

The Institutional Review Board (IRB) at Boston University Medical Center determined this study was IRB-exempt as non-human subjects research; a HIPAA waiver was issued. Survey development and study population are described below.

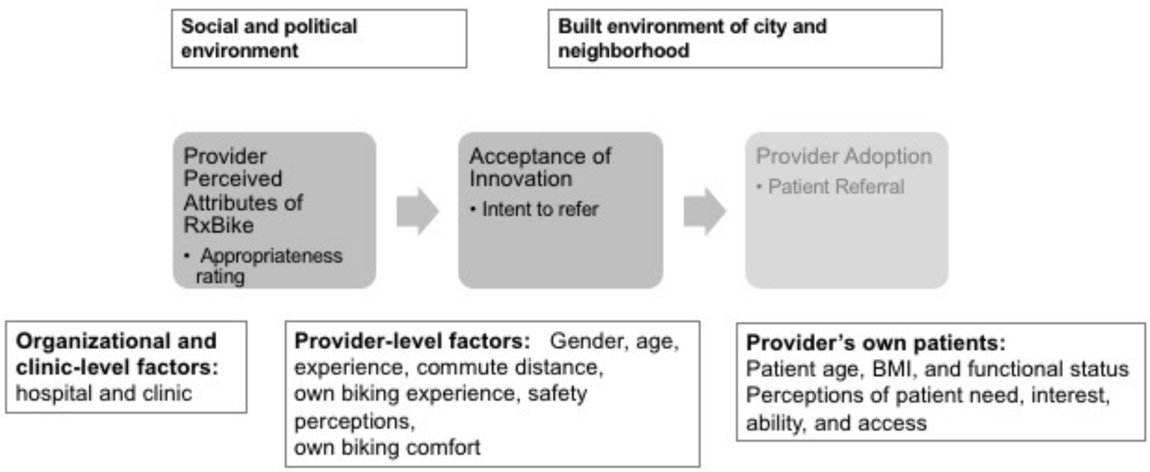
Design and Methods

In this this cross-sectional study I collected primary data to examine the relationships among provider characteristics, provider biking, provider perceptions of own patients' biking, and provider perceptions of the RxBike innovation. The outcomes of interest were perceived attributes and acceptance of the innovation.

Relationship to Conceptual Model: See the figure below for a depiction of the linkage between this study and the overall project conceptual model. A principal factor impacting adoption within DOI theory is the perceived attributes of the innovation. Perceived attributes serve as the foundation for the decision to accept or reject the innovation, and the subsequent act of adoption.

The five characteristics of perceived attributes are relative advantage, compatibility, complexity, trialability, and observability. Each characteristic is based on the subjective perception of the implementation targets (primary care providers). In the survey instrument created for this study (Study Two), constructs included predisposing characteristics, bilking experience, perceptions of safety, and provider evaluation of own patients' biking as these factors may predict the compatibility or fit of RxBike with provider preferences. In the face of equipoise regarding patient benefits and harms, safety was hypothesized to be a key construct. The previously presented evidence base for net health benefit of biking is on a population level, and not predictive of individual-level outcomes for the BMC patients.

Figure 3.1: How Study Two Relates to the Conceptual Model for the Overall Project with Study Outcomes



Variable Specification: See table below for description of constructs, variables, measures and data sources for study two.

Table 3.1: Variable Specification for Study Two

Construct	Variable	Measure	Data Source
Clinician-Level Explanatory Variables			
Provider Characteristics	Gender, age, experience, work setting, role	Gender, years of experience post training (proxy for age), clinic location, provider type	Provider survey
Provider Perceptions on Biking	Experience, reasons for biking, urban biking experience, bike commuter, potential for bike commuting, experience with bike share	Commute distance in miles, frequency of biking, seasonality of bike commuting, reasons for biking, locations of biking, use of bike-share, use of Hubway	Provider survey
Perceptions on Safety	Perspective of safe driving behavior of car operators, perspective of safe driving behavior of bikers	Opinion on cars sharing road, opinions on bikes sharing road	Provider survey

Perception of patient biking interest	Relevance of RxBike to patient population, potential safe biking behavior of patients	Proportion of patients with: ability to bike, access to bikes, interest in biking, comfort on bike, access to Hubway, use of helmet, familiarity with bike rules	Provider survey
Perceived Attributes of Innovation	Relative advantage, trialibility, complexity, compatibility, observability	Provider perceptions of barriers to use: time, hassle, appropriateness Provider concern about liability and patient safety	Provider survey
Acceptance of Innovation	Decision to accept of reject	Appropriateness	Provider survey
Clinician-Level Outcome Variable			
Intended Uptake	Proxy for use of program	Willingness to refer a patient to program	Provider survey

Instrument Development: Initial review of the literature did not identify an existing survey instrument to address the research questions. Development of the 'Primary Care Provider Survey on Biking' was loosely based on the process described by Streiner and Norman (2008).[106] The study team met to discuss content areas of interest based on literature review as well as previous discussions about the potential barriers and facilitators to provider uptake. Thirty-eight potential questions were grouped into content areas. Individual questions were evaluated for face and content validity by the implementation team. The Boston Bikes staff provided expert opinion on questions regarding biking behavior and rider perceptions of safety. Dr. Meyers served as expert on both primary care practice and urban bike commuting. The team deleted items, expanded the questions on safety, and retained only the items of greatest interest to develop a brief instrument. The final constructs of interest were provider characteristics, provider biking, provider perceptions of own patients' biking, and provider perceived attributes of the RxBike innovation. See table below for description of the variable types and response scales.

Table 3.2: Structure of the Primary Care Survey on Biking

Subsection	Screen	Number of Questions*	Response Type and Scale
Provider Characteristics	1	6	Categorical/nominal, binary, numeric, ordinal
Provider biking habits	1	5	Unipolar, ordinal frequency- 4 point scale (year-round to never), categorical/nominal
Provider biking safety perceptions	2	4	Bipolar, ordinal 5 point scale for level of agreement (strongly agree to strongly disagree); 1 question had N/A option for non bikers
Provider beliefs about patient biking	2	7	Bipolar, ordinal 5-point scale for estimate proportion (most to none) and option for unable to answer
Provider perceived attributes of RxBike innovation	2	7	Bipolar, ordinal, level of agreement- 5 point scale (strongly agree to strongly disagree)

The second step was to determine response options for questions. Some items were clearly nominal (gender, provider type, clinic location). For questions in which the response was on a continuum, adjectival scales were used with descriptors listed for each response option. Effort was made to phrase the question stems to be a logical fit with a consistent scale for consecutive questions. Most questions had five response options to balance the need to capture detailed information with minimal respondent burden using straightforward quantifiers. An odd number of choices was offered with a neutral or mid-point as the team thought there was validity to neutral responses. For the questions on provider perceptions on own patients' biking, a non-ordinal, sixth response option was added to indicate respondent inability to estimate own patients' biking. It was thought preferable to have a response off the ordinal continuum of 'how many' to avoid skipped questions and unreliable responses.

The final step was to create a Survey Monkey™ version of the paper instrument.

Images of the instrument are located in Appendix C1. The on-line survey was divided into two pages. Questions were grouped by content area; subsections were not labeled to promote flow. Response choices were displayed horizontally with the text descriptions of each response choice at the top of the nested question. There were open-ended optional comment boxes at the end of each closed-ended question except for gender and clinic. The final question was an open-ended text question inviting the respondent to offer additional information on biking or the RxBike program. A bar at the bottom of each page indicated percent completion. None of the questions was formatted for a forced response. The bottom of the second page included a thank you for participation statement and explanation of the incentives for survey completion.

Pilot Testing: An informal pilot testing phase used a convenience sample of volunteers, including health services research students and graduates, physicians, and registered nurses. Volunteers were sent the Survey Monkey link and asked to complete the survey in order to to provide feedback regarding time to complete, clarity of instructions, and applicability of response choices. Feedback from volunteers was received verbally and electronically. Minor modifications were made to wording and instructions based on feedback. Formal literacy analysis was not performed on the instrument because all subjects have completed more than a college education.

Subjects and Settings

Boston Medical Center (BMC) was chosen as the site for this study as it is the only facility with the RxBike program. Four primary care clinics were chosen as the principal sites for adult primary care within the institution: General Internal Medicine

(GIM); Family Medicine; HIV Primary Care; and Pediatric and Adolescent Primary Care (cares for young adults to age 22 years). All primary care providers were included in the study (attending physicians, trainee physicians, mid-level providers).

The department chair of each clinic approved the study before clinicians were contacted. There was no formal consent process; survey completion was used as a proxy for consent.

Recruitment: Each department provided a distribution list for primary care providers. A Survey Monkey hyperlink was sent to each provider with an introductory note via BMC email. See Appendix C2 for the text of the introductory email.

There were two separate incentives provided to increase response rate. After survey completion and submission, subjects were brought to a new screen with links to participate. Respondents could opt to enter the raffle to win a Target gift card; each respondent could also request a one-day Hubway pass. To preserve anonymity of the data, incentive requests were collected into separate datasets and not linked to the row level subject responses to the questionnaire.

Within each clinic the providers received an initial e-mail invitation, and three follow-up email requests. The survey was performed in spring 2014 to serve as a baseline before commencing RxBike implementation in the clinical areas.

Analysis Plan

Results were downloaded from Survey Monkey into Microsoft Excel 2010™ for data preparation, and imported into SAS™ (Cary, NC; version 9.4) for analysis. The overall strategy was intent to treat; each subject with at least 75% of the survey completed was included in the analysis. Significance testing was performed using two-sided statistical tests with an a priori α level set at 0.05. Response rates were calculated overall, and by clinic site.

Descriptive statistics were calculated to examine the distribution of responses for each question. Initial description of the populations used frequencies, measures of central tendency, proportions, and graphics. Variables coded with Likert or similarly ordered response scales were analyzed as ordinal. Categorical, ordinal, and binary variables were described graphically and with frequencies (bar chart if categorical and histogram if ordinal, count, proportions). Number of clinic sessions per week and years of experience post-training were examined as numeric variables using mean, standard deviation, quartiles, range, normality statistics, and visual representations of the distributions. Categorical and binary variables were created from numeric variables to allow description and analysis as frequencies.

Cronbach α scores were calculated for each subsection to evaluate for within-section internal consistency reliability. Impact of individual items within the subscale was assessed with each item deleted. Homogeneity of items within the subscale was evaluated with item-total correlations using a matrix for the associations between each pair of items. Standardized scores were used for subsections with consistent response scales. Alpha scores above 0.7 were considered to be indicative of acceptability to evaluate the question set as a single construct.

Specific statistics used in the analytic portion were dependent upon the distributional properties of the variables from the initial analyses. Categorical variables with at least three response choices were collapsed into fewer categories and/or binary outcomes. Bivariate description and analysis were performed to examine differences between groups. Comparisons between groups by gender, years of experience (proxy for age), clinical department, trainee status, and sessions per week were performed with χ^2 tests for homogeneity across groups, Fisher's exact test when cell size not appropriate for the standard χ^2, and Mantel-Haenszel χ^2 for linear trends in ordinal variables. Similar inferential statistics were performed to assess the associations between each covariate with the dependent variable (willingness to refer a patient to RxBike).

Exploratory factor analysis (EFA) was performed on the questions on provider estimation of patient biking, and provider perceived attributes of RxBike due to the *a priori* assumption of intercorrelation between variables; tests included communalities (using the squared multiple correlations of each variable for the prior estimates), Eigen values (cutoff > 1.0), proportion of variance explained (cutoff >0.10) and cumulative proportion of variance for each added variable (cutoff >= 75%). A scree plot was created to visualize the relative contribution of each identified factor to total variance. Orthogonal factor loadings were examined for each variable to determine allocation of variables with correlation coefficients of at least 0.3 to the identified factors. The number of factors retained and the specific items included within each factor were based on results of the testing, interpretation of Scree plot, number of items with high loadings within each factor, and congruence or meaningfulness of content with conceptual model. Each retained factor was named related to content. Results of the factor analysis were used to create composite variables, and in regression modeling.

Logistic regression was used to examine the associations between provider characteristics, provider biking, provider perceptions of own patients' biking, and provider perceived attributes of the RxBike innovation with the dichotomized outcome of strong agreement with intent or willingness to refer. The planned approach was to build the model manually using both forward and backward techniques to maximize explained variance Selection of explanatory variables was based on cross-tabs, results of factor analysis, literature review and the conceptual model.

Sample size and power: As previously described, all primary care providers in the four clinics of interest were surveyed. The decision was made to survey the entire population of providers to maximize sample size for analysis.

For the studies that were hypothesis generating in intent, a 95% CI for proportion of the primary outcome (intent to refer) was calculated. The proportion of agreement with non-agreement was 0.9125 with a 95% CI of 0.8505 to 0.9745. Dichotomizing the outcome variable as strong agreement ("strongly agree") and a combination of the other response choices resulted in a proportion of 0.30 with a 95% CI of 0.20 to 0.40. Power calculations for the logistic regression examining the associations of the explanatory variables with intent to refer to the program revealed the ability to detect an odds ratio as small as 2.4 with 80% power at a two-sided α of 0.05 assuming a proportion of 0.30 for the category of interest versus the referent.

Results

Eighty-one surveys were returned; eighty contained sufficient data to include for analysis. The overall response rate was 36.44%. The response rates ranged from 18.75% in family medicine to 55.00% in pediatrics.

Thirty-nine variables were derived from twelve questions. Open-ended comment fields were not included in this quantitative analysis.

Provider characteristics

Each of the four clinical areas was represented in the sample of respondents. Select descriptive frequencies for provider characteristics are presented in Table 3.3; additional categorization of variables is in Appendix C3.

Table 3.3: Description of Provider Characteristics

	Frequency	Percent
Gender (n=79)		
Female	49	62.03
Male	30	37.97
Clinic Site (n=80)		
Family practice	3	3.75
General Internal Medicine	35	43.75
HIV primary care	9	11.25
Pediatrics	33	41.25
Clinic Type (n=80)		
Adult	47	58.75
Pediatric	33	41.25
Position (n=79)		
Attending	37	46.84
Fellow	3	3.80
Nurse Practitioner	5	6.33
Resident	34	43.04
Experience (n=80)		
Trainee	33	41.25
1–5 years	16	20.00
6–10 years	13	16.25
11–20 years	7	8.75
21–40 years	9	11.25
>40 years	2	2.50

Sessions per Week (n=80)		
Up to 1/week	37	46.25
Between 2 and 5/week	34	42.50
More than 5/week	9	11.25
Commute in miles (n=79)		
<1 miles	15	18.99
1 to 3 miles	25	31.65
4 to 5 miles	16	20.25
5 to 10 miles	11	13.92
10 to 15 miles	3	3.80
>15 miles	9	11.39

The clinical sites were grouped as pediatric (Pediatric and Adolescent Clinics) and adult (GIM, HIV, Family medicine) because the absolute numbers of respondents from HIV primary care and Family Practice were low (3 and 9 respondents respectively); 41.25% of the respondents were in pediatric clinics and 58.75% were in adult clinics.

Providers were divided into staff (53.16%) and trainee (46.84%) using respondent self-report of clinical position because only three nurse practitioners and five fellows responded. More than half of the respondents self-identified as female (62.03%), one respondent did not select a gender.

Clinical experience and sessions per week were asked as numeric variables. See Table 3.4 for univariate statistics for these results; more complete results with statistics for subset of staff providers are in Appendix C4.

Table 3.4: Univariate statistics for numeric provider characteristics

	Experience in years	Clinic sessions per week
N	80	79
Range	0 to 43	0.5 to 8
Mean	7.16	2.75
Standard Deviation	10.34	2.01
IQR (P25 to P75)	0 to 10	1 to 4
Median	2	2
Mode	0	1

Clinical experience was asked as years of experience post-training. Trainees were instructed to enter 0 to indicate lack of post-trainee primary experience. The respondents reported a wide range of years in practice post-training from 0 to 43 years. Experience demonstrated a non-normal distribution (Shapiro-Wilk W=0.723976; $p<0.0001$) with strong positive skew (skewness 1.70774144), a heavy tail and mode at the value of 0 years. Univariate testing was repeated after excluding trainees. The distribution of the staff subset was shifted to the right (n=42). The mean for experience almost doubled when trainees were removed from the sample (7.1626 to 13.2857143 years). The standard deviation slightly increased, which may be due to the smaller sample (from 10.339155 to 11.137733). The median increased five-fold towards the mean with a widening and shift in the IQR from 0 to 10 years for all providers to 5 to 22 years for staff providers only. The distribution remained non-normal, but less so (Shapiro-Wilk W 0.891525; $p= 0.0008$). Visual inspection of the distribution before and after removal of trainees by histogram, box and Q-Q plot confirmed the description above.

Experience was categorized into four ordinal levels as the lack of normality was a concern for violating the assumptions of parametric inferential statistics. Less than half of the respondents reported < 1 year of clinical experience post-training (41.2%). About one-fifth of the sample (21.25%) reported 1–5 years of experience; 16.25% reported 5–10 years and 21.25 reported > 10 years. Experience was also categorized as two dichotomous variables with cut-points of 5 years and 10 years.

Number of half-day clinic sessions per week was asked as a numeric variable. As with experience in years, sessions per week was analyzed for the whole group and then for staff providers. For the entire group, mean number of sessions was 2.75000 with a standard deviation of 2.0060; median was lower at 2.00. The distribution was non-normal with a Shapiro Wilk W statistic of 0.831608 (p<0.0001) and positive skew.

Repeat analysis without the trainees revealed a shift to the right, although the mode remained at the minimum value of 1 session per week. The mean and standard deviation increased (3.6845 and 2.0534). The median doubled (2 to 4) and the lower bound of the IQR increased (IQR 0.5 to 8 for total sample, and 1 to 8 for staff providers). The shift was confirmed with visual inspection of the histogram, box and whiskers plot, Q-Q plot.

The numeric variable for sessions was reclassified as a three level ordinal variable: up to and including 1 session per week (46.25%), between 2 and 5 sessions per week (41.25%) and > 5 sessions per week (12.5%). The two dichotomous variables for sessions were up to including 1 per week (schedule typical for residents) and > five sessions per week (more than one half-day session each weekday).

Commute distance from home to BMC was asked as a categorical variable to assess distance in miles to control for distance in the association between bike commuting, biking in Boston, and outcome variables. Half of the respondents live with 3 miles of BMC (50.63%), 34.18% live within 4–10 miles and 15.19% live more than 10 miles from BMC. The commute variable was also dichotomized with cut points of 3 miles, 5 miles and 10 miles.

Relationships within provider characteristics

In the three adult sites, more than half of respondents were staff providers (range 54.29% in GIM and 88.89% in HIV primary care). Only pediatrics demonstrated higher proportion of respondents as trainees than staff members (57.88% trainee).

Females comprised 62.03% of the sample, 55.32% of the adult providers, and 71.88% of pediatric providers. GIM had the most even distribution with 54.29% female. In pediatrics 71.88% of respondents were female. HIV primary care demonstrated the greatest proportion of female respondents with 77.78% of respondent were female. The association between gender and department missed statistical significance as the Fisher's Exact test did not meet the threshold (statistic 0.0007, p=0.0504, n=79). Gender was not associated with years of experience, sessions per week, or commute.

Given the descriptive differences previously described in provider characteristics by trainee status, the decision was made to examine statistical associations between trainee status and provider characteristics. Trainees were more likely to have fewer than five years experience, have only one clinic session per week, and have a commute of under five miles to BMC. Gender was not associated with trainee status. See Table 3.5 for breakdown of provider characteristics by trainee status. More complete results, including odds ratios with 95% CIs are in Appendix C5–6.

Table 3.5 Description of provider variables by trainee status

		Trainee	Staff	Full Sample	χ^2 , df	p-value
All respondents	#	37	43	79/79	NA	NA
	%	46.25	53.75	100		
Female provider	#	22	27	49/79	0.0235	0.8782
	%	61.11	62.29	62.03	1	
Provider in adult clinic	#	18	29	47/80	2.8983	0.0887
	%	48.65	67.44	58.75	1	
More than 5 clinic sessions/week	#	0	9	9/80	8.7258	0.0031
	%	0.00	20.93	11.25	1	
More than 5 mile commute from home	#	3	20	23/79	13.8393	0.0002
	%	8.33	46.51	29.11	1	

Sessions per week as an ordinal, row variable showed a statistically significant linear trend with trainee status; crosstab and testing are included in Appendix C7. The majority of trainees had up to one session per week and none had more than five. Staff provider session distribution was inverted U-shaped. Staff providers were equally likely to have one session and more than five (21.43% each) with the remaining 57.14% in clinic between two and five times weekly. Trainees had 11.7531 times the odds of having only one session per week compared to staff providers (95% CI 4.1102 to 33.6076).

Results for associations between experience and provider characteristics with odds ratios for experience dichotomized with a five-year cutpoint are presented in Appendix C8–9. As expected, a significant linear trend was seen for experience and trainee status, as trainees by definition are inexperienced; this comparison served as a check of internal validity. Experience in years was not shown to be associated with gender or clinic type. Experience in years as an ordinal variable did show an association with sessions (CMH 10.2876, df = 3, $p<0.001$). The providers with up to five years of experience had 5.41 times the odds of having no more than 1 session weekly (95% CI 1.9534 to 15.003). Associations between experience and commute are discussed below.

Commute distance was examined for associations with other provider characteristics. Distance from home to BMC was significantly associated with all provider characteristics except gender and clinic type. See Appendix C10 for full results. Commute distance in miles as an ordinal variable showed a statistically significant linear trend within at least one commute stratum with trainee status; crosstab and results of testing in Appendix C11. The distribution of staff providers by commute distance is a shallow, inverted, U-shape; 32.56% of staff providers lived within 3 miles of the hospital, 41.86% lived between four and ten miles, and 25.58% lived greater than 10 miles from the hospital.

Directionality for these associations was evaluated with odds ratios for the commute variable divided into within 5 miles of BMC and greater than 5 miles from BMC. See Table 3.6 for these proportions, odds ratios and 95% confidence intervals. The providers more likely to live within 5 miles of BMC were trainees (91.67%), had fewer clinic sessions per week (75.51% had <= 5 sessions), and were less experienced (81.25% of those with < 5 years experience lived within 5 miles and 77.05% of those with under 10 years of experience lived within 10 miles). The relationship for experience was maintained with cutoffs of 5 and 10 years. There was no relationship seen between the dichotomized commute variable with gender or pediatric provider status.

Table 3.6: Odds ratios between commute up to 5 miles with select provider characteristics

	n	% living w/in 5 miles		OR	95%LCI	95%UCI
Gender		Female	Male			
	78	70.83	70	1.0408	0.3834	2.8252
Clinic type		Adult	Pediatric			
	79	70.21	71.88	0.9224	0.3419	2.488
Trainee status		Trainee	Staff			
	79	91.67	53.49	9.5652	2.5421	35.991
Sessions per week		<=5	>5			
(up to 5)	79	75.71	33.33	6.2353	1.4057	27.658
Experience in years		<=5y	>5y			
(up to 5y)	79	81.25	54.84	3.5686	1.2962	9.8251
Experience in years		<=10y	>10y			
(up to 10y)	79	77.05	50	3.3571	1.1176	10.0844

Odds ratios for experience with provider characteristics were rerun with a subset of staff providers only (see Appendix C12). When looking at only staff providers none of the odds ratios maintained significance, which suggests a potential confounding role of trainee status with the other provider characteristics.

Provider biking

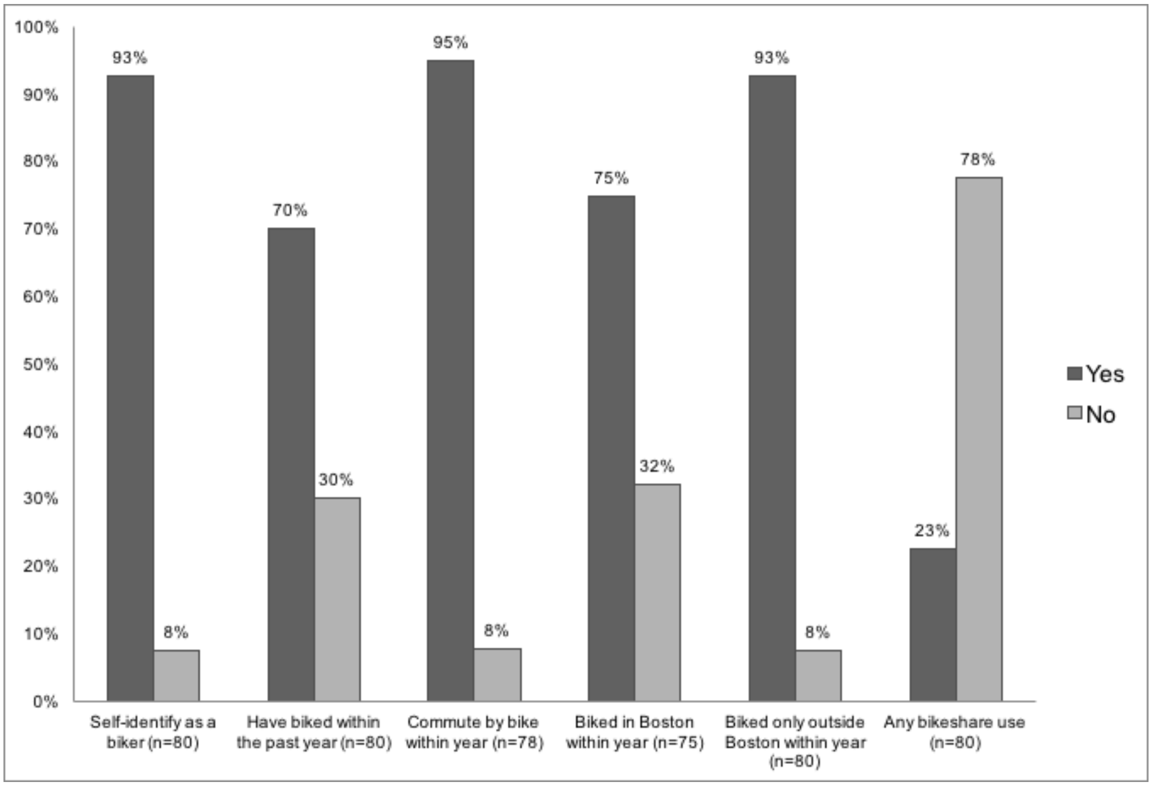
A series of questions assessed provider biking. These are presented in Table 3.7; see Appendix C13 for complete descriptives of biking questions. Overall 92.5% of the sample self-identified as bikers. The proportion of active or current bikers was assessed by asking about specific bike practices over the past 12 months. The response options were categorical: never, occasionally, regularly when warm, year-round. The most common reason for biking regularly was commute (32.47%) followed by health (29.84%) and pleasure/leisure (24.08%).

Table 3.7 Description of Provider Biking Responses

	Frequency	Percent
Biking Composite within 12 months (n=78)		
Not a biker	24	30.77
Yes, non-commuting	22	28.21
Yes, some commuting	18	23.08
Yes, year-round commuting	14	17.95
Bike for Health in Year (n=78)		
Never	35	44.87
Occasionally	20	25.64
Regularly when warm	16	20.51
Regularly year-round	7	8.97
Bike for Pleasure in Year (n=78)		
Never	25	32.05
Occasionally	35	44.87
Regularly when warm	15	19.23
Regularly year-round	3	3.85
Bike for Commute in Year (n=77)		
Never	45	58.44
Occasionally	7	9.09
Regularly when warm	11	14.29
Regularly year-round	14	18.18
Bike in Boston in Year (n=75)		
Never	41	54.67
Occasionally	14	18.67
Regularly when warm	11	14.67
Regularly year-round	9	12
Only bike outside Boston this year (n=80)		
I am not a biker	24	30
I do not bike in Boston	17	21.25
I bike in Boston	39	48.75

Biking at least occasionally within the past year was measured with a composite variable using provider indication of at least occasional use for the reasons above; 30.77% of respondents reported not biking within the past 12 months. 28.21% indicated biking for non-commute, and 41.03% indicated bike commuting.

Figure 3.2 Provider report of own biking



Biking within the city of Boston was also asked about with 12 months as the recall period. More than half of respondents reported not biking in Boston within 12 months (54.67%), followed by occasional (18.67), regularly when warm (14.67%) and regularly year-round (12.0%). The biking variables were dichotomized as yes/no, results are shown in Figure 3.2. The group of 41 respondents who reported not biking within Boston was examined to determine the relative proportions of those not biking anywhere in the past year (n=24), and those biking only outside of Boston (n=17). Bike-share use was not asked with a timeframe to capture any previous use of a bike-share program; 22.5% of respondents reported having used a bike-share program. Of these 18 respondents, 15 had tried the Hubway program and two had been members.

Relationships between provider characteristics and provider biking

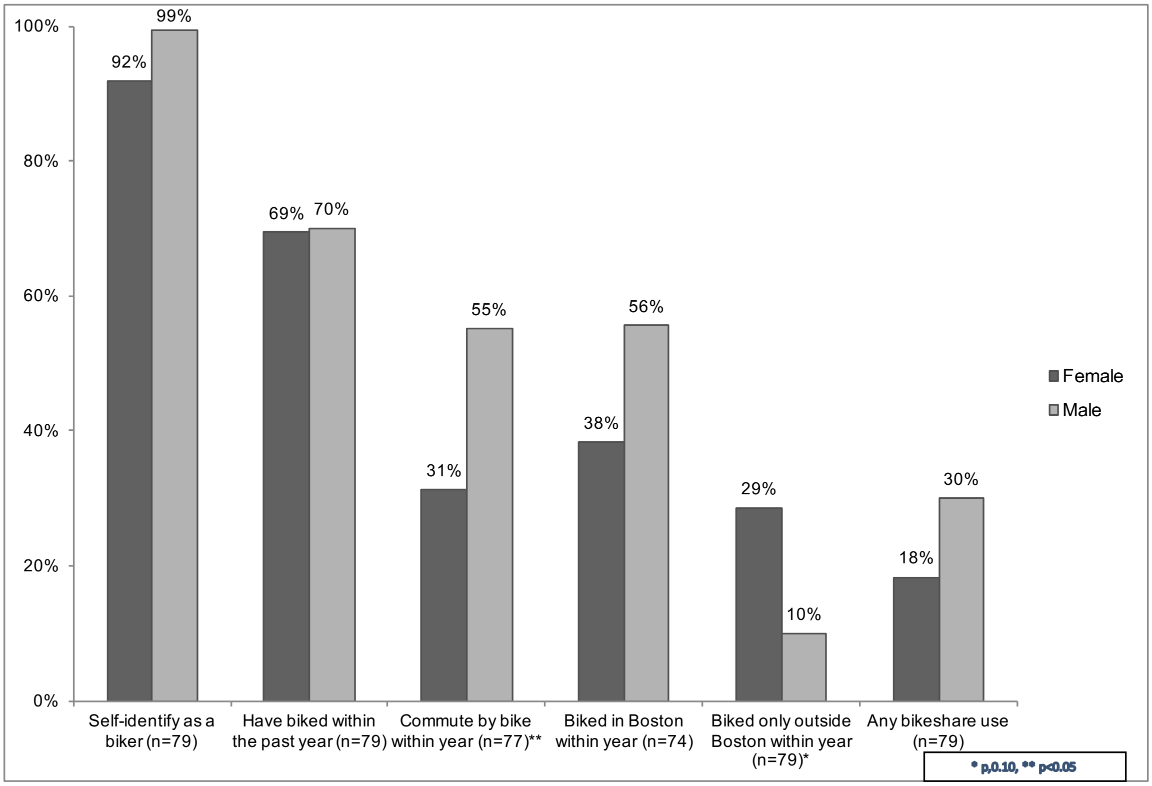
The next step was bivariate testing of associations between provider characteristics and biking using χ^2 tests for both categorical and ordinal variables. For dichotomous comparisons, odds ratios were calculated with 95% confidence intervals.

Figure 3.3 displays provider biking stratified by gender. For all variables except biking outside of of Boston, males endorsed higher levels of biking. Females were almost three times as likely to report biking only outside of Boston compared to males; this association approached statistical significance (Fisher's Exact 0.0343, $p = 0.0885$). Prevalence of bike commuting as a dichotomous variable between gender showed that 31.25% of females reported bike commuting as opposed to 55.17% of males. Males had 2.7077 times the odds of being bike commuters (95% CI 1.0441 to 7.0219). Self-identification as a biker and report of biking within the past year were not associated with gender. No associations were seen between gender and biking for fitness or bike share use; complete results in Appendix C 14–15.

The only association found between clinic type and biking was for bike share use; 31.91% of adult providers reported bike share use as opposed to 9.09% of pediatric providers ($\chi^2 = 5.7919$, df = 1, p=0.0161, n=80). There were no statistically significant associations found between the ordinal variables for sessions per week and experience in years with the provider biking variables.

Commute distance had been hypothesized to be related to bike commuting because providers living at a distance from the hospital may be less likely to commute by bike. It was also postulated that providers living closer to the hospital would be more

Fig 3.3 Provider biking by gender



likely to have used bike-share as the Hubway system had only recently moved to placing multiple kiosks in outlying municipalities. Conversely, provider living within Boston (close to BMC) may be less likely to bike near home if concerned about urban traffic on roadways and/or less likely to bike commute if living in very close proximity.

Dichotomizing the commute variable did reveal differences in prevalence of biking behavior between those commuting within 5 miles of BMC and those commuting more than 5 miles. These results are presented in Table 3.8. Those living within 5 miles of BMC were about twice as likely to have used bikeshare (26.79% versus 13.04%) and to have biked in Boston during the past year (51.92% and 27.27%). Those living within 5 miles were also more likely to identify as bikers, report biking within the past year, and bike commute. None of these differences in proportion reached a level of statistical significance in this sample. No associations were found between trainee status and biking.

Table 3.8: Provider biking odds by commute using 5 miles as the cutpoint

Affirmative response	n	% Commute <= 5 miles	% Commute > 5 miles	OR	95% LCI	95% UCI
Self-identify as biker	79	98.21	78.26	15.2778	1.6726	139.5488
Biked for commute within past 12 months	77	46.3	30.43	1.9704	0.6987	5.5571
Biked in Boston within past 12 months	74	51.92	27.27	2.8800	0.9736	8.5194
Biked only outside of Boston with past 12 months	79	19.64	26.09	0.6926	0.2214	2.1667
Use of bikeshare	79	26.79	13.04	2.439	0.6323	9.4078

Provider beliefs about biking and safety

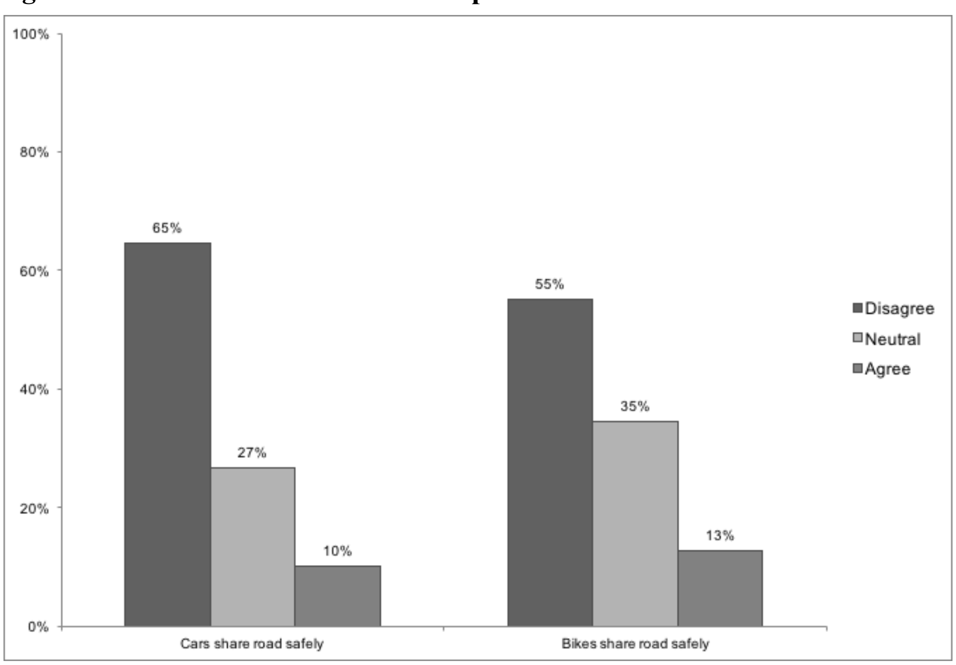
Two sets of questions were used to evaluate provider comfort with biking and provider perceptions of road safety. Perceptions of road safety were assessed with the following questions: 1) cars safely share the roads with bikes, 2) bikes safety share the road with cars. Response options were on a five-point Likert scale with anchors of strongly disagree to strongly agree; response frequencies are presented in Table 3.9. There was minimal provider endorsement for cars sharing the road safely with bikes with 10% agree and 0% strongly agree. About one quarter or providers indicated a neutral position (25.25%) and the majority indicated disagreement (43.75% disagree and 20.00% strongly disagree). There was slightly more agreement about safe bike behavior on the roads (12.50%) with more neutrality (33.75%) and a smaller majority indicated disagreement (53.75%). See Appendix C16 for complete descriptives. There was evidence of a positive linear association between perceptions of car road sharing and bike road sharing with a Spearman's correlation coefficient of 0.67362, n= 80, p<0.0001).

Table 3.9 Provider rating of reciprocal safe road behavior for cars and bikes (%)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Cars share the road safely with bikes (n=80)	20.00	43.75	26.25	10.00	0.00
Bikes share the road safely with cars (n=80)	15.00	38.75	33.75	11.25	1.25

The 5-point scale was collapsed into three categories for disagreement (strongly disagree and disagree), neutral position, and agreement (agree and strongly agree). Figure 3.4 displays the frequency each category by question. Visual comparison indicates a high degree of disagreement with the safe behavior of both modes of transportation (more than 50% for each), these frequencies decreased in linear fashion moving towards agreement. Frequency of disagreement is higher for cars.

Figure 3.4 Provider assessment of reciprocal safe road behavior for cars and bikes



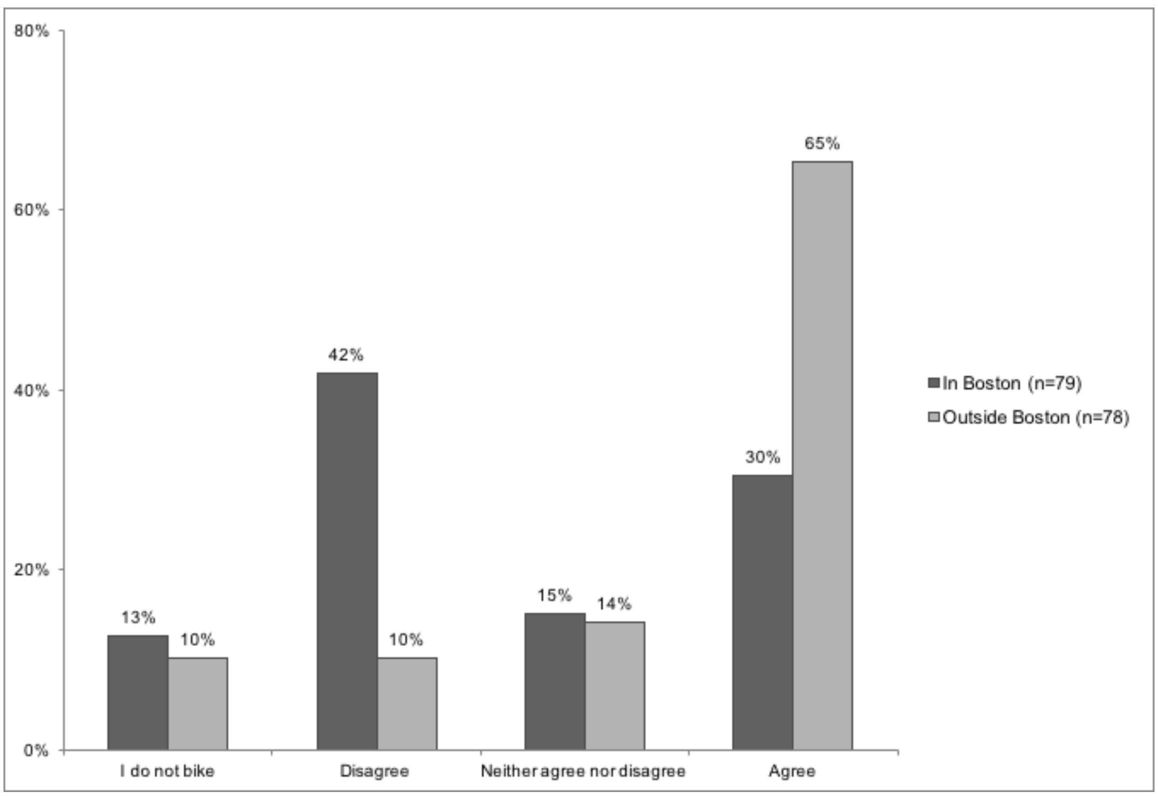
Respondents were asked to rate level of comfort biking within and outside of Boston using a 5-point Likert scale with anchors of strongly disagree and strongly agree. A categorical option was added of 'I do not bike'. One-third of respondents indicated disagreement with feeling safe and comfortable biking in Boston and 10.26% indicated an equal level of discomfort outside of Boston. At the other end of the scale, 30.38% agreed or strongly agreed to feeling safe and comfortable biking within Boston, while 65.38% indicated comfort biking outside of Boston. See Table 3.10 and Appendix C16 for description of responses.

Table 3.10 Provider perception of comfort biking in and outside of Boston (%)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not biking
Provider comfort biking in Boston (n=79)	18.99	22.78	15.19	22.78	7.59	12.66
Provider comfort biking outside Boston (n=79)	2.56	7.69	14.10	50.00	15.38	10.26

The 6-point scale was collapsed into four categories for not biking, disagreement (strongly disagree and disagree), neutral position, agreement (agree and strongly agree). A chart showing frequency for the collapsed response categories is Appendix C17. Focusing only on those providers responding with a level of agreement, the two variables for comfort demonstrated a moderate linear association with a Spearman's r of 0.44566, n=70 and p = 0.0001. The data demonstrated a U-shaped distribution for comfort within Boston as disagreement had the highest frequency, followed by agreement, neutrality was the least chosen response. A quasi-linear distribution was seen for biking outside of Boston. Level of not in agreement was low, only a slight increase for neutrality, followed by a more than three-fold increase in for agreement with comfort. Figure 3.5 displays provider comfort biking by location. Examination of disagreement and agreement with comfort revealed an interesting pattern. Comfort biking in Boston had four-fold the level of disagreement and half the level of agreement. About 42% of providers endorsed disagreement with comfort for biking within Boston compared to only 10% disagreement with comfort within Boston. Agreement with comfort was reversed as 30% indicated comfort biking in Boston and 65% indicated comfort outside Boston.

Figure 3.5: Provider perception of comfort biking in and outside of Boston (%)



Relationships between perceptions of road safety and provider biking comfort

The data were examined to determine if provider perception of road safety differed by degree of comfort biking both within and outside of Boston. Respondents reporting not biking in Boston or out of Boston at the level of each question on comfort were excluded to create an ordinal scale for comfort. See Appendix C18 comparison of descriptive statistics for the question sets. Disagreement was stronger for safe reciprocal road sharing than for own comfort biking (median score of disagree). Comfort biking within Boston had a median score of neutral; comfort biking outside Boston had a median score of agree.

There was strong evidence for a positive linear relationship between comfort biking within Boston and reciprocal safe road sharing behavior using Spearman's correlation coefficients, with a greater association for car behavior than for bike behavior (Appendix C19). Evidence for a linear relationship between comfort biking outside of Boston and reciprocal road sharing behavior was less robust, and again there was a stronger relationship with perceptions of car behavior than for bikes.

The comfort and road safety variables were then compared in dichotomous form. Odds ratios with 95% CIs were calculated (Table 3.11); similar patterns were seen in both sets of testing. The focus will be on the subset of respondents biking by area. The majority of believing that cars did not share the roads were not comfortable biking within Boston (90.48% discomfort; 27.14 times the odds of endorsing discomfort). A similar pattern for comfort was seen for those endorsing unsafe bike behavior. Providers reporting cars did not share the roads safely were less likely to feel unsafe biking outside of Boston (33-38%); those with negative opinions of bike behavior had more than three times the odds of endorsing discomfort when biking out of Boston. More extensive results for testing associations are located in Appendices C20.

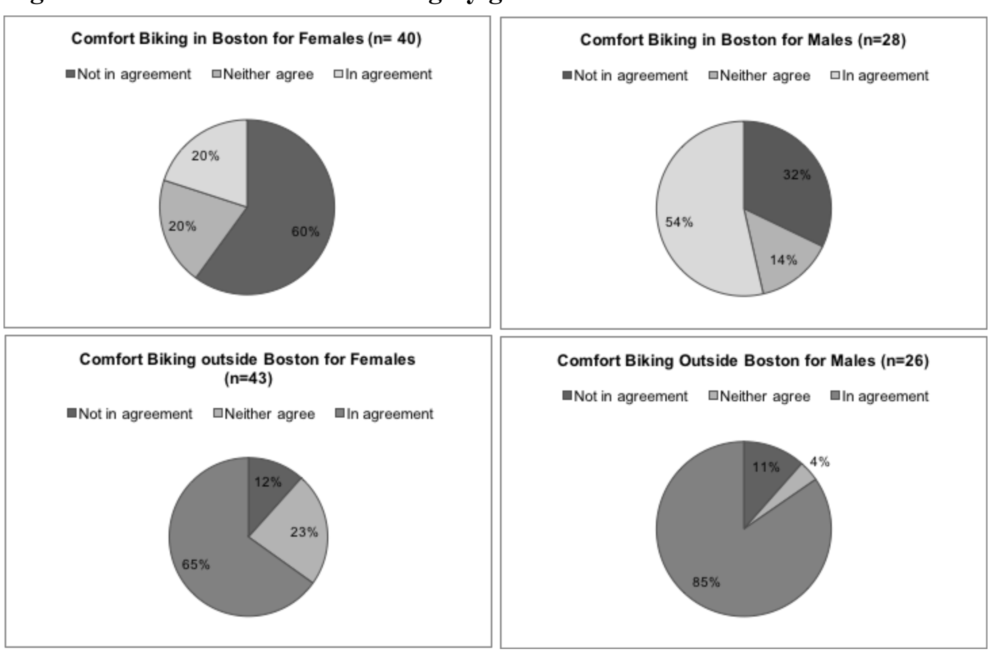
Table 3.11 Binary comparisons for perceptions of road safety with level of biking comfort for respondents biking within and outside of Boston

	n	% not comfortable	% comfortable	OR	95% CI	
Feel safe and comfortable biking in Boston						
Disagreement that cars safely share road	69	84.44	16.67	27.1429	7.0895	103.9193
Disagreement that bikes safely share road	69	68.89	8.33	24.3571	5.0213	118.1499
Feel safe and comfortable biking outside Boston						
Disagreement that cars safely share road	70	78.95	58.82	2.625	0.7628	9.0338
Disagreement that bikes safely share road	70	73.68	43.14	3.6909	1.155	11.7949

Relationships between provider characteristics and perceptions of comfort and safety

The data on road safety and biking comfort were evaluated for associations with provider characteristics. Gender had significant associations with both safe road sharing and comfort with own biking. Figure 3.6 presents degree of comfort biking by gender for biking inside and out of Boston.

Figure 3.6 Provider comfort biking by gender and location



Female respondents had more than twice the odds of disagreeing that either cars or bikes shared the roads (OR 2.7692 with 95% CI 1.0643 to 7.2053 for cars; 2.5833; 95% CI 1.0160 to 6.5685). Females had more than four times the odds of not agreeing to comfort biking in Boston (80.00%) when compared to male counterparts (46.43%). See Table 3.12 for testing for OR and CI below.

Table 3.12 Odds ratios for gender and road safety; gender and provider biking comfort

	n	% female	% male	OR	95% LCI	95% UCI
Disagreement that cars safely share road	79	73.47	50.00	2.7692	1.0643	7.2053
Disagreement that bikes safely share road	79	63.27	40.00	2.5833	1.016	6.5685
Disagreement with comfort biking in Boston	68	80	46.43	4.6154	1.578	13.4991
Disagreement with comfort biking outside Boston	69	34.88	15.38	2.9464	0.8559	10.1434

There were minimal associations found when examining the relationships among the remaining provider characteristics with road sharing and biking comfort; results presented in Appendices 21–23. Providers with more than 10 years of experience had more negative ratings of reciprocal road sharing behavior and more disagreement with own comfort biking. There was no evidence of linear relationships with sessions per week or commute. Most providers with more than 10 years of experience did not believe that cars shared the roads (83.33% versus 58.06% of those with less experience; χ^2 3.8544, df = 1, n= 80, p=0.0496). The relationship between provider experience and bikes safely sharing roads also showed more disagreement among the more experienced providers (66.67% versus 50.00 for the less experienced) but this relationship was not statistically significant. Providers with more than a five mile commute reported more disagreement with reciprocal road sharing behavior and biking comfort, but these differences did not reach a level of statistical significance.

Relationships between provider biking and perceptions of road safety

The final step in examining safety perspectives was to look for relationships of provider biking with perceptions of road safety and comfort with provider own biking. For both car and bike road sharing behaviors, the non-bikers had higher levels of disagreement with safe driving behavior; the only exception is the higher level of disagreement for those biking only outside of Boston. Select results are in Table 3.13, more extensive testing is in Appendix C24.

Bike commuters and Boston bikers voiced about 20% more disagreement with unsafe car behavior (71.74% v 50.00%, 70.73% v 52.94%); odds ratios approached statistical significance. A bigger effect was found in ratings of unsafe bike behavior. Bike commuting and Boston biking providers had 3.9 to 4.5 times the odds of disagreeing with unsafe bike behavior. The opposite relationship was seen for providers biking only outside of Boston with a 0.2797 times the odds of disagreement.

Table 3.13: Odds ratios for provider biking and negative perceptions of reciprocal road sharing

	n	non bikers % disagree	bikers % disagree	OR	95% LCI	95% UCI
CARS do not share the roads safety						
Have not biked within past 12 months	80	66.67	62.5	1.200	0.4386	3.2831
Have not bike commuted within past 12 months	78	71.74	50.00	2.5385	0.9871	6.5277
Have not biked in Boston within past 12 months	75	70.73	52.94	2.1481	0.8292	5.565
BIKES do not share the roads safety						
Have not biked within past 12 months	80	62.50	50.00	1.6667	0.6265	4.4338
Have not bike commuted within past 12 months	78	67.39	31.25	4.5467	1.7255	11.9807
Have not biked in Boston within past 12 months	75	68.29	35.29	3.9487	1.5074	10.3441

Feel safe and comfortable biking in Boston

Provider biking was also examined for differences in levels of confidence biking by location. As seen in ratings of road sharing, biking within Boston and bike commuting were key variables. For comfort biking without and outside Boston, the non-bikers had less agreement with comfort, the opposite relationship was seen when biking was defined as biking only outside Boston.

Select results are presented below in Table 3.14; see Appendix C25–26 for more extensive testing for provider biking with safe road behavior and biking comfort. Those more likely to be comfortable biking within Boston were bike commuters (53.13% versus 13.33% for the non-commuters; OR 7.37, 95% CI 2.4402 to 22.2394) and Boston bikers (47.06% versus 12.5% for the non-Boston bikers; OR 6.22, 95% CI 1.9625 to 19.7283). The group biking only outside of Boston had the lowest odds of report confidence (5.88%; OR 0.11, 95% CI 0.0132 to 0.8525). For biking outside of Boston the level of comfort for all respondents was higher than for biking within Boston. Those with the greatest odds of reporting comfort were those biking in the past year (77.78% versus 37.5%), bike commuting (80.65% versus 55.33%), and biking within Boston (78.79% versus 50.00%). Biking only out of Boston did not have an effect on out of Boston biking comfort.

Table 3.14: Odds ratios for provider biking and own comfort biking by location

	n	% bikers agreement	% non-biker agreement	OR	95%CI	
Feel comfortable biking in Boston						
Have biked this year	79	35.71	17.39	2.6389	0.7878	8.8393
Bike commuted this year	77	53.13	13.33	7.3667	2.4402	22.2394
Biked in Boston this year	74	47.06	12.5	6.2222	1.9625	19.7283
Biked only outside Boston this year	79	5.88	37.1	0.106	0.0132	0.8525
Feel comfortable biking outside of Boston						
Have biked this year	79	77.78	37.5	5.8333	2.0491	16.6062
Bike commuted this year	77	80.65	55.33	3.6458	1.2553	10.5892
Biked in Boston this year	74	78.79	50	3.7143	1.3134	10.5038
Biked only outside Boston this year	79	64.52	68.75	0.8264	0.2544	2.6847

Provider estimation of own patients' biking

Nine questions were asked to explore the providers' assessment of their own patients' biking. These questions were on a 6-point scale with five ordinal responses (1=none, 2=few, 3=some, 4=many, 5=most) with one categorical option for 'unable to answer' (=0). The last option was added to avoid skipped or unreliable responses from forced estimates. Figure 3.7 shows percentage of providers able to estimate patient biking for each question. Nearly all providers could answer the question on patient benefit (only 2.5% unable). About one in five providers could not estimate if patients could, do, or would bike. About two in five were unable to estimate comfort biking, knowledge of rules, and access to Hubway.

Figure 3.7 Provider ability to estimate own patients' biking

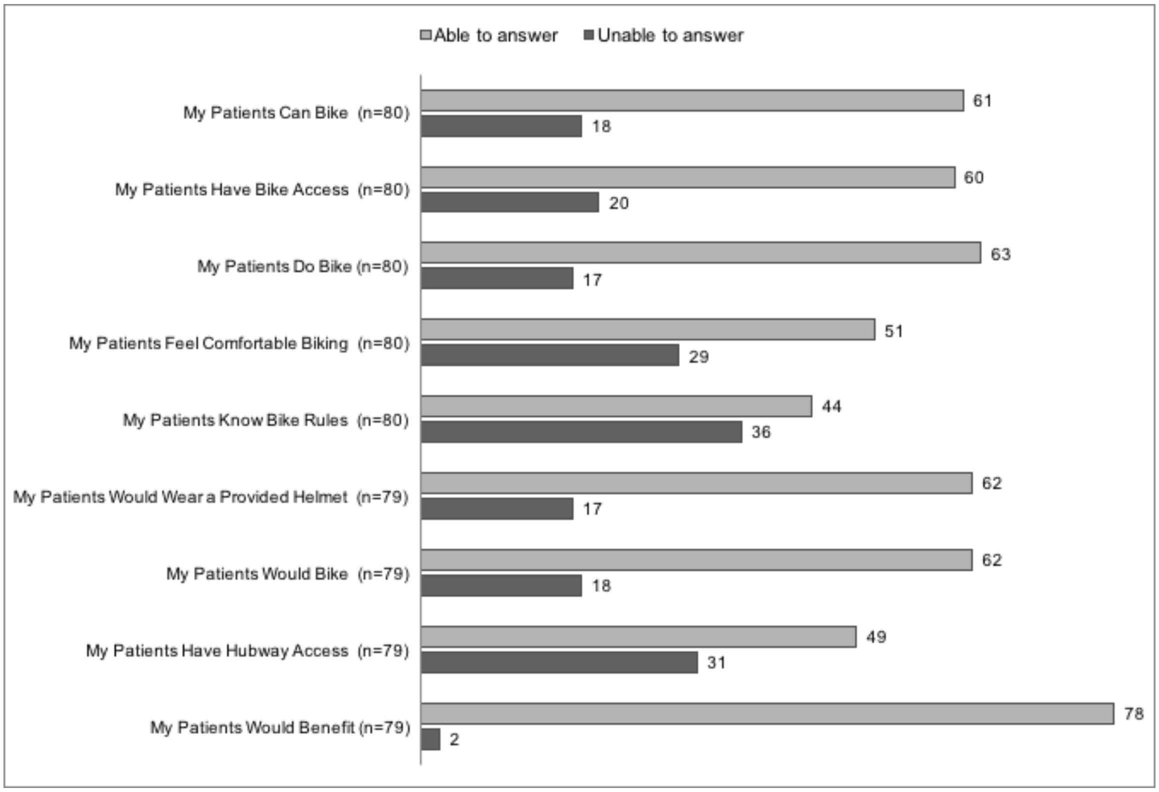


Table 3.15 presents provider responses by question. Responses to the question on benefit were discordant from the rest of the set. Nearly all providers indicated that many to most of their patients would benefit from biking. The question on benefit was excludes from the analysis on the question set because the lack of homogeneous responses limited ability to discriminate among subjects. The proportion of responses at each point on the scale was heterogeneous. For providers able to provide a quantitative estimate, few and some were the most frequently chosen response categories.

Table 3.15: Provider responses to items on own patients' biking

	n	None	Few	Some	Many	Most	Unable to answer
My Patients Can Bike	80	0	8	42	8	3	18
My Patients Have Bike Access	80	2	25	32	1	0	20
My Patients Do Bike	80	2	21	35	3	2	17
My Patients Feel Comfortable Biking	80	0	20	28	3	0	29
My Patients Know Bike Rules	80	3	23	16	1	1	36
My Patients Would Wear a Provided Helmet	80	1	11	30	16	4	17
My Patients Would Bike	79	0	13	42	5	2	18
My Patients Have Hubway Access	79	3	13	24	8	1	31
My Patients Would Benefit	79	0	1	3	22	52	2

Relationships between provider characteristics, provider biking, provider safety perceptions and provider ability to estimate own patient biking

Analyses for ability to estimate biking were performed on pre-imputation variables. Providers biking in Boston and bike commuting were more likely to provide a quantitative estimate for Hubway access and comfort riding, and less likely to estimate helmet use, knowledge of rules, and bike access. None of these patterns rose to the level of statistical significance in this sample. Provider perceptions of cars and bikes sharing the road did not reveal any associations with ability to estimate patient biking.

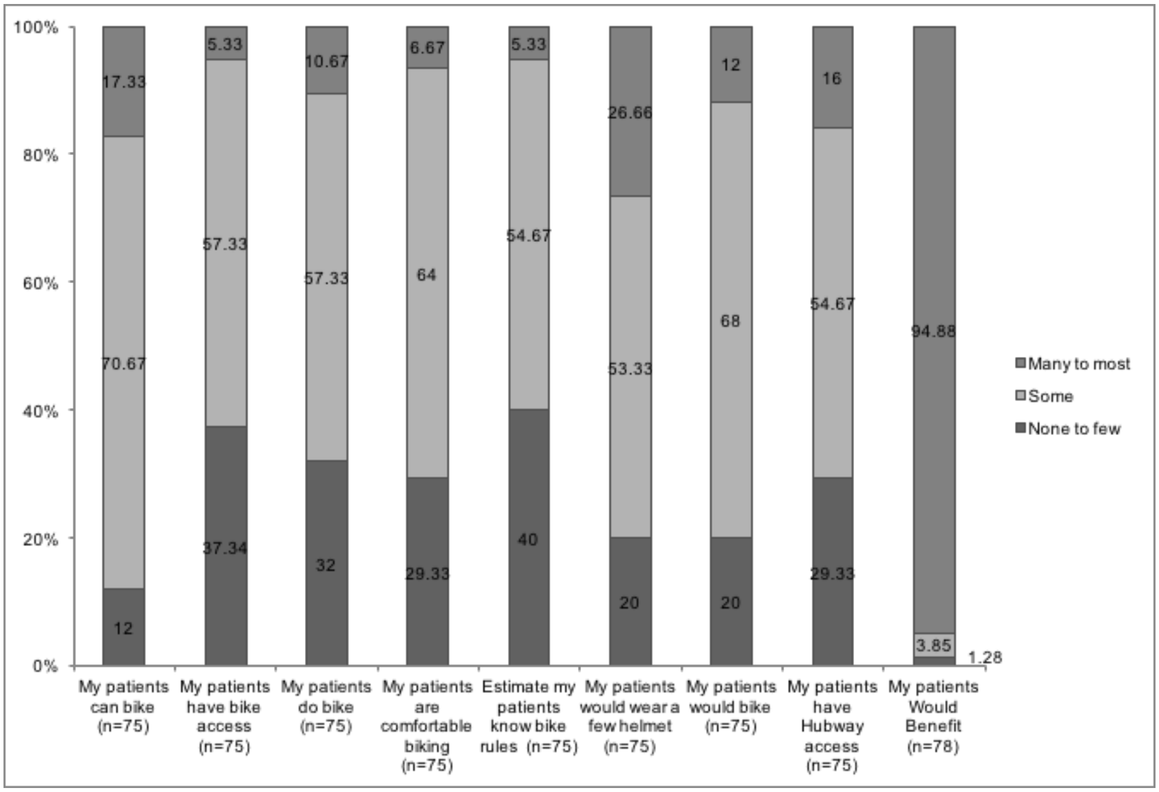
The first set of tests was to investigate associations between provider characteristics, provider biking, and provider safety perceptions with the ability to estimate own patients' biking. The ability to estimate own patients' biking was a dichotomous variable. An estimate from none to most was considered to be evidence of the ability to estimate. Those providers with bikeshare experience were more able to provide and estimate own patients' access to Hubway (χ^2 4.7722, df = 1, n=80, p=0.0289; 83.33% of bikeshare users versus 54.84% of the non bikeshare users). There were no other associations identified between ability to estimate and provider characteristics

Imputation for missing estimates

The number of responses for unable to estimate decreased the power to examine associations between these questions and other survey domains. The decision was made to impute values based on the mean response on the provider-level to questions for which an estimate was provided. Patient benefit was not included in the calculation of the mean; benefit did not require imputation. A second set of imputed variables was calculated for categorical analyses by rounding the imputed value. After imputation there were 75 responses to the estimate of own patient biking. Summary statistics for the original and imputed variables are in Appendix C27. Subsequent analyses were performed on the set of variables with imputations unless otherwise noted.

Figure 3.8 presents the estimates for patient biking using imputed variable set. The 5-point scale for responses was collapsed to group none with few, and many with most. As previously discussed, almost all providers had high estimates of the proportion of patients with potential benefit from biking. Of the remaining questions, providers had the highest estimates for patient use of free helmet (26.66% responded many to most) and the lowest estimates for knowledge of rules (40.00% responded none to few).

Fig 3.8 Post-imputation provider estimates of own patent biking



A correlation matrix using Spearman's coefficient was created to identify linear associations among questions. The benefit variable did not show any evidence of linear association with the own patient biking questions. Inspection of item-item correlation demonstrated moderately strong, positive correlations between 20 of the 36 pairs of variables (defined as $r > 0.40$ and $p \leq 0.0001$). The strongest item-item correlation was between patients' knowledge of bike rules and patient comfort biking (r=0.67322). Seven of the item-pairs had more moderate correlations, which retained statistical significance. The question on benefit did not demonstrate a linear association with any other questions in the set. The full matrix is presented in Appendix C28.

Psychometrics for questions on estimation of own patient biking

Measures of internal consistency reliability were performed for the set of questions to quantify the degree to which the individual questions related to each other using the Cronbach α correlation coefficient and item-total correlations. The question for benefit was excluded from the analysis because the distribution and correlations were not concordant with the rest of the item set. Factor analysis using an orthogonal rotation was performed to identify latent factors underlying the patient biking questions; again the benefit question was excluded. See Appendix C28 for the technical summary and results on psychometric testing.

Two composite variables were created based on results of testing, the conceptual model, and review of the literature. The composite for safety and intent was the mean score for comfort, knowledge of rules, helmet use and would ride. The composite for actual patient biking consisted of the variables for can bike, do bike and bike access. Summary statistics are in C29. The composites had a strong correlation with each other (Spearman r 0.64664; n=75; p< 0.0001). Cronbach alpha coefficients with item-total correlations for each of the composite variables were 0.806008 for safety and intent and 0.759417 for actual biking). See Appendices C30–31.

Relationships between provider characteristics, provider biking, provider safety perceptions and provider estimates of own patient biking for those providers able to provide an estimate

The individual patient biking questions and the two composite variables were examined for associations using Spearman's correlation coefficients and χ^2 testing, based on variable type. Provider commute in miles and sessions per week did not demonstrate evidence of linear relationship with the patient biking items; there was a hint of a positive relationship with experience and helmet use as well as patient can bike (Appendix C32). This was explored further using categorical tests. Examination of cross-tabulations identified vey few associations. Providers with more than 5 years of experience provided higher estimates of helmet use. The association was statistically significant when using a cutpoint of 10 years; 50% of those with more than 10 years experience endorsed many to most wore helmets versus 20.34% of those with under 10 years of experience (χ^2 5.6626; p=0.0173). No associations were identified with the remaining provider characteristics, including gender.

Estimates of own patients' biking were dichotomized with some to most as the reference category (as opposed to none to few) to examine data for associations with provider biking. For most categories the bike commuters had higher estimates of patient biking. The odds ratios only reached a level of significance for access to bikes and the actual biking composite. Providers only biking out of Boston had lower estimates for the majority of patient biking questions. Those biking only outside the city had 12–30 times the odds of endorsing none to few patients have access, do bike, are comfortable biking, know rules and the actual biking composite. Select results are below in Table 3.16, the complete set are in Appendix C33.

Table 3.16 Estimates of patient biking using composite variables by provider biking with odds ratios

Estimate of none to few patients	n	% for provider biking only outside Boston	% for providers not biking only outside Boston	Odds Ratio	95% LCI	95% UCI
Safety and intent composite	75	26.67	20.00	1.4545	0.3934	5.3777
Actual biking composite	75	53.33	18.33	5.0909	1.5228	17.0193
Estimate some to all patients	**n**	**% bike commuting providers**	**%non-bike commuting providers**			
Safety and intent comp	73	76.67	79.07	0.8697	0.2836	2.6671
Actual biking comp	73	86.67	65.12	3.4821	1.0226	11.8576

Linear associations were not identified between estimates of patient biking and perceptions safety and comfort (Appendix C34). Perceptions of road sharing and comfort biking outside Boston were associated with estimates that at least some patients were comfortable biking. Crosstabs for the dichotomized variable for own patient comfort with dichotomized variables for road safety and provider biking comfort were created to calculate odds ratios and test for associations. Providers believing that cars safely share the roads had 5.65 times the odds of endorsing some to most of their patients were comfortable; the odds were 4.7909 for those believing that bikes share the road. Providers agreeing with own biking comfort had higher endorsement of own patient comfort, but these differences did not meet a level of statistical significance. Complete results are in Appendix C35–36.

Perceived Attributes of the RxBike Innovation and Intent to Refer

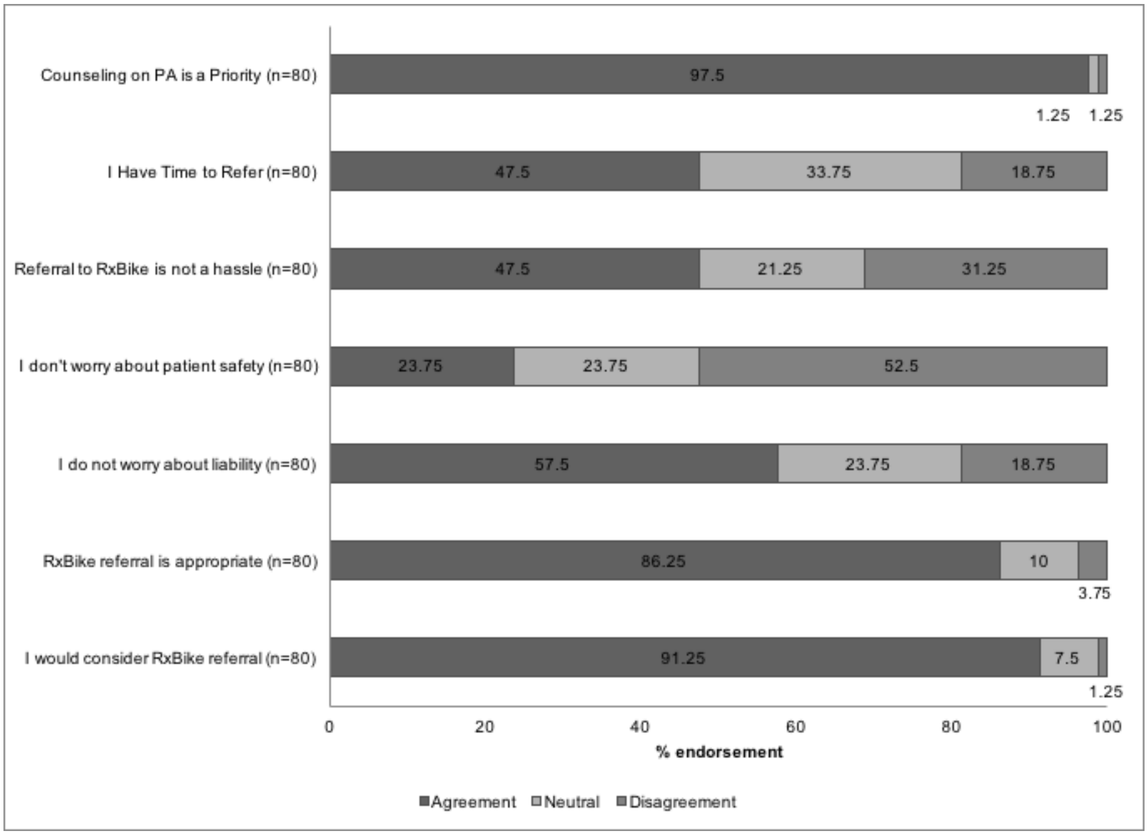
Perceived attributes of the innovation and intent to refer were evaluated with a series of seven questions. The response options were on a 5-point Likert scale from strongly disagree to strongly agree. Both positive and negative wording were used in the questions stems.

Selective reverse coding was performed to make the stems consistent for analysis. Table 3.17 presents provider level of agreement by questions using positive wording for question stems. Original response coding is used in Appendix C37. Figure 3.9 presents responses to the questions after collapsing strongly disagree with disagree, and strongly agree with agree.

Table 3.17 Provider responses to perceived attributed of the RxBike innovation (%)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Counseling on PA is a Priority (n=80)	0.00	1.25	1.25	42.50	55.00
I Have Time to Refer (n=80)	2.50	16.25	33.75	36.25	11.25
RxBike referral is not a hassle in Logician (n=80)	3.75	43.75	21.25	27.50	3.75
I Would Not Worry about Patient Safety (n=80)	11.25	41.25	23.75	22.50	1.25
I Would Not Worry about Liability (n=80)	3.75	15.00	23.75	46.25	11.25
RxBike is an Appropriate Referral (n=80)	1.25	2.50	10.00	48.75	37.50
I would consider RxBike referral (n=80)	0.00	1.25	7.50	61.25	30.00

Figure 3.9 Level of Provider Agreement to Perceived Attributes by Question (%)



There was near uniform agreement that counseling for physical activity was a priority (97.5%); more than half of respondents strongly agreed with this statement. Responses to the questions about perceived attributes and consideration of referral were less consistent between and within questions (see Appendix C38 for summary statistics). Provider concerns about RxBike were worry about patient safety (52.5% agreement), hassle of referral process (31.25% agreement), concern about liability tied with lack of time to refer (18.75% agreement), and lack of appropriateness of referral (3.75% agreement). Worry about liability demonstrated the greatest amount of variability in terms of range, spread, and variance.

Appropriateness and consider referral were skewed towards agreement (86% and

91% agreement) with about one-third of responses as strong agreement for each. These variables were recategorized to strongly agree, agree, and neutral to disagree to recognize the increased intensity of strong agreement.

Psychometrics for questions on perceived attributes of the innovation.

Consistency among questions was evaluated with the Cronbach α correlation coefficient and Spearman correlation coefficients. The highest correlation among variables was between appropriateness and consider referral ($r=0.6308$, $n=80$, $p<0.001$; r^2 39.79 %); see matrix in Appendix C38. Complete results of psychometric testing are in Appendix C39. Appropriateness had the highest item-total correlation. Time and hassle correlated with each other, appropriateness, and consider referral. Safety and liability were intercorrelated. Priority of counseling did not correlate with anything except appropriateness. Testing did not suggest a high degree of reliability for the question set as a whole.

Factor analysis using an orthogonal rotation was performed to identify latent factors underlying the question set. Based on the factor loadings and conceptual model of this study the decision was made to create a composite variable for time, hassle, appropriateness, and consideration of referral named Process Perceived Attributes. Questions on safety and liability were used for a Concern Perceived Attributes composite. The composite variable was the mean of the scores to each question with positive wording used across the set Appendix C38); the mean was rounded for use as a categorical variable. Counseling was not used for either composite. The two composite variables did not correlate with each other. Description and results of all psychometric testing for this question set are in Appendix C40–41.

Relationships between provider characteristics, provider biking, provider safety perceptions and perceived attributes

Provider characteristics were examined for associations with PAs; the 5-point ordinal PA responses were grouped in two ways: disagreement, neutrality, and agreement; and strong agreement, agreement, and neutrality to disagree. Staff providers and providers with more than 10 years experience had more concerns about safety. Trainees, providers with fewer years of experience, and those with shorter commutes had higher endorsement of appropriateness. Provider perceptions of the hassle of the referral process and liability concerns were shown to relate to both experience in years and commute status. The results of χ^2 testing for these variables is in (Appendix C42). Both overall agreement and strong agreement were higher for pediatric providers, trainees, those with fewer than 10 years of experience, and those with commutes under 5 miles.

Pediatric providers and those with under 5 mile commute had slightly more endorsement of agreement (strong agreement and agreement to consider referral), but these differences were not significant. Providers with up to 10 years of experience gave near uniform agreement (92.86%) while those with more than 10 years of experience had a somewhat lower rate of agreement (86.96%); this was a significant association using Fisher's Exact test (Appendix C43).

Gender was examined for associations with PAs. Nearly 60% of females endorsed safety concerns compared to 43% for males, see Table 3.18. Liability concerns were relatively lower for both genders; liability was more of a concern for female providers (22.45% versus 13.3%). Crosstabs for select PAs and gender are in Appendix C44. Only the association between gender and the concern composite was significant; female providers had 3.75 times the odds of agreeing with concern compared to males (95% CI 1.4388 to 9.7739). There was no association of appropriateness with gender, although female providers endorsed more strong agreement than males. Crosstabs with results of association testing are in Appendix C45.

Table 3.18 Provider perceived attributed by gender

	% Females	% Males
I worry about safety	59.18	43.33
I worry about liability	22.45	13.33
RxBike is not appropriate referral	4.08	3.33
I would not refer a patient to RxBike	2.04	0.00
Process inhibitors	2.04	6.67
Concern inhibitors	20.41	13.33

Perceived attributes did show some differences by provider biking status, but most of these did not yield a level of statistical significance. Overall, Boston bikers and bike commuters had more favorable perceptions. See Table C19 for differential responses by bike commuting status. All providers expressed concerns for patient safety, but agreement with safety concerns was 10% lower for the bike commuters. Bike commuters had minimal concerns about liability, compared to about one-quarter of the non bike commuters. Bike commuters were about half as likely to endorse time as a barrier. Appropriateness did not reveal associations with provider biking.

Table 3.19 Perceived attributes of RxBike by bike commuting status

	% bike commuters	% non bike commuters
Safety concerns	46.88	57.8
Liability concerns	9.38	26.09
Time as a barrier	12.5	23.91
Hassle as a barrier	28.13	32.61
Agreement with appropriateness	90.63	82.61
Strong agreement with consider referral	46.88	17.39

Perceived attributes were examined for associations with provider perceptions of road safety due to reciprocal road sharing, and provider comfort biking. As provider rating of road sharing by bikes and comfort biking in Boston became more negative, provider agreement with referral consideration decreased (Spearman's r 0.32223, p=0.0036 for bike road sharing; 0.32999, p=0.0056 for own comfort biking in Boston). Respondents believing that cars do not share the roads safely had 4.0741 times the odds of agreeing with safety concerns while those with negative beliefs about bike road sharing behavior had 2.475 time the odds of safety concerns. Concern for liability displayed a similar pattern in that providers with negative reciprocal road sharing behaviors were more likely to have liability concerns versus those with less unfavorable opinions about the roads; the difference did not reach a level of statistical significance. There were no demonstrable associations between road safety and the remaining perceived attributes, including appropriateness (Table 3.20). Testing for associations and crosstabs for road safety with PAs for safety and liability are in Appendix C46–47.

Table 3.20 Associations and odds ratios for dichotomous provider perception of road safety and comfort biking with PAs

	n	OR	95% LCI	95% UCI
Agreement with safety concerns				
Cars do not share the roads with bikes	80	4.0741	1.5382	10.7905
Bikes do not share the roads with cars	80	2.475	1.0045	6.0979
Not comfortable biking within Boston	69	4.0000	1.3765	11.6234
Comfortable biking outside Boston	70	2.6377	0.8662	8.032
Agreement for liability concerns				
Cars do not share the roads with bikes	80	1.7188	0.4931	5.9913
Bikes do not share the roads with cars	80	2.8359	0.8179	9.8333
Not comfortable biking within Boston	69	2.3784	0.4628	12.2226
Comfortable biking outside Boston	70	4.1964	0.9904	17.7806

Providers not comfortable biking were more likely to endorse concern for patient safety and liability, but this only reached statistical significance for dichotomized comfort biking within Boston and concern about patient safety (OR 4.0000, 95% CI 1.3765–11.6234, n=69). The remaining perceived attributes did not vary by biking comfort. Variables for provider estimation of own patient biking and perceived attributes of the RxBike innovation were examined for evidence of linear correlation. Provider worry about safety declined as estimates of helmet use increased; increased estimates of patients knowing rules correlated with higher endorsement of having the time for referral. The strongest correlations were for estimates of patient benefit from biking with both appropriateness of referral and consideration of referral. Estimate of patient comfort biking did not correlate with any perceived attribute. See Appendix C48 for correlation matrices.

Associations were found for the actual biking composite (can, do, and access) and the safety/intensity composite (would, rules, helmet, comfort) with strong agreement for both appropriateness and consider referral (Appendix C49). Crosstabs revealed higher endorsement of agreement with appropriateness and consider referral. Agreement with appropriateness and consideration of referral increased with higher estimates of patient biking behaviors. Associations were shown for appropriateness with can bike, access to bikes, and access to Hubway. Consider referral was associated with helmet use, would bike, and access to Hubway. Crosstabs and complete results are in Appendix C50.

Bike commuters had higher endorsement of strong agreement for consider referral. The association was only statistically significant for bike commuting; bike commuters had 4.1912 times the odds of strong agreement with consider referral. See Appendix C51 for crosstabs and results of testing. Consider referral was examined to identify with variables for road safety and provider comfort. Significant associations and trends were found for bikes sharing the roads safely and strong agreement with consider referral. More than half of the providers with positive perceptions of reciprocal road sharing endorsed strong agreement for consider referral, most providers with negative perceptions of road sharing did not endorse strong agreement. Providers comfortable biking in Boston were close to evenly divided between strongly agreeing and agreeing with consideration of referral, fewer than 5% were neutral or disagreed (Appendix C52).

Multivariate analysis

The initial analysis plan was to identify predictors of potential RxBike adoption, defined as consideration of patient referral as the only outcome variable; the study team had concerns about the generalizability of results using only this outcome. Consideration of referral could be impacted by the patient population at BMC and the individual provider's panel composition (age, functional status, income, living within Boston); thus limiting generalizability of consider referral as an indicator of true potential of RxBike for adoption in other patient populations. The location of BMC was a potential threat to external validity as adoption of the RxBike intervention could be influenced local bike infrastructure and vehicular behavior patterns specific to Boston. After examination of the initial statistics and review of conceptual model it was determined that appropriateness of RxBike as a primary care referral should be separately modeled as appropriateness should be less influenced by the context of BMC.

Explanatory model for appropriateness of RxBike as a primary care referral

The final model for appropriateness dichotomized appropriateness as agreement versus disagreement or neutrality. In the full sample 69 providers indicated agreement and 11 indicated lack of agreement (n=80). Three dichotomized variables were used as covariates: 1) commute of > or <= 5 miles, 2) estimate of few to some versus many to most patient biked using the composite variable for actual biking, and 3) gender.

There was evidence that failure to include an estimate of patients' biking would lead to underestimation of the gender effect and overestimation of the commute effect. Failure to include commute distance also resulted in a lower estimate of the gender effect on appropriateness. Gender did not show evidence of confounding for either covariate.

After exclusion of observations for which there was not complete data on all listed covariates, 64 providers indicated agreement with appropriateness and 9 indicated lack of agreement (n=73). The model is described below (Table 3.21); technical summary including examination of covariates for evidence of confounding in Appendix C53–54.

$$\text{Log }[p/(1\text{-}p)] = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3$$

Logit of not agreeing with appropriateness = -3.9323 + 2.0030 (commute > 5 miles) + 1.9574 (estimate none to some patients bike) + 1.3730 (male gender)

Table 3.21 Summary of explanatory model for appropriateness

	Coefficient	Standard error	Standardized β	Odds ratio	95% CI for OR	
Constant	-3.9323	0.9483				
Model inputs						
Commute ≥ 5 miles	2.003**	0.8455	0.5034	7.411	1.413	38.864
Many to most patients bike composite‡	1.9574**	0.9647	0.3199	7.081	1.069	46.905
Male gender	1.373*	0.8494	0.373	3.947	0.747	20.861
Effects	**Wald χ2**	**df**	**p-value**			
Model (Global)	9.6309	3	0.022			
Commute	5.6129	1	0.0178			
Patient biking composite	4.117	1	0.0425			
Female gender	2.6126	1	0.106			
N	73					
Pseudo R2	0.3175					
Hosmer-Lemeshow χ2 (df, p-value)	0.4603	2	0.7944			
c-statistic	0.817					
** <.15, ** <.05*						
‡ reference group is none to some of patients						

In the final model, the outcome of lack of agreement with appropriateness was predicted by the covariates of commute of more than 5 miles, male gender, and estimate that many to most of the provider's own patients were bikers. The model demonstrated evidence of calibration and a high level of discrimination; there was no evidence of interaction for the covariate pairs. In the logistic regression analysis there was evidence of association between commute distance and lack of agreement with appropriateness. Providers with longer commutes had 7.4 times the odds of not agreeing with RxBike appropriateness compared to providers living within 5 miles of BMC, controlling for estimates of patient biking and gender.

There was evidence of a significant association between estimates of patient biking lack of agreement with appropriateness. Providers with lower estimates of patient biking had 7.081 times the odds of not agreeing with RxBike appropriateness compared to providers estimating that many to most of their patients biked, controlling for estimates of commute distance and gender.

Results suggest that male providers had increased odds of not agreeing with RxBike appropriateness, while controlling for commute distance and estimates of patient biking. The association between gender and the outcome of appropriateness did not reach the apriori level of statistical significance. The p-value for the Wald χ^2 approached significance, which suggests that the analysis may have lacked power to detect a true association for gender and appropriateness (n=73). Male providers had higher odds of not agreeing with appropriateness compared to female providers when controlling for commute distance and estimate of patient biking.

In unadjusted analyses, females had equal likelihood of biking this year, but lower likelihood of biking in Boston when compared to male providers. Female gender was strongly associated with more negative perceptions of road safety and provider comfort biking. Female agreement with appropriateness was 93.18% compared to 79.31% for males. For these reasons the inclusion of gender in the logistic regression is supported as provider biking practices and safety perceptions would be expected to impact provider perceptions of attributes of the RxBike program and decisions about patient referral.

Explanatory model for consider referral of a patient to RxBike

The final model for consider referral dichotomized consider referral as strong agreement versus lack of strong agreement; strong agreement was separated from agreement because the responses for this question were very skewed towards agreement. In the full sample 24 providers indicated strong agreement and 56 indicated lack of strong agreement (n=80).

Thus, a new categorical variable (gender-bike commuting composite variable) was created to examine the effect of gender by bike commuting status. Of the 77 subjects with complete data for gender and bike commuting, 42.86% were females not biking commuting, 19.485% were female bike commuters, 16.88 % were males not bike commuting, and 20.78% were male bike commuters. This new variable did have a statistically significant association with strong agreement with consider referral (Fisher's Exact statistic 0.0002, p= 0.0297, n=77); see Appendix C55 for crosstab and results. Female non-bike commuters had the lowest level of strong agreement (15.15%), followed by male non-bike commuters (23.08%). The bike commuting counterparts had more than double the strong agreement, with persistence of the gender effect (46.67% for female bike commuters and 50.00% for male bike commuters).

After exclusion of observations for which there was not complete data on all listed covariates, 54 (70.12%) providers indicated lack of strong agreement with consider referral and 23 (28.97%) indicated strong agreement (n=77). The model is described below (Table 3.22); see Appendix C55–56 for technical summary of model, including examination of covariates for evidence of confounding.

Table 3.22: Summary of explanatory model for appropriateness

Log [p/(1-p)] = $\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$

Logit of lacking strongly agreement with consideration of referral = 0.7369 + 2.4365 (no strong agreement with APP) + 1.9306 (female not bike commuting) + 0.0339 (female bike commuting) - 0.0792 (male non bike commuter)

	Coefficient	Standard error	Standardized	Odds ratio	95% CI for OR	
Constant	-3.5849	1.3335				
Model inputs						
Do not strongly agree with appropriateness	4.8729**	1.2163	1.3008	130.705	12.051	>999.999
Female non bike commuter ǂ	3.816**	1.4168	1.048	45.422	2.827	729.849
Female bike commute ǂ	1.9193	1.4333	0.4218	6.816	0.411	113.137
Male non bike commuter ǂ	1.8062	1.4264	0.3755	6.087	0.372	99.674
Effects	Wald χ2	df	p-value			
Model (Global)	18.2307	4	0.0011			
Lack of strong agreement with appropriateness	16.0521	1	<.0001			
Gender-bike commute composite	8.0063	3	0.0459			
N	77					
Pseudo R2	0.6768					
Hosmer-Lemeshow χ2 (df, p-value)	1.6547	5	0.8946			
c-statistic	0.939					
**<.05, ** <0.01*						
ǂ reference group is male bike commuters						

In the final model, the outcome of lack of strong agreement with consider referral was predicted by the covariates strong agreement for appropriateness of referral and the gender-bike commuting composite. The model demonstrated evidence of calibration and a high level of discrimination, there was no evidence of interaction between the two independent variables.

In the controlled analyses, there was evidence of association between strong provider perception of appropriateness of RxBike referral and lack of strong agreement with consider RxBike referral.

There was also evidence of association between the gender-bike commuting composite variable of and lack of strong agreement with consider RxBike referral, with adjustment for appropriateness rating. Only the contrast between the female non bike commuters and the male bike commuters was shown to increase likelihood of not endorsing strong agreement, when controlling for appropriateness; females had 45 times the odds of not agreeing. In the unadjusted analysis the highest proportions for not strongly agreeing with strongly consider referral were for the female non bike commuters and lowest for male bike commuters. Results suggest that bike commuters have higher strong agreement with consider referral, regardless of gender. Tabulation of the four levels of the gender-bike commute composite with strong agreement with appropriateness resulted in small cell sizes, these were further decreased after separating by strong agreement with consideration of referral. This analysis was not powered to allow conclusions about the relative difference in likelihood of referral for bike commuting females or non-bike commuting males.

Discussion

Primary care providers expressed strong support for RxBike in the context of safety concerns and barriers to the referral process. In the controlled analysis, negative perceptions of the innovation were associated with lower rates of acceptance; this finding is consistent with Diffusion of Innovation Theory.[93] Factors most relevant to acceptance were gender, commute distance from hospital, bike commuting status, and estimate of own patients' biking.

Bike commuters had less negative views of urban biking, and higher estimates of patient access and knowledge of rules. It is not surprising that bike commuters are more likely to consider patient referral. Female providers had higher ratings of intervention appropriateness than males, but less likely to refer. This dissonance has face validity given the safety concerns of females in our sample, and the existing literature on gender and perceptions of biking risk. The providers with the lowest rates of acceptance were the non-bike commuting females. Results suggest that when controlling for appropriateness, bike commuting status has a greater effect on consider referral than gender.

From the implementation perspective, increasing provider perception of appropriateness of referral at the organizational level may improve rates of adoption; this may not be enough to counteract concerns for patient safety.

Improving safety perceptions and increasing the proportion of bike commuting providers has the potential to increase referral rates, but these strategies are not likely within the realm of the clinical implementation team.

Two important challenges to external reliability are the sample and the setting. The proportion of bike commuting respondents and biking prevalence reported by female providers was much higher than seen in the general population or within Boston.[80,107] In addition, response rate was relatively low: all providers were surveyed, and under 40% responded. It is possible that both subject area interest and the one-day pass to Hubway created selection bias to favor RxBike acceptance.

Generalizability of these results may also depend on context. In geographic areas with increased rates of bike commuting, better biking infrastructure, fewer incidents of biking injury, and weather more conducive to year-round biking, providers may endorse fewer safety concerns and higher likelihood of referral.

CHAPTER FOUR

Evaluation of the Prescribe a Bike Program

Study Description

Diffusion of any innovation in a medical care setting is a challenge. Introduction of a non-traditional innovation without an evidence base for efficacy is an especially formidable undertaking; RxBike is one such intervention. One goal of RxBike is to facilitate bike-share access to reduce current income-based disparities for health and transportation. RxBike allows healthcare providers to make a referral as a printed "prescription" for this program. The patient is then eligible for the $5 subsidized membership, which comes with a free helmet and longer usage intervals before usage fees are charged. Despite multiple information sessions, initial uptake of RxBike at Boston Medical Center (BMC) has been low. The institution can support the RxBike program and create the electronic infrastructure for referral, but these steps do not ensure enrollment. It is not known if the barrier to enrollment is provider understanding of the innovation, provider acceptance of the innovation, the provider process of referral, patient interest in referral, or a combination of these factors. Understanding patterns of provider adoption of RxBike is essential to creating an implementation plan tailored to address provider and patient barriers. This study is a preliminary evaluation of the implementation of the RxBike innovation at BMC. Lessons learned will inform program expansion to community health centers, and may be generalizable to other urban bike-share programs.

Research question(s)

Was the BMC implementation of RxBike successful? What was provider uptake of the program? What were the barriers and facilitators to implementation by providers?

Specific aims

Objective 1: To describe the characteristics of the providers referring patients to the RxBike Program.

Objective 2: To describe the characteristics of patients referred to the RxBike program in terms of predisposing characteristics, socio-demographics, BMI, and neighborhood resources.

Objective 3: To describe provider perceptions and perceived attributes of the RxBike program using qualitative research methods.

Data source(s):

The BUMC Clinical Data Warehouse (CDW) provided encounter and patient data for visits at which a prescription for RxBike was created; the limited dataset was derived from the electronic medical record at BMC from January 2013 through December 2015. The Institutional Review Board (IRB) at Boston University Medical Center determined the analysis of this CDW data was IRB-exempt as non-human subjects research; a HIPAA waiver was issued.

Data on neighborhood population, socioeconomic markers, health indicators, and racial/ethnic composition at the neighborhood level were provided by the Research and Evaluation Unit of the Boston Public Health Commission (BPHC). BPHC data sources were the US Census (2010), the American Community Survey (ACS; 2008–2012), The

Massachusetts Center for Health Information and Analysis (2012), Boston's Behavioral Risk Factor Surveillance Survey (BRFFS; 2013), and the Massachusetts Department of Public Health (MA DPH; 2008–2013). See Appendix B14 for technical notes.

Qualitative responses to optional, open-ended comment fields by primary care providers from the survey described in Study Two were used to describe provider perspectives. Contextual data from minutes, outreach efforts, and perspective of the participant observer[108(chap3)] as both program evaluator and member of the implementation team were used for description of the implementation.

Design and Methods

This study used mixed methods with multiple data sources to evaluate RxBike implementation.

Relationship to Conceptual Model: See the figure below for a depiction of the linkage between this study and the project conceptual model. The measurable quantitative outcome is provider placement of a patient referral in the BMC EMR. *Provider perceived attributes* of the RxBike innovation and features of the implementation process (*barriers and facilitators*) were examined using qualitative methods.

Several conditions must be met before RxBike can diffuse through the clinician community. The institution must approve the innovation, providers must become aware of the innovation and form positive attitudes (*persuasion stage*). Attitude will be based on provider characteristics, practice variables, and perceived attributes. The final step for the provider is the decision that that referral (*adoption*) is the best course of action for a specific patient. Referral may also serve as an enabling action by the provider and may be a cue to action for an individual patient.

Figure 4.1: How study three relates to the conceptual model for the overall project and outcomes

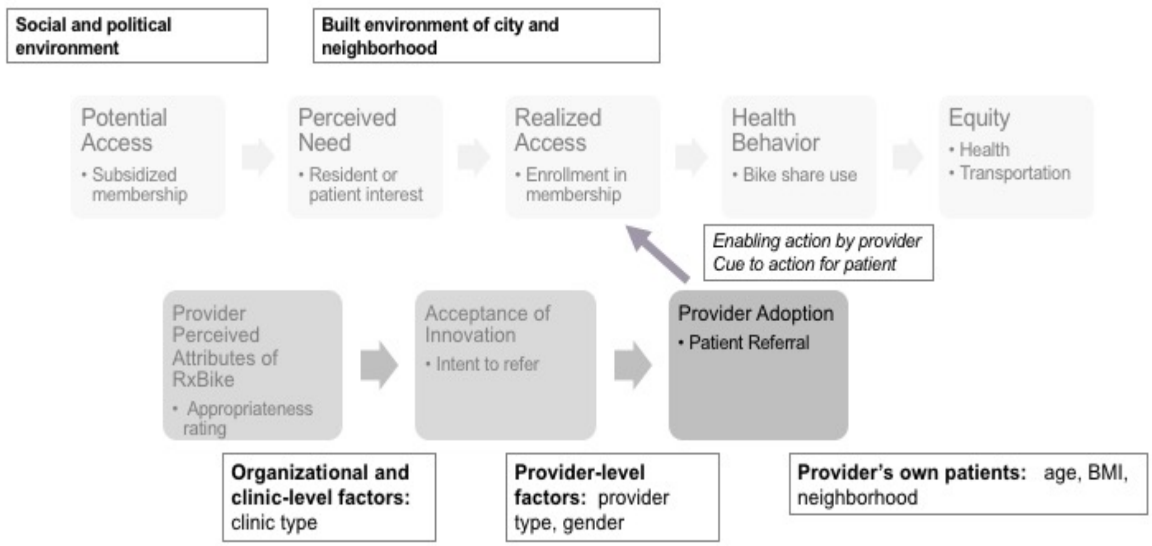


Table 4.1: Variable specification for study three

Construct	Variable	Measure	Data Source
Clinician-Level Explanatory Variables			
Perceived attributes	Qualitative feedback from providers on constructs in Study Two	Open ended comment sections for each survey section and at end of survey	Provider survey
Clinician-Level Process Variable			
Actual uptake	Adoption (Implementation)	Referrals made through medical record	CDW
Patient-Level Intermediate Explanatory Variables			
Patient characteristics	Gender, age, zip code, insurance type, BMI	Referrals made through medical record	CDW
Neighborhood resources (Place)	Community-level social determinants of health, potential access to bikes	Sociodemographic and health indicators for neighborhood	BPHC
Potential access	Referral	Referrals made through medical record	CDW

Variable Specification: See Table 4.1 for description of constructs, variables, measures and data sources for Study Three.

Subjects and settings: Clinical locations at BMC comprise the setting for this study. All referrals were made by BMC providers for BMC patients. Qualitative data were obtained from BMC primary care providers in four clinics – General Internal Medicine, Family Medicine, Pediatric Medicine, HIV Primary Care.

Analysis Plan

Quantitative and qualitative methods were used. The CDW dataset was downloaded into Microsoft Excel 2016™ for data preparation, and imported into SAS™ (Cary, NC; version 9.4) for analysis. Significance testing was performed using two-sided statistical tests with an a priori α level set at 0.05. Measurement variables for age and BMI were evaluated with measures of central tendency, dispersion, precision, presence of missing data points, and violations of normality. Distributions were visually inspected using boxplots and histograms. The numeric variables were evaluated in both categorical form. BMI was categorized using the conventional cutoffs of < 18.5 for underweight; 18.5 to < 25 for normal weight; 25 to < 30 for overweight; > 30 for obese; and the subset with BMI > 40 as extreme obesity.[109] Categorical variable analyses were performed using frequency tables and bar charts. Providers were categorized by clinic

Referred patients were linked to neighborhoods using the BPHC's zip-code crosswalk used in study one.[101] Analysis was primarily descriptive. See Analysis Plan for Study One (Chapter Two) and Appendix B14 for detail on how neighborhoods were classified using socioeconomic markers, health indicators, and racial/ethnic composition.

Enrollment data were used to describe individual level characteristics of the enrollees through Boston Bikes. Significance testing was performed using two-sided statistical tests with an a priori α level set at 0.05. The characteristics of enrollees were compared to the characteristics of the patients for whom a prescription was generated using inferential statistics appropriate for each measurement type to identify predictors of enrollment after provider referral. Analyses performed include quantitative measures of central tendency and dispersion, and visual examination.

The qualitative data from the optional comments on the provider survey were downloaded from Survey Monkey™ into downloaded into Microsoft Excel 2010™ and Microsoft Word 2016™. Data were coded using a recursive process; text was read to identify themes or phrases to represent the essence of the text. The identified codes were examined for patterns and connections within and between conceptual categories.[110(chap12)]

Results

Description of referrals

Seventy-two referrals were made through the electronic medical record EMR by 27 unique providers for patients age 15 years and above from 2013–2015. RxBike referrals did not have an expiration date; 15-year-old patients were included because they could become eligible before the next scheduled visit. The referred patients were 47.22% female, more than half identified as Black/African-American and the majority (77.78%) had health insurance coverage through Medicaid and/or Medicare. Twelve (16.67%) of the patients who received referrals were listed in the hospital database as living outside of

Boston, which is a violation of RxBike eligibility. Descriptive statistics are contained in Tables 4.2 and Appendix D1.

Table 4.2 Patient level descriptive statistics for RxBike referrals, 2013–2015 (n=72)

	Frequency	Percent
Patient gender		
Female	34	47.22
Male	38	52.78
Age Group		
under age 18 y	7	9.72
18 to 24 years	17	23.61
25 to 34 years	6	8.33
35 to 44 years	7	9.72
45 to 54 years	21	29.17
55 to 64 years	12	16.67
65 to 79 years	2	2.78
BMI grouping (n=71)		
underweight	3	4.23
normal weight	13	18.31
overweight	12	16.9
obese	30	42.25
extreme obesity	13	18.31
Insurance group		
Public	56	77.78
Private	8	11.11
None	5	6.94
Unknown	3	4.17
Race		
Asian	2	2.78
Black/African American	41	56.94
Hispanic/Latino	9	12.5
Unknown	10	13.89
White	10	13.89
Hispanic/Latino		
No	54	75
Yes	18	25
Lives in Boston		
No	12	16.67
Yes	60	83.33

Patient age in years demonstrated a bimodal distribution at ages 18 to 24, and 45 to 64. The median age was 42.5 years; the middle 50% of patients were between 19 and 52 years.

The mean patient BMI was 34.52 ±9.2115 m^2/kg and the median was 31.51. The 95th percentile BMI was 50 and the maximum was 63. One patient had a recorded BMI of 199 and this was marked as missing. Additional description of the numeric variables may be found in Appendix D2–3.

Of the 60 patients residing in Boston, the majority were from four proximal neighborhoods to BMC: South Dorchester, North Dorchester, Roxbury, and the South End. There were not any referrals from the Allston-Brighton, Charlestown, Fenway or West Roxbury neighborhoods.

Descriptives on the provider-level are in Table 4.3. The pediatric and adolescent clinics made the most referrals (33.33%) followed by HIV primary care (27.78%), and general internal medicine (16.67%). Only one referral was placed in 2013. The majority of referrals were placed before the hospital switched to a new EMR in spring 2015 (81.94%). More than half of referrals were made by male providers. Only 15.28% of referrals were made by trainees.

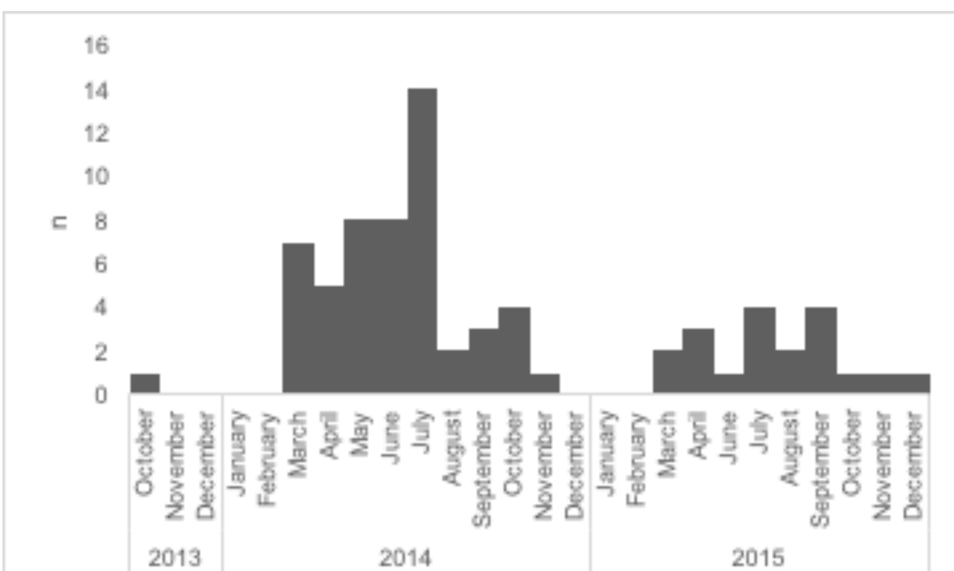
Referral trends

Referral rates were highest in the spring (34.72%) and summer (43.06%). One-quarter of referrals were placed in the month of July; see Figure 4.2 for referral frequency by month across the study period.

Table 4.3 Provider level descriptive statistics for RxBike referrals, 2013–2015 (n=72)

	Frequency	Percent
Year of Referral		
2013	1	1.39
2014	52	72.22
2015	19	26.39
Season		
Spring	25	34.72
Summer	31	43.06
Fall	15	20.83
Winter	1	1.39
Clinic		
Adult internal medicine	12	16.67
Women's health	6	8.33
HIV primary care	20	27.78
Pediatric/Adolescent	24	33.33
Other BMC	10	13.89
Provider gender		
Female	29	40.28
Male	43	59.72
Staff provider		
No	11	15.28
Yes	61	84.72

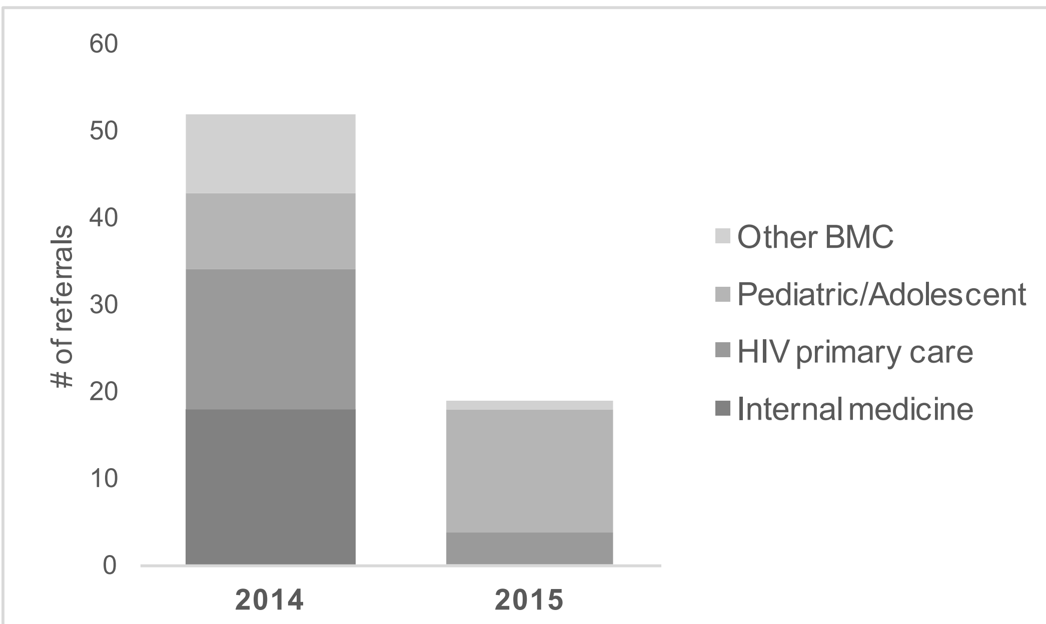
Figure 4.2 Referrals to RxBike by month 2013–2015 (n=72)



The single referral from 2013 was excluded from the analyses of referral across years. Referrals dropped from 52 in 2014 to 19 in 2015; this is a 63.46% decrease. The decrease was not proportional across clinic type or patient age.

As seen in Figure 4.3, the combined adult primary care clinics (adult internal medicine, family practice, and HIV primary care) placed 34.61% of referrals in 2014, these clinics did not place any referrals in 2015.

Figure 4.3 Change in composition of referrals between 2014 and 2015 (n=71)



Selected differences in patient and provider characteristics between 2014 and 2015 are in Table 4.4. The proportion of referrals for young adults (age under 25 years) increased from 17.3% in 2014 to 73.68% in 2015. In 2014, only one minor (age below 18 years) was referred; in 2015 the six minors constituted almost one-third of referrals. Pediatric/adolescent providers had 13.3778 times the odds of placing a referral in 2015 versus 2014 (95% CI 3.8384, 46.6248). Patients referred in 2015 were more likely to be female, Caucasian, not living in Boston, and to be on a public insurance program or be uninsured compared to referrals from 2014. Cross tabulations and results of testing for patient gender and provider type by year are in Appendices D4–5.

Table 4.4 Proportion of referrals by provider and patient characteristics for 2014–2015 (n=71)

	2014	2015
Adult medicine	82.69	26.32
Staff provider	80.77	94.74
Female provider	42.31	36.84
Female patient	42.31	63.16
Minor	1.92	31.58
Hispanic/Latino ethnicity	21.15	36.84
Caucasian race	9.62	26.32
Not a Boston resident	15.38	21.05
Medicaid coverage	55.77	68.42

Patient BMI

The majority of patients (78.46%) were classified as overweight to extremely obese. Between 2014 and 2015, the proportion of extremely obese patient dropped fourfold and the proportion of overweight patients almost tripled; cross tab is presented in appendix D6. Further investigation into the decrease in obesity between years revealed that the pediatric clinics had both higher proportion of 2015 referrals and a lower proportion of obese patients. The majority of female patients were obese (76.47%) as opposed to only 44.44% of the males. See appendix D7 for cross tabs and testing.

Neighborhood equity

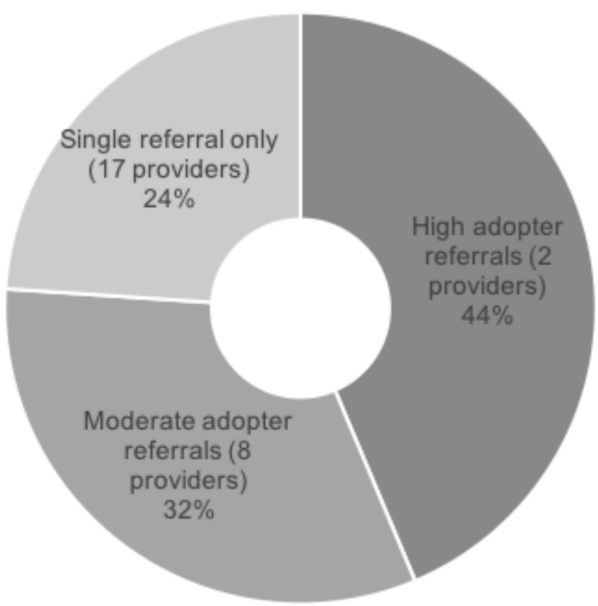
As in Study One, the socioeconomic markers, health indicators, and racial/ethnic composition of each neighborhood were compared to the entirety of Boston. More than half of referrals were from neighborhoods with higher poverty levels, higher rates of diabetes admissions, higher homicide rates, and higher mental health admissions than

Boston as a whole. Patients given RxBike referrals resided in neighborhoods with lower proportion of Whites (<50% of total Boston composition) and a higher proportion of Blacks (>150% total Boston composition); this racial/ethnic distribution is associated with health disparities. See Appendix D8 for these descriptive statistics.

Provider adoption

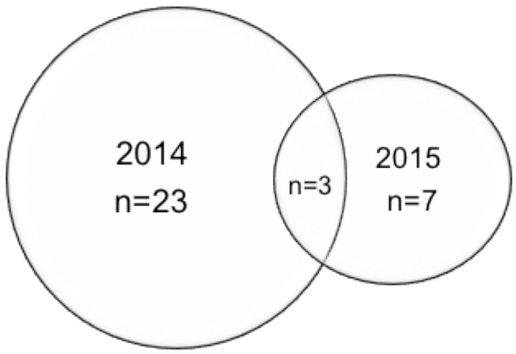
Referrals placed from 2013 to 2015 were examined for provider-level referral patterns. Only two providers were classified as having high adoption rates of RxBike. These providers constituted 7% of the referral base but made 44% of the referrals by referring 15 to 16 patients each. Eight other providers (30% of referral base) placed two to four referrals each. The remaining 17 providers completed one referral each. See Figure 4.4 for a description of the proportion of referrals by provider adoption rate.

Figure 4.4 Proportion of referrals by provider adoption rate (n=72)



Examination of provider utilization of the RxBike program across the two-year period demonstrated that 20 of the 23 providers who referred in 2014 did not refer any patients in 2015 (discontinuance). Four providers began referring patients in 2015.

Figure 4.5 Provider participation by year (n=27)



Description of provider perspectives

The provider survey included eight spaces for open-ended provider comments; seven of these spaces followed question sets. For the final comments section respondents were invited to provide additional information on their perspectives, about the RxBike program. Review of the comments revealed several themes related to the project's conceptual model. Safety was a common issue that cut across the themes. See Table 4.5 for tabular presentation of identified themes; complete set of comments in Appendix D9.

Table 4.5 Linkage of identified themes to conceptual model in provider comments

Themes	Description and terms
DOI Perceived attributes	
Relative advantage	Risk or benefit to patient, includes safety (does not include elements in Complexity below)
Complexity	Process of referral placement, hassle, time
Socioecological framing	
Provider-level	Own biking and own concerns and experience
Patient-level	Patient ability, needs, and access
Organization-level	Referral process
Community-level	Traffic, safety, and infrastructure specific to Boston, access to bike-share kiosks in neighborhoods

Safety

Comments on safety fell on a wide spectrum from mild discomfort ('*I probably would not feel safe* ') to fear of own death while biking. Specific phrases used by providers included *'I am afraid', 'I don't feel safe',* and *'I am a little scared'.* There were no positive endorsements of comfort, safety perceptions, or road safety in this sample. The most extreme safety comments are below (unique providers):

Riding in Boston remains a risky activity, have direct knowledge of deaths related to bike riding in Boston

I have seen 3 bike accidents involving cars over the last 2 years alone.

One provider expressed the desire to bike commute tempered by safety concerns writing, *'I am afraid of being killed in traffic or I would ride my bike to work'*.

Diffusion of innovation for perceived attributes

Two themes arose from the perceived attributes in the DOI model: relative advantage and complexity of the innovation.[93] The majority of these comments were about relative advantage. Relative advantage refers to the benefit of an innovation compared to the existing practice. There were not any comments with negative opinions about bike-share, patient biking, or the concept of RxBike as a medical referral. There were mentions of outright acceptance '*This is a fantastic program!' and* recent adoption ('I *referred my first patient yesterday'*). Several comments captured positive opinion of the program in the context of concern for patient safety. In the words of one provider:

I think it would be great but I do worry about safety bicycling in Boston-mainly due to the drivers but also due to lack of knowledge on the part of 2 [sic] bicyclists.

RxBike is not a replacement for an existing element of care. In this case, the decision is between committing to a referral to RxBike or rejecting the program through omission. One comment captured the provider's low rating of relative advantage with a decision to reject RxBike:

The exercise benefits are modest and the hazards of riding a bicycle in heavy traffic outweigh any benefits for me.

Liability was mentioned by several respondents as a potential downside of the program. A few providers affirmed liability ('*issue of physician liability is real')*, another questioned whether a RxBike referral was any riskier than other advice about physical activity

would I be liable if I referral [sic] pt to exercise in a gym and they injured themselves? It would be the same.

Other providers were neutral to undecided. One wrote that *'I hadn't thoughts [sic] about liability until reading the last question'.*

The second element of perceived attributes identified was complexity. Several providers referenced the referral process as the '*burden of an additional task'*. There was some mention of time required to place a referral in the EMR. The following comment is from a provider who adopted the innovation (referred a patient) about the referral process:

I have referred patients using the current referral form in Logician[1], but it is cumbersome 2 to go through Letters, etc. to find it. A better process would be welcome

Another provider endorsed the program, but voiced reservations about including RxBike given the competing demands at clinical encounters.

I just need to shoe horn it into a session that is already overbooked with prevention discussions and running over schedule. But worthy and will try.

Many providers communicated a positive perception of the program, but asked that the referral task be delegated to a different member of the clinical team:

great program but mostly shodu [sic] be taken out of the hands of providers.

In a more extreme example, a provider voiced frustration with the existing current expectations for clinical care and brought into question the feasibility of incorporating RxBike into the workflow of primary care providers:

As a PCP, I already cannot meet expectations to deliver preventive care, nutrition advice, mental health screening, survive logician and meaningless use, oh...yeah, take care of illness? and are you serious- refer to Bike Share through Logician? Why do docs have to everything?

Socio-ecological perspective

There were also themes related to the socio-ecologic framework. Comments could be linked to the levels of the provider, patient, organization, and community. Provider-level comments referred to the providers' own biking and hesitancy to bike within Boston. Two providers stated they did not know how to ride a bike. As seen in the

[1] Logician™ was the BMC EMR before spring 2015 transition to EPIC™

comments about relative advantage, most comments were positive regarding RxBike and concerned about safety. For example, one provider said:

I enjoy biking for recreation and wish I had more time to do it

Another PCP stated: '*too dangerous to ride in Boston'*. More than one provider mentioned decreasing or ceasing biking because of safety concerns. One provider '*previously biked to work for a 1 months [sic] - stopped due to discomfort riding in traffic'*.

In terms of patient-level factors, several providers mentioned concerns specific to their own patient populations regarding knowledge of biking rules, use of safety equipment, and access to bike-share. Provider requests for their patients included *'bike helmet and safety reminders'* as well as *'culturally appropriate educational material'*. Two providers commented about patients with physical limitations that could preclude bike use.

I also have many disabled patients, and elderly patients, who would have problems with bicycles.

There was also mention of pediatric providers not having patients old enough to enroll in the program.

Comments about RxBike at the level of the organization were specific to the operationalization of the program at BMC. These were primarily about the complexity of the referral process. Many comments made specific mention of barriers within the existing EMR and the upcoming transition to a new EMR. For example, one provider said about the new EMR:

do the form in EPIC. otherwise you will have to train folks again in Feb

The majority of comments at the community level were about safety biking in Boston (‘*need bike lanes’*); a few providers made negative comparisons of biking in Boston with biking in other cities. For example, one wrote:

I do not bike in Boston because I feel unsafe in traffic. I have biked in other cities where I felt much safer.

As second provider specifically noted the lack of dedicated bike paths to separate bikes from cars seen in other cities.

A final extended comment about community-level issues addressed the mismatch between neighborhoods where BMC patients reside and the current (at the time of survey) expansion of the Hubway system. This comment pulls together relative advantage, program adoption, provider level biking behavior, and access for patients:

I am very enthused about the idea of Hubway (both for myself - I use the service regularly) and for my patients. My main concern is the current distribution of hubway stations which favors the central parts of Boston to the exclusion of the Southern neighborhoods (Roxbury, Dorchester, Mattapan, Roslindale, etc) where 3 of my patients reside. I was shocked, for example, to realize that Upham's corner is the southern4 docking station in Dorchester. I suspect I personally will be more likely to consider referring when I am more confident that there is adequate service in the neighborhoods where my patients live.

Barriers to adoption

It is clear that there were multiple barriers to the acceptance and adoption of RxBike by

PCPs. Table 4.6 summarizes identified barriers to program success based on the qualitative comments from the survey; perspective of the participant-observer (this writer) who served in a dual role as evaluator and member of the implementation team; discussions among implementation team members; and quantitative survey results from Study Two (Chapter Three). The change in EMR in late spring 2015 is highlighted as a formidable obstacle to sustaining the referral rates of 2014. The disruption of this transition on provider attention and workflow cannot be underestimated.[111,112]

Table 4.6 Identified barriers to adoption and potential confounders of provider adoption

Level of Barrier	Description
Provider	Safety concerns Declined offers by patients would be self-reinforcing if provider unsure about utility of program Competing demands at the clinical visit, especially with a vulnerable patient population May not have considered offering RxBike during the off-season Less aware of Hubway bike-share if not living in a covered municipality Less aware of the less treacherous places to bike within Boston if not living in the area Unsure if patients have biking experience, ability, and interest
Patients	May have been offered referral and said no for a myriad of reasons: perceived safety, ability to bike, feasibility of biking with other responsibilities, knowing there were not bike-kiosks neighborhood, preference for riding own bike Patient ineligibility because not Boston resident or age under 16 years Functional impairments limiting ability to bike
Organization	BMC switch to a new EMR had two effects, 1) provider focus on learning new system took up visit time, 2) changed workflow because referral letter located in different place Normal staff turnover at academic medical center in which 1/3 of the trainees leave at the end of June to be replaced by newly minted MDs with no awareness of the
Community	Multiple bike crashes with motor vehicles in summer of 2014[113] may have reinforced safety concerns. Continued constructions at 3 of the 4 streets surrounding BMC resulted in more hazards when biking or crossing the streets proximal to the hospital No bikes where majority of BMC patient live. Providers may have known this, or patients told them when offered a membership

Implementation efforts	Implementation efforts were not sustained for 2015, Only champions in pediatrics where majority of patients are not eligible, Efforts continued to target MDs and NPs when survey clear about need to assign task to a different member of the healthcare team
Other	Prolonged winter of 2015 late start to biking season; mid-Spring installation of stations may have dampened enthusiasm for patients and decreased provider awareness of the program [114]

Discussion

Analyses of referral data showed that RxBike could extend the reach of bike-share to BMC patients at high individual health risk living in disadvantaged neighborhoods. However, the impact on the BMC patient population was minimal because so few patients were referred to the program.

In DOI theory, Rogers describes the innovation–decision process as four stages from knowledge acquisition to innovation use.[93(chap5)] Study 2/Chapter 3 examined persuasion and the decision process from survey data using quantitative methods. The measurable outcomes were appropriateness of RxBike as a primary care referral and intent to refer.

This study built on Study Two by exploring the qualitative aspects of persuasion, and measured program adoption using patient referral data. According to DOI theory, early adopters have initial uptake; as more providers adopt the innovation, the rate of uptake should rise and then flatten. On the contrary, in RxBike there was some uptake by early adopters, but the rate of adoption plummeted and the majority of early adopters disappeared in the second year.

Rogers writes that the decision to refer patient is not a terminal stage.[93(chap5)] A provider who had previously referred patients could discontinue by either active decision to reverse the adoption decision or passive cessation of referrals. The differential referral patterns seen between years 2014 and 2015 illustrate discontinuance coincident with the transition to the new EMR at BMC.

The provider comments were from a survey performed at program inception in spring 2014. Positive opinions of the program were evident. Providers voiced pronounced concerns for their own safety biking, resultant reluctance to bike in Boston, and concerns for patient injury while biking. Boston was noted as a particularly unsafe city for biking with insufficient infrastructure to protect bikers. As previously mentioned, the population-level health benefit of biking cannot predict risk to an individual patient. A series of local bike versus motor vehicle crashes in the summer of 2014 may have heightened concern.[113] Thus, referral of a patient to RxBike could be a perceived by providers as violation of the Hippocratic Oath to do no harm. Safety concerns may have outweighed the positive intent to refer, especially in the context of a disruptive switch to a new EMR.

An intensive level of provider outreach was required in 2014 yielded only a modest number of referrals. That level of implementation effort was unable to be sustained in 2015 due to lack of dedicated resources. Referral to RxBike is not a billable service for providers nor is it the standard of care. Even if safety concerns were not a barrier to referral, the opportunity cost for PCP placement of referral may be an unreasonable expectation. RxBike success will require the engagement of an implementation team with ability to consistently engage with and remind providers about the program. Additionally, it will require consistent outreach to members of the ambulatory care team beyond physicians and primary care providers. Nurses, case managers, and other members of the primary care team need to be meaningfully and actively engaged.

A final point is that even with renewed efforts at provider outreach, provider referrals to RxBike only facilitate enrollment. An important limitation of this study was the inability to obtain data to measure realized access to membership, or subsequent bicycle utilization among the BMC patients. However, it is important to note that many of the BMC patients referred to the program resided in neighborhoods with little to no penetrance of bike kiosks, making patient interest in referral and meaningful bike utilization less likely.

For the organizational-level RxBike innovation to have meaningful impact on health and transportation equity, two conditions must be met at the community-level: 1) increase in evidence-based infrastructure within Boston to decrease risk and improve safety perceptions; and 2) better access to bike-share via installation of bike kiosks in neighborhoods where BMC patients live.

CHAPTER FIVE

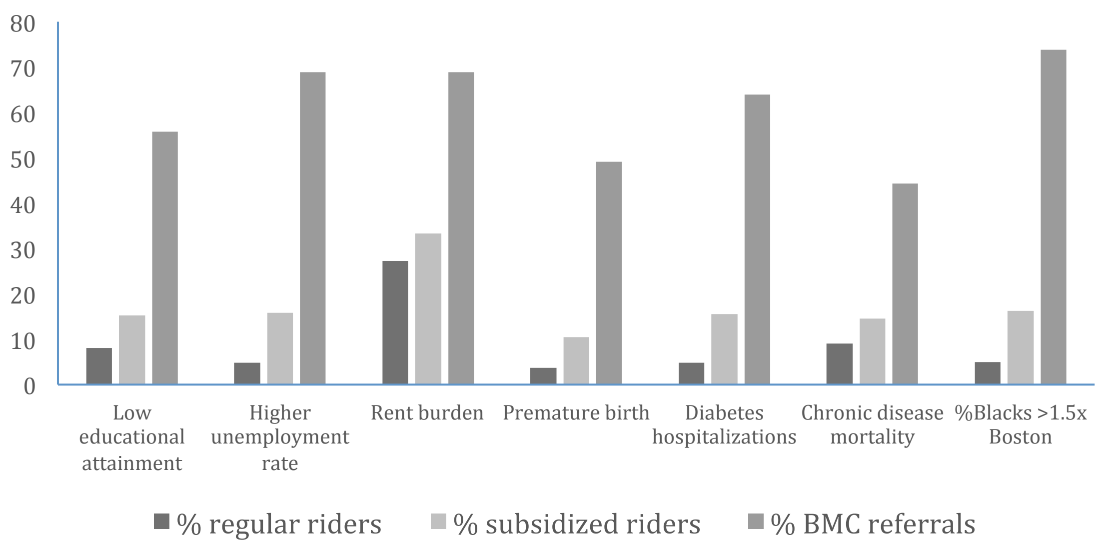
Conclusions

RxBike has the potential to integrate physical activity into daily living for low-income, Boston residents at the greatest need for health benefit and affordable transportation. The city's subsidized Hubway membership provides potential access to these low-income residents. Funding the subsidized membership and credit card waiver for the unbanked are city-level socioeconomic interventions intended to remove financial barriers to bike-share use. Study One (Chapter Two) showed the success of the subsidized membership at reducing disparities in bike access. The subsidized riders disproportionately resided in neighborhoods with socioeconomic and health disadvantage, and in neighborhoods with a racial/ethnic composition consistent with health disparities. The downstream effect should be improvement in both health and transportation equity. For the subsidized membership to have meaningful impact on the low-income population of Boston, the city must also must address the non-financial barriers in terms bike-kiosk placement in disadvantaged neighborhoods.

The RxBike program facilitates access as an individual-level intervention using the power of a PCP recommendation to encourage enrollment in the subsidized membership. In Study Two, PCPs at BMC had positive attitudes about the RxBike innovation, but there was hesitation in referral associated with both uncertainty as to the utility of bike-share for their patients and safety concerns. Male providers and bike commuters had less discomfort biking in Boston, better rating of reciprocal road sharing for bikes with cars, and higher likelihood of intent to refer.

Study Three had two sets of findings. The EMR data demonstrated the BMC patients referred to RxBike were high risk for poor health outcomes. The age and adiposity profiles of referred patients demonstrated cardiovascular risk, and the referred patients disproportionately resided in neighborhoods at marked disadvantage from the perspective of the social determinants of health. The neighborhood profile of BMC referrals was even more proportionally disadvantaged than the disadvantage demonstrated in the overall subsidized membership. as shown in Figure 5.1 and Appendix E1. However, this comparison must be viewed with caution as the subsidized rider data are at the trip level for members, and the small cohort of BMC referrals are for persons who may not have enrolled or used the bikes.

Figure 5.1 Proportion of riders or referred patients from neighborhoods with sociodemographic and health disadvantage by indicator



Regular riders N= 1,166,227, subsidized riders N = 90,158, BMC referrals N = 61

RxBike at BMC should therefore contribute to an increase in access to bike-share for this vulnerable population, but the enrollment data did not support meaningful impact.

At the provider level, the drop in referrals between 2014 and 2015 is extremely concerning; the timing of the transition to a new EMR surely interfered with 2015 adoption. Provider comments revealed multiple concerns about biking safety in Boston for themselves and their patients. These are reasonable concerns, and may be especially influential in the Boston context of biker injuries and deaths across the study period. Providers also highlighted the burden of the referral process, and suggested a transfer of the referral task to a non-PCP, clinical staff member. This is certainly an option as the RxBike referral not limited to prescribers.

Providers will have minimal tolerance for harm in recommending a program without an evidence base for efficacy or safety, such as RxBike. Strategies to improve provider uptake of RxBike must put safety first with modifications to the built environment intended to improve biker safety. Providers need to see changes to biking infrastructure at the community-level and a resultant drop in crashes of bikes with motor vehicles to decrease perception of risk.

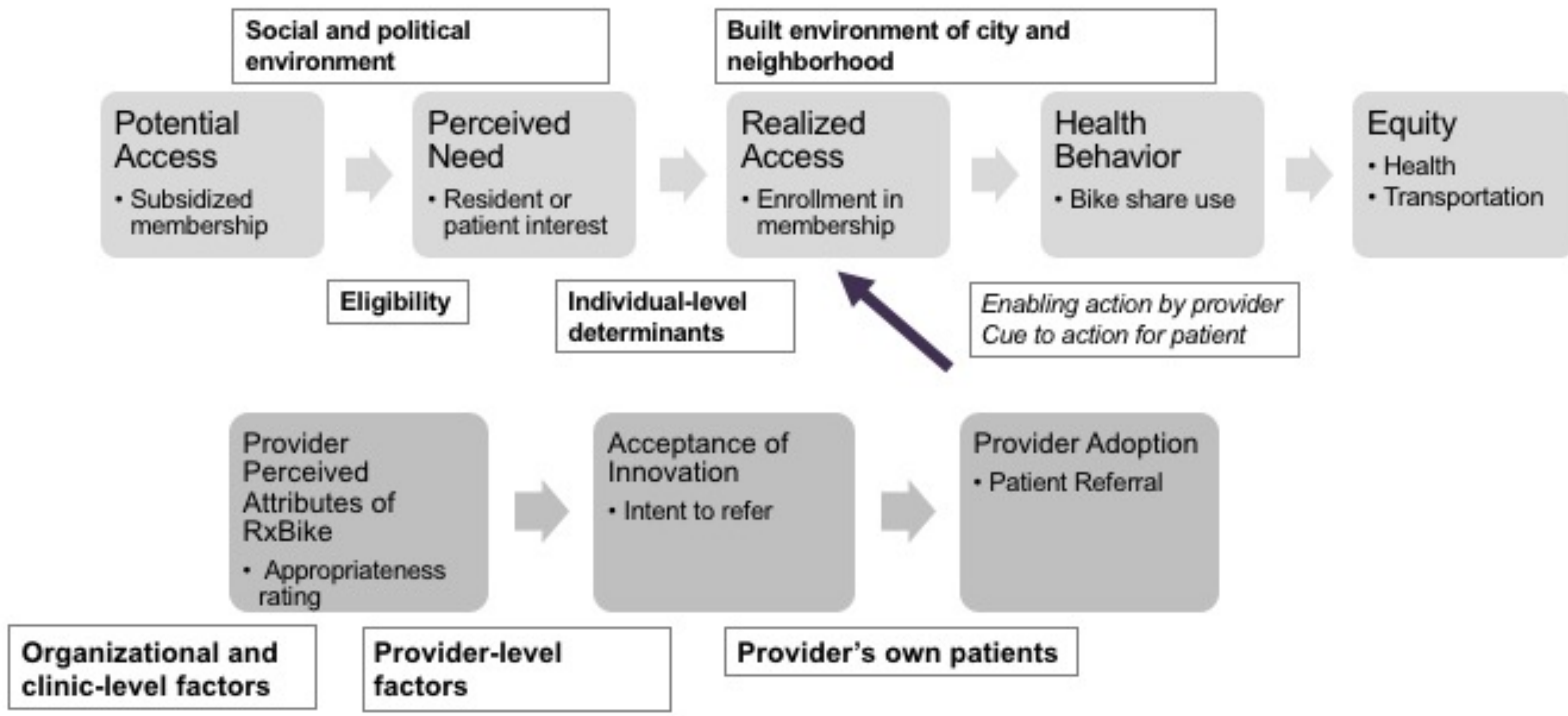
The next step would be to expand kiosk availability in disadvantaged neighborhoods, especially those neighborhoods representing the BMC patients. Only then will investment in resources for RxBike program growth at BMC have meaningful impact on the patient population.

Appendix A: Chapter One

Appendix A1: Strengths and Weaknesses of National Data on Prevalence of Cycling and Incidence of Bike-Related Injuries[35,36,38,38,39,45]

	Strength	**Weakness**
NHTS (2001, 2009)	Captures trips not related to work commutes. Periodic survey. Mails travel diary to subject for assigned future date.	Before national implementation of bike-share. Land line sampling and low response rate limit external validity (Individual level N = 324,184, response 20%).
ACS (2000 Census, 2008–2012)	Large sample size (3 million/year) with high response rate (>97%). Detailed sociodemographic information. Ability to analyze small geographic areas.	Commuter trips only. Did not collect information on cycling if not the primary part of commute.
NTSB	Not a sample. Annual. Surveillance	Only collected those noted by law enforcement and involving a motor vehicle. Excludes off-road incidents. Possible misclassification as each state collects data to report to the federal agency.
NEISS-AIP	Detail on degree of injury. Captures off road and crashes not involving a motor vehicle.	Sample. Only collected those perceived as serious enough for ED visit. No ETOH or helmet info,

Appendix 1B: Conceptual Model

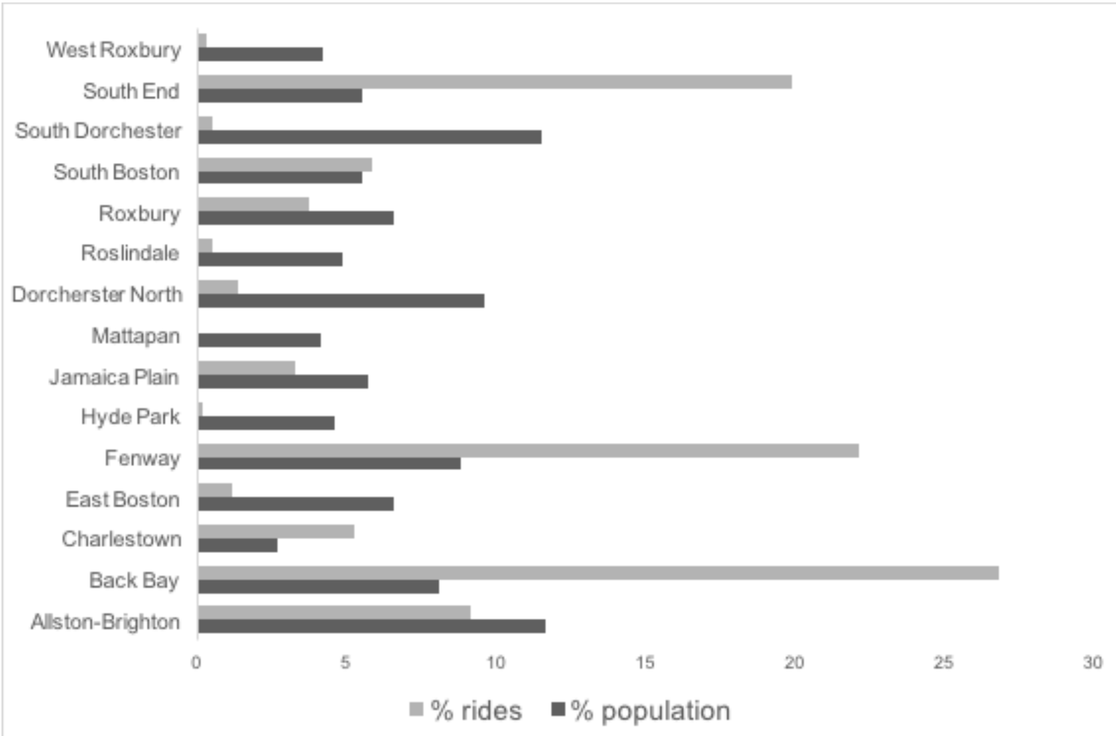


Appendix B: Chapter Two

B1 Additional descriptive statistics

	Frequency	Percent
Boston neighborhood		
Allston-Brighton	114,551	9.12
Back Bay	337,419	26.86
Charlestown	65,609	5.22
East Boston	14,597	1.16
Fenway	278,076	22.13
Hyde Park	1,858	0.15
Jamaica Plain	40,932	3.26
Mattapan	304	0.02
Dorchester North	17,112	1.36
Dorchester South	5,891	0.47
Roslindale	5,938	0.47
Roxbury	46,444	3.7
South Boston	73,706	5.87
South End	250,073	19.9
West Roxbury	3,875	0.31
Gender by membership type		
subsidized female	29,826	2.37
subsidized male	60,332	4.8
regular female	311,118	24.76
regular male	855,109	68.06
Trip length		
up to 15 min	948,106	75.46
15–30 min	278,952	22.2
30–45 min	21,501	1.71
45–60 min	4,509	0.36
60–75 min	1,549	0.12
75–90 min	873	0.07
90–120 min	895	0.07
Trip up to 15 minutes		
up to 15 minutes	948,106	75.46
over 15 minutes	308,279	24.54

B2 Comparison of distribution of Boston population by neighborhood (n= 617,591) and proportion of trips by neighborhood residents (n=1,256,835)



B3 Distribution of rides by each membership type among neighborhoods (n=1,256,385)

	# rides	% subsidized member	% regular member
Allston-Brighton	114,551	11.52	8.93
Back Bay	337,419	13.81	27.87
Charlestown	65,609	4.38	5.29
East Boston	14,597	0.44	1.22
Fenway	278,076	17.57	22.49
Hyde Park	1,858	0.40	0.13
Jamaica Plain	40,932	4.44	3.17
Mattapan	304	0.30	0
Dorchester North	17,112	5.37	1.05
Dorchester South	5,891	0.59	0.46
Roslindale	5,938	1.32	0.41
Roxbury	46,444	9.55	3.24
South Boston	73,706	4.45	5.98
South End	250,073	25.65	19.46
West Roxbury	3,875	0.22	0.31
Total rides #	1,252,510	90,158	1,166,227
%		7.18	92.82

B4 Crosstab and testing for proportion of trips by females each year (n=1,256,385)

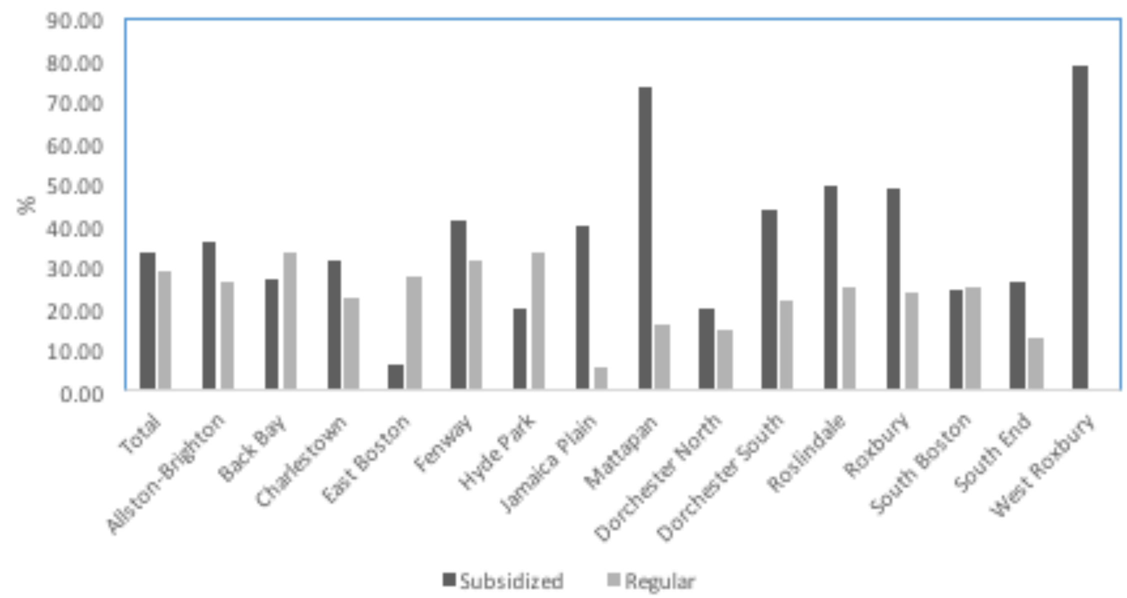
	% Female	% Male	Total
2012	27.41	72.59	216,673
2013	26.52	73.48	307,536
2014	27.53	72.47	399,251
2015	27.06	72.94	332,925
Total #	340,944	915,441	1,256,385
Total %	27.14%	72.86%	

	DF	Statistic	P-value
CMH $\chi 2$	1	0.8228	0.3644
$\chi 2$	3	99.5584	<.0001

B5 Distribution of members by gender among neighborhoods (n=1,256,385)

	# rides	% female	% male
Allston-Brighton	114,551	29.20	70.80
Back Bay	337,419	26.45	73.55
Charlestown	65,609	33.27	66.73
East Boston	14,597	21.80	78.20
Fenway	278,076	28.44	71.56
Hyde Park	1,858	28.90	71.10
Jamaica Plain	40,932	34.12	65.88
Mattapan	304	65.13	34.87
Dorchester North	17,112	17.02	82.98
Dorchester South	5,891	17.04	82.96
Roslindale	5,938	27.10	72.90
Roxbury	46,444	29.33	70.67
South Boston	73,706	23.92	76.08
South End	250,073	24.81	75.19
West Roxbury	3,875	15.95	84.05
Total rides #	1,256,385	340944	915441
%		27.14	72.86

B6 Proportion of rides within membership by females by neighborhood



B7 Proportion of rides by females within membership type by neighborhood and odds that trip was by a female for subsidized versus regular members (n=1,256,385)

	% Female rides within membership type					
	Total rides	**Subsidized %**	**Regular %**	**Odds Ratio**	**95% Confidence Interval**	
Allston-Brighton	114,551	36.02	28.52	1.4103	1.3528	1.4704
Back Bay	337,419	26.56	26.45	0.9958	0.9570	1.0362
Charlestown	65,609	31.19	33.40	0.9068	0.8462	0.9718
East Boston	14,597	6.35	22.23	0.2523	0.1692	0.3760
Fenway	278,076	40.78	27.69	1.8072	1.7497	1.8665
Hyde Park	1,858	19.51	31.19	0.5416	0.4103	0.7148
Jamaica Plain	40,932	40.00	33.49	1.3363	1.2510	1.4274
Mattapan	304	73.13	5.56	47.8819	11.2284	204.1853
Dorchester North	17,112	19.66	15.98	1.3404	1.2326	1.4575
Dorchester South	5,891	43.77	14.40	5.2002	4.3178	6.2631
Roslindale	5,938	49.66	21.43	3.6838	3.2271	4.2051
Roxbury	46,444	48.68	24.93	2.8930	2.7575	3.0350
South Boston	73,706	24.30	23.90	1.0032	0.9318	1.0801
South End	250,073	26.36	24.65	1.0972	1.0644	1.1311
West Roxbury	3,875	78.71	12.50	27.0780	19.0793	38.4300
Total	1,256,385	33.08	26.68	1.3688	1.3392	1.3786

B8 Measures of central tendency and normality for trip duration in minutes

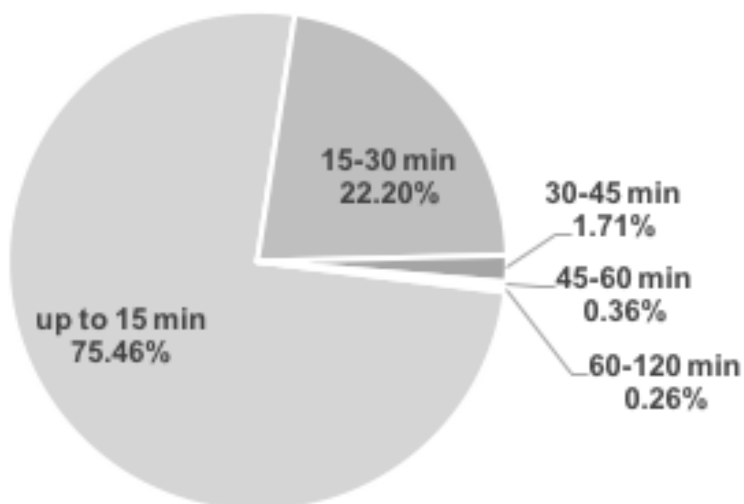
N	1,256,385	**Nmiss**	0
Skewness	3.1706153	**Kurtosis**	22.2875629
Mean	11.73788	**Std Dev**	7.92696
Median	9.7853	**Variance**	62.83672
Mode	6.0911	**Range**	116.9727
		P75-P25	8.4331

Test for Normality	**Statistic**	**p Value**
Anderson-Darling	45767.37	<0.0050

B9 Description of trip time in minutes with stratification by gender-membership composite (n=1,256,385)

	N	Mean	Std Dev	Mean 95% CI		5^{th} %ile	25^{th} %ile	Median	75^{th} %ile	95^{th} %ile
All trips	1,256,385	11.74	7.93	11.72	11.75	3.86	6.44	9.79	14.87	25.19
Subsidized female	29,826	14.32	10.46	14.20	14.44	4.19	7.38	11.47	18.12	33.14
Subsidized male	60,332	14.41	11.13	14.32	14.50	3.87	6.73	11.22	18.47	36.01
Regular female	311,118	12.68	8.10	12.66	12.71	4.25	7.25	10.85	16.11	26.03
Regular male	855,109	11.12	7.38	11.1	11.13	3.76	6.14	9.30	14.10	23.88

B10 Categorization of trip time in minutes



B11 Crosstab and odds ratios for trip longer than 15 minutes by membership type and gender (n=1,256, 385)

	Within 15 minutes	Over 15 minutes	Total
Subsidized	31,502	58,656	90,158
row %	*34.94*	*65.06*	
Regular	276,777	889,450	1,166,227
row %	*23.73*	*76.27*	
Total	308,279	948,106	1,256,385
	24.54%	*75.46%*	
Odds ratio	**95% LCI**	**95% UCI**	
1.7259	1.7013	1.7508	

	Within 15 minutes	Over 15 minutes	Total
Female	101,043	239,901	340,944
row %	*29.64*	*70.36*	
Male	207,236	708,205	915,441
row %	*22.64*	*77.36*	
Total	308,279	948,106	1,256,385
	24.54%	*75.46%*	
Odds ratio	**95% LCI**	**95% UCI**	
1.4394	1.4267	1.4521	

B12 Crosstab and testing for linear trend in trip time from 2012 to 2015 (n=1,256, 385)

	Within 15 minutes	Over 15 minutes	Total
2012	171,216	45,457	216,673
row %	*79.02*	*20.98*	
2013	236,913	70,623	307,536
row %	*77.04*	*22.96*	
2014	296,161	103,090	399,251
row %	*74.18*	*25.82*	
2015	243,816	89,109	332,925
row %	*73.23*	*26.77*	
Total	948,106	308,279	1,256,385
	75.46%	*24.54%*	

	DF	Statistic	P-value
CMH $\chi 2$	1	3008.3798	<.0001

B13 Explanatory model for trip duration of greater than 15 minutes using logistic regression

Trip length was modeled with trip duration of more than 15 minutes as the binary outcome; 24.54% of trips were greater than 15 minutes (n=308,279 of the 1,256,385). The initial model using membership type, gender, and year as explanatory variables showed significant main effects for each variable, but did not capture the interaction of gender and membership type previously described in the unadjusted analyses. The final model used four level composite variable of membership by gender and year; year of ride was also categorical.

$Log\ [p/(1-p)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$ *Logit of trip more than 15 minutes* = -1.4704+ 0.3915 *(regular female member))* + 0.6390 *(subsidized female member)* + 0.6462 *(subsidized male member)* + 0.1072(year 2013) + 0.2543 (year 2014) + 0.3078(year 2015)

Technical Summary

	Gender-membership composite and year of trip
Model inputs (OR with 95% CI)	
Subsidized male member ǂ	1.479 (1.466,1.493)
Subsidized female member ǂ	1.895 (1.849,1.941)
Regular female member ǂ	1.908 (1.875,1.942)
Year 2013 vs. 2012§	1.113 (1.098,1.128)
Year 2014 vs. 2012§	1.29 (1.273,1.306)
Year 2015 vs. 2012§	1.36 (1.343,1.378)
Effects (Wald χ2)	
Model (Global)	14989.9514 (df=6, p<.0001)*
Gender-membership type composite	11924.1912 (df=3, p<.0001)*
Year	2854.6225 (df=3, p<.0001)*
N	1,256,385
Pseudo R2	0.0175
c-statistic	0.57
Hosmer-Lemeshow χ2 statistic	26.8269 (df=5,p <.0001)

**p < 0.0001*
ǂ reference group is male non-subsidized (regular) members
§ reference group is 2012 trips

<u>Global Test</u>
Global H_0: There is no association between trip duration of more than 15 minutes and any of the predictors.
Global H_1: There is an association between trip duration of more than 15 minutes and at least one of the predictors.
Level of significance = 0.05
Estimates of interest
Global test Wald χ^2 14,989.9514, df =6 , p <.0001
Conclusion: Reject the null hypothesis. There is evidence of an association between trip duration of more than 15 minutes and at least one of the predictors.

Main Effects Testing

Gender-membership composite H0: There is no association between the gender-membership composite and trip duration of more than 15 minutes, adjusting for year of trip.
Gender-membership composite H1: There is an association between the gender-membership composite and trip duration of more than 15 minutes, adjusting for year of trip.
Wald $\chi^2_{\text{gender-membership composite}}$ = 11,924.1912 , df = 3, p<.0001
Conclusion for gender-membership composite: Reject the null hypothesis. There is evidence of an association between the gender-membership composite and trip duration of more than 15 minutes, adjusting for year of trip.

Year of trip H_0: There is no association between the year of trip and trip duration of more than 15 minutes, adjusting for the gender-membership composite
Year of trip H_1: There is an association between the year of trip and trip duration of more than 15 minutes, adjusting for the gender-membership composite
Wald $\chi^2_{\text{year of trip}}$ = 2,854.6225, df = 3, <.0001
Conclusion for year of trip: Reject the null hypothesis. There is evidence of an association between the year of trip and trip duration of more than 15 minutes, adjusting for the gender-membership composite

Contrasts for gender-membership composite H_0: There is no association between all categories of the gender-membership composite and trip duration of more than 15 minutes, adjusting for year of trip.
Contrasts for gender-membership composite H_1: There is an association between at least one category of the gender-membership composite and trip duration of more than 15 minutes, adjusting for year of trip.
$\beta_{\text{regular female member}}$ =0.3915 (SE = 0.00474), p<.0001
Odds ratio $_{\text{regular female member v regular male member}}$ = 1.479 (95% CI 1.466,1.493)
$\beta_{\text{subsidized female member}}$ = 0.6390 (SE= 0.0125), p<.0001
Odds ratio $_{\text{subsidized female member v regular male member}}$ = 1.895 (95% CI 1.849, 1.941)
$B_{\text{subsidized male member}}$ = 0.6462 (SE=0.0089445), p<.0001
Odds ratio $_{\text{subsidized male member v regular male member}}$ = 1.908 (95% CI 1.875, 1.942)
Conclusion for gender-membership composite: Reject the null hypothesis. Odds are 1.908 times greater that a subsidized male had a trip longer than 15 minutes compared to a regular male member. Longer trips also had higher likelihood of being by a subsidized female (1.895 odds) and by a regular female member (1.479 odds) compared to regular male members.
ok
Contrasts for year of trip H_0: There is a no difference in odds between any year of trip and trip duration of more than 15 minutes, adjusting for the gender-membership composite.
Contrasts for year of trip H_1: There is a difference in odds between at least one year of trip and trip duration of more than 15 minutes, adjusting for the gender-membership composite
$\beta_{\text{year 2013}}$ = 0.1072 (SE =0.00683), p<.0001
Odds ratio $_{\text{year 2013 versus year 2012}}$= 1.113 (95% CI 1.098, 1.128)
$\beta_{\text{year 2014}}$ = 0.2543 (SE =0.00643), p<.0001
Odds ratio $_{\text{year 2014 versus year 2012}}$= 1.290 (95% CI 1.273, 1.306)
$\beta_{\text{year 2015}}$ = 0.3078 (SE= 0.00660), p<.0001
Odds ratio $_{\text{year 2015 versus year 2012}}$= 1.360 (95% CI 1.343,1.378)
Conclusion for contrasts for year of trip: Reject the null hypothesis. The odds for lack of trip duration beyond 15 minutes is higher for trips during 2013, 2014, and 2015 compared to 2012,

controlling for the gender-membership composite. The odds of a longer trip increased annually from 1.113 for 2013 versus 2012 to 1.360 for 2015 versus 2012).

Examination of the standardized beta coefficients shows the strongest effect was for regular female members followed by subsidized male members, the year 2015, the year 2014, subsidized female members, and the smallest effect was for the year 2013. The reference groups were regular male members and the year 2012.

<u>**Goodness of Fit**</u>

Goodness of fit was assessed as model calibration and outcome discrimination ability.
H_0 for calibration: There is no difference between the observed and expected values for the outcome of trip duration longer than 15 minutes.
Level of significance = 0.05
Hosmer-Lemeshow test of goodness-of-fit χ^2statistic = 26.8269 df = 5, p <.0001
C-statistic = 0.570
Conclusion for model calibration: Reject the null hypothesis; the model was not able to predict the outcome of a trip longer than 15 minutes in this model. The model demonstrated low discriminatory ability between trip up to 15 minutes and trip lower than 15 minutes.

B14 Technical notes

Data used for neighborhood disadvantage and demographics were obtained directly from the BPHC Research and Evaluation Unit (REU) and their 2014–2015 Health of Boston report[101]. Original data sources are listed with indicators below. REU performed the analyses necessary to describe the population at the neighborhood-level.[101]
In BPHC analyses, Back Bay includes Beacon Hill, Downtown, North End, and West End; South End incudes Chinatown, and Dorchester is separated into North Dorchester and South Dorchester.

Socioeconomic indicators[115]
Data source: American Community Survey, 2008–2012, U.S. Census Bureau
BPHC provided a point prevalence with a 95% CI for each indicator for Boston and by neighborhood. I compared the neighborhood statistic to the statistic for the city. If there was no overlap of the 95% CI I classified the neighborhood as worse than (disadvantaged) or better than (advantaged) Boston. If there was overlap of the 95% CI I classified the neighborhood as same as Boston. Note: it was not possible to remove each neighborhood from the Boston statistic. This method may not have been sensitive to true differences between the neighborhood and the rest of the city, especially in the larger neighborhoods.
<u>Linguistically Isolated Households by Neighborhood</u> is defined as one in which all adults in the household (age 14 years and above) speak a language other than English, and none of them speaks English "very well." This measure will be referred to as linguistic isolation.
<u>Renter-Occupied Housing Units Paying at Least 30% Income Towards Rent</u> will be referred to as rent burden.
<u>Educational Attainment by Neighborhood</u> is the percent of the population age 25 years and above with less than a high school diploma. This measure will be referred to as low education.
<u>Unemployment Rate by Neighborhood</u> is based in the rate of persons age 16 years and above meeting the following criteria: no job, looked for a job within past 4 weeks, available to start work, includes temporary lay offs is expectation of recall to work.

Percent of Population with Income Below Poverty Level is based on pre-tax income by household size, benefits such as SNAP and housing subsidies are not included

Health indicators[101]

Data sources on hospitalization and mortality: Massachusetts DPH two year annualized age adjusted death rates, 2010–2011 [‡]; 2012 inpatient hospital discharge databases of the Massachusetts Center for health information and analysis[§]; age-adjusted mortality rates from Massachusetts DPH, 2009–2013.[†]

Admission rates for diabetes[§]

Mortality rates for diabetes [‡]

Statistics for diabetes hospitalizations and mortality were provided by quartile. The neighborhood with the lowest quartile had the highest mortality rates along neighborhoods; mortality rates below the 25^{th} percentile will be classified as relatively disadvantaged.

Chronic disease mortality rates [‡]

Chronic disease hospitalization rates[§]

BPHC created this composite and variable using mortality data for diabetes, cerebrovascular disease, and heart disease. The index was account of how many times each neighborhood had a mortality rate in the bottom two quartiles. A score of zero to one indicate low mortality rates. A score of two is considered to be moderate, and a score of three indicates high mortality rates relative to the rest of Boston. The high score will be considered to be a poor health outcome at the level of the neighborhood. This process was repeated for chronic illness hospitalizations.

Mental health hospitalizations[§]

Communities were categorized by BPHC as having hospitalization rates which were lower than then overall Boston, same as Boston, or higher than Boston.

Homicide rates[†]

BPHC calculated an annual average rate by neighborhood. I classified each neighborhood into one of three categories relative to the entire city of Boston. Neighborhoods with homicide rates under 50% of the city were classified as lower than Boston. Neighborhoods between 50% and 150% of the Boston rate were classified as same as Boston. Only 637,015 of the 1,256,385 ride were classified using homicide rate because the two neighborhoods with the greatest number of resident bike rides did not have a sufficient number of homicides for the neighborhood level analysis (Back Bay and Fenway).

Data sources on birth outcomes: Massachusetts DPH preterm birth as a percentage of all live births, 2008–2012*; Massachusetts DPH statistics on live birth and death, preterm birth, and low birth weight births**.

Preterm births *

Statistics were provided by quartile. The neighborhood with the lowest quartile had the highest preterm birth weights among neighborhoods. I classified any neighborhood with a proportion of preterm births below the 25^{th} percentile will be classified as advantaged, and any neighborhood above the 75^{th} percentile as disadvantaged.

Birth outcome index**

BPHC created this composite with account of how many times each neighborhood was in the bottom two quartiles for each of the three adverse birth outcomes (infant mortality rate (IMR), proportion of preterm births, proportion of low birth weight births). The scores were classified by BPHC as low, moderate, or high. A high score is considered to be a poor birth outcome at the neighborhood level. West Roxbury is not included in the index because the IMR for that neighborhood was not sufficient for reporting.

Self-reported Race/Ethnicity by Resident[116]
Data Source: 2010 United States Census
Black, White, Latino
The categories reported by BPHC were Asian, Black, Latino, White, Other, and Iwo or more races. I created individual variables for Black, White, and Latino. Neighborhoods with proportion of each race under 50% of the city proportion were considered to be lower than Boston. Neighborhoods with a proportion of that race between 50% and the hundred and 50% of Boston were considered to be same as Boston, neighborhoods with proportion of each race above 1 50% of Boston were considered to be higher than Boston. These variables were not categorized as indicative of advantage or disadvantage. Note the neighborhood composition of higher proportion of Blacks and lower proportion of Whites if often associated with health disparity.

Table B15 Spearman correlation and internal consistency reliability of indicators

A correlation matrix was created and Cronbach α statistic calculated for the individual measures of socioeconomics and health indicators. Homicide was not included because of the significant lower sample size
Spearman correlations were performed. A high degree of internal consistency reliability with a raw Cronbach α score of zero point 91.01. The variables with lowest item total correlations were mortality and low rates of high school graduation. The highest item total correlations were seen for unemployment, poverty, and mental health hospitalization.

Cronbach Coefficient Alpha	
Raw	0.910152

Cronbach Coefficient α with Deleted Variable (Raw)

Variable	Item-total correlation	α without variable
Chronic disease death	0.400559	0.912555
Mental health admit	0.788665	0.895227
Chronic disease admit	0.730212	0.90077
Poor birth outcome	0.611888	0.904426
Preterm birth	0.715208	0.899256
Diabetes mortality	0.304263	0.915582
Diabetes admit	0.619212	0.905394
High rent burden	0.69011	0.900498
Unemployment	0.898231	0.894277
Poverty	0.781869	0.895622
Low education	0.491788	0.909029
Linguistic isolation	0.763842	0.897007

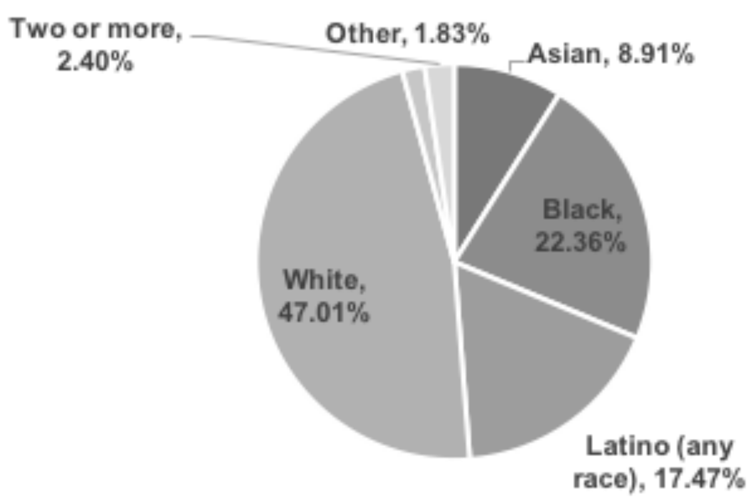
The majority of itemized correlations were positive and moderate to high. The highest item-item correlations were seen for mental health hospitalization with poverty and linguistic isolation, and rent burden with poor birth outcomes. The socioeconomic variables demonstrated high inter-item correlation, with the exception of low high school graduation rates.

B16 Socio-economic and health indicators for population of Boston

Health indicator	Age-adjusted rate
Mortality per 100,000	
Heart disease	129.9
Diabetes-related	19.4
Cerebrovascular disease	30.1
Homicide	6.6
Hospitalization per 1,000	
Heart disease	9.8
Diabetes-related	1.9
Cerebrovascular disease	2.3
Adverse birth outcomes	
Infant mortality per 1,000	5.0
Percent low birth weight	9.0
Percent preterm birth	9.5

Indicator	Boston point prevalence (95% CI)
Linguistically isolated households	**11.8% (11.3–12.4)**
Population with less than a high school diploma	15.5% (14.9–16.1)
Unemployment rate	10.3% (9.7–10.8)
Income below poverty level	21.2% (20.4–22.0)
Housing units with rent burden	49.1% (47.8–50.5)

B17 Self-reported racial/ethnic composition of Boston (n=617,591) US Census, 2010)*



** Census 2010 used instead of more recent ACS data because neighborhood level data only available from 2010 Census and these proportions are used to compare composition of neighborhoods*

B18 Descriptive statistics for the neighborhood of residence for each rider (n=1,256, 385; non-unique)

	Frequency	Percent
Neighborhood poverty		
Worse than Boston	706,256	56.21
Same as Boston	186,442	14.84
Better than Boston	363,687	28.95
Neighborhood unemployment		
Worse than Boston	69,751	5.55
Same as Boston	591,474	47.08
Better than Boston	595,160	47.37
Neighborhood rental cost-burden		
Worse than Boston	347,827	27.68
Same as Boston	390,892	31.11
Better than Boston	517,666	41.20
Neighborhood linguistic isolation		
Worse than Boston	281,782	22.43
Same as Boston	453,062	36.06
Better than Boston	521,541	41.51
Neighborhood low level of education		
Worse than Boston	108,168	8.61
Same as Boston	370,562	29.49
Better than Boston	777,655	61.90
Neighborhood premature birth rate		
Bottom 25% (worst performance)	52,639	4.19
2nd quartile	547,119	43.55
3rd quartile	443,960	35.34
Top quartile (best performance)	212,667	16.93
Neighborhood diabetes mortality rate		
Bottom 25% (worst performance)	52,639	4.19
2nd quartile	125,511	9.99
3rd quartile	939,274	74.76
Top quartile (best performance)	138,961	11.06
Neighborhood diabetes admission rate		
Bottom 25% (worst performance)	69,447	5.53
2nd quartile	293,167	23.33
3rd quartile	259,804	20.68
Top quartile (best performance)	633,967	50.46
Neighborhood homicide rate (n=637,015)		
More than 1.5x Boston rate	69,751	10.95
Close to Boston rate	438,116	68.78
Less than half Boston rate	129,148	20.27

Neighborhood mental health hospitalization rate		
More admits than Boston	695,035	55.32
Same admits as Boston	135,628	10.80
Fewer admits than Boston	425,722	33.88
Neighborhood chronic disease mortality index		
More deaths than Boston	117,944	9.39
Same deaths as Boston	330,021	26.27
Fewer deaths than Boston	808,420	64.34
Neighborhood chronic disease hospitalization index		
More admits than Boston	71,609	5.70
Same admits as Boston	264,670	21.07
Fewer admits than Boston	920,106	73.23
Neighborhood poor birth outcome score (n= 1,252,510)		
High score (disadvantage)	301,079	24.04
Moderate score	298,679	23.85
Low score (advantage)	652,752	52.12
Self-reported Black race/ethnicity		
Less than half of Boston	887,833	70.67
About the same as Boston	296,943	23.63
More than 1.5x Boston	71,609	5.70
Self-reported White race/ethnicity		
Less than half of Boston	69,751	5.55
About the same as Boston	706,025	56.19
More than 1.5x Boston	480,609	38.25
Self-reported Latino race/ethnicity		
Less than half of Boston	341,598	27.19
About the same as Boston	827,411	65.86
More than 1.5x Boston	87,376	6.95

B19 Trend in socioeconomic and health advantage by neighborhood of rider (n=1,256,385)

Indicator of advantage	2012	2013	2014	2015	χ^2 for trend	p-value
Fewer households with linguistic isolation	37.53	41.00	41.94	44.07	3215.69	<.0001
Fewer residents without HS diploma	60.20	63.60	62.00	61.58	440.9464	<.0001
Fewer unemployed residents	43.14	48.14	47.73	48.74	261.1639	<.0001
Fewer residents in poverty	32.84	31.08	27.18	26.57	16.022	<.0001
Fewer housing units with rent burden	37.23	40.87	41.58	43.65	1229.307	<.0001

Indicator of advantage	n	2012	2013	2014	2015	$\chi2^2$ for trend
Lower premature birth weight	1,256,385	12.86	15.13	18.80	18.99	4,667.19*
Lower diabetes mortality rate	1,256,385	9.19	10.97	12.08	11.13	547.26*
Lower diabetes admission rate	1,256,385	55.82	53.68	48.81	45.97	547.26*
Lower mental health admission rate	1,256,385	64.25	65.39	67.28	66.61	463.15*
Lower chronic illness mortality rate	1,256,385	64.68	62.08	65.63	65.38	812.46*
Lower chronic illness admission rate	1,256,385	74.94	73.78	73.73	68.55	1,576.35*
Lower birth adverse outcome rate	1,252,510	53.49	54.59	51.78	46.25	3,494.98*
Lower homicide rate‡	637,015	18.67	21.87	21.23	18.78	32.98*

***p<0.0001; df = 1 for all tests; ‡ n for subsidized = 61,663 n =575,352 non subsidized**

B21 Racial composition of neighborhood of rider by year (n=1,256,385)

	2012	2013	2014	$\chi2$ for trend
Higher proportion of Whites	35.96	39.22	37.78	362.1601*
Lower proportion of Blacks	67.89	72.70	71.35	27.1712*
Lower proportion of Hispanics	31.08	29.40	25.22	3525.7339*

***p<0.0001; df = 1 for all tests**

B22 Crosstab for trend in Latino composition of neighborhood by rider type (n=1,256,385)

	2012	2013	2014	2015
Below Boston	31.08	29.4	25.22	24.98
Similar to Boston	63.65	65.55	66.95	66.26
More than Boston	5.28	5.05	7.83	8.76
Total	216673	307536	399251	332925

Mantel-Haenszel $\chi2$ df= 1 6080.0105 p<.0001

Appendix C: Chapter Three

Appendix C1 Electronic Version of Survey

Primary care provider survey on biking

1. In which clinical areas at BMC do you provide primary care to patients?
Check all that apply

- ☐ Family medicine
- ☐ Pediatrics
- ☐ Adolescent center
- ☐ Infectious disease
- ☐ Women's center
- ☐ Internal medicine
- ☐ I do not provide primary care at any of these BMC locations
- ☐ I am not a primary care provider

Other area, please enter

2. What is your current position at BMC?

- ○ Attending physician
- ○ Fellow
- ○ Resident
- ○ Nurse practitioner
- ○ Physician assistant
- ○ Certified nurse midwife

Other position, please enter

3. In a typical week, how many outpatient sessions (half day or evening) do spend providing primary care at BMC? This includes sessions spent supervising physician-trainees.

4. How many years have you worked as a primary care provider post-training? If you are a trainee please enter 0.

5. What is your gender?

- ○ Female
- ○ Male

6. How far is your commute from home to BMC in miles?

- ○ < 1 mile
- ○ 1 to 3 miles
- ○ 4 to 5 miles
- ○ 5 to 10 miles
- ○ 10 to 15 miles
- ○ Greater than 15 miles

Optional comment

7. In the past 12 months how often did you ride a bicycle:

	On a regular basis year-round	On a regular basis during good weather	Occasionally	Never
For the exercise or health benefits	○	○	○	○
For pleasure/leisure	○	○	○	○
As part of work commute	○	○	○	○
Within the city of Boston	○	○	○	○

Optional comment

8. Have you ever used a bike share program? (Check all that apply)

- ☐ I have used the Boston-area Hubway program
- ☐ I have used a different bike share program
- ☐ I have been a bike share member
- ☐ I have used a 1 or 3 day pass for any bike share
- ☐ No

Optional comment

50%

Next

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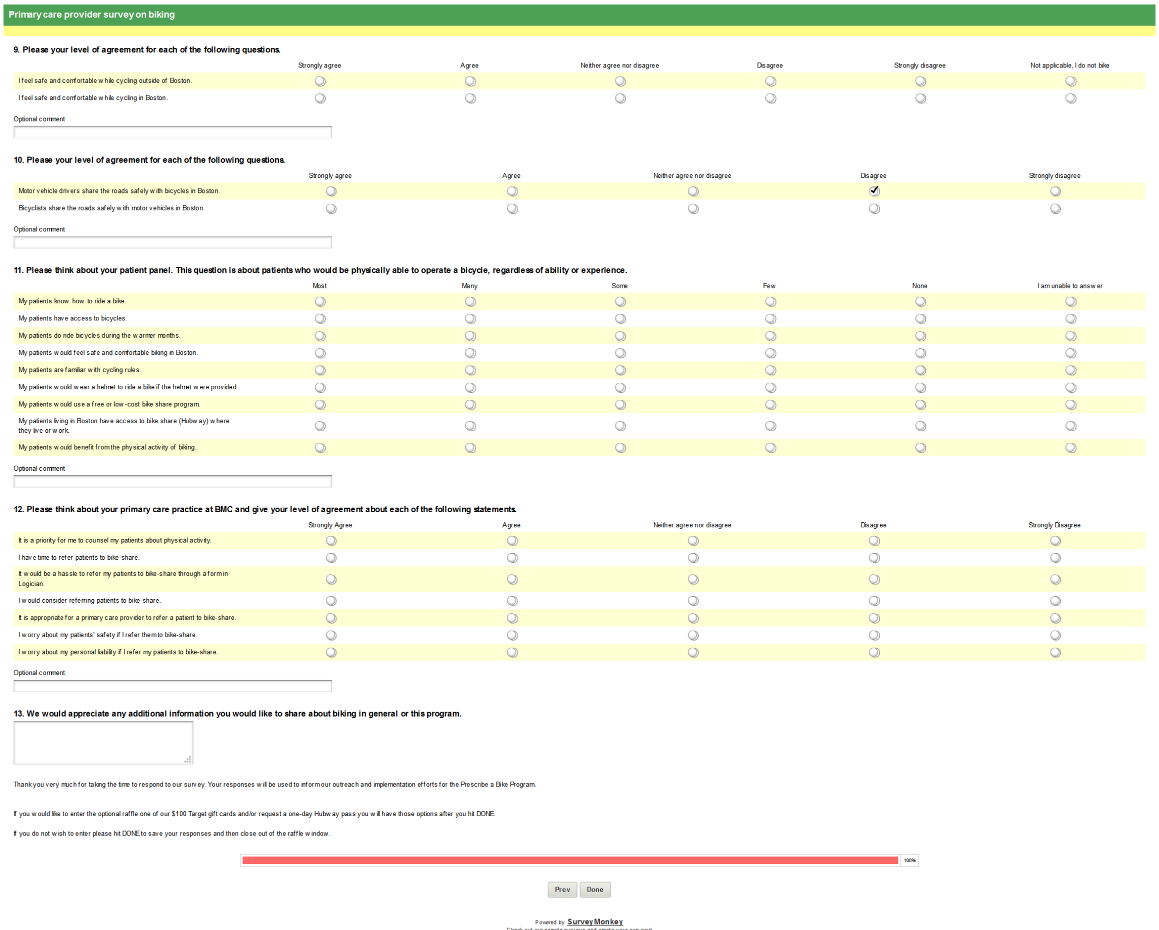

Primary care provider survey on biking

9. Please your level of agreement for each of the following questions.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Not applicable, I do not bike
I feel safe and comfortable while cycling outside of Boston.	○	○	○	○	○	○
I feel safe and comfortable while cycling in Boston.	○	○	○	○	○	○

Optional comment

10. Please your level of agreement for each of the following questions.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Motor vehicle drivers share the roads safely with bicycles in Boston.	○	○	○	✓	○
Bicyclists share the roads safely with motor vehicles in Boston.	○	○	○	○	○

Optional comment

11. Please think about your patient panel. This question is about patients who would be physically able to operate a bicycle, regardless of ability or experience.

	Most	Many	Some	Few	None	I am unable to answer
My patients know how to ride a bike.	○	○	○	○	○	○
My patients have access to bicycles.	○	○	○	○	○	○
My patients do ride bicycles during the warmer months.	○	○	○	○	○	○
My patients would feel safe and comfortable biking in Boston.	○	○	○	○	○	○
My patients are familiar with cycling rules.	○	○	○	○	○	○
My patients would wear a helmet to ride a bike if the helmet were provided.	○	○	○	○	○	○
My patients would use a free or low-cost bike share program.	○	○	○	○	○	○
My patients living in Boston have access to bike share (Hubway) where they live or work.	○	○	○	○	○	○
My patients would benefit from the physical activity of biking.	○	○	○	○	○	○

Optional comment

12. Please think about your primary care practice at BMC and give your level of agreement about each of the following statements.

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
It is a priority for me to counsel my patients about physical activity.	○	○	○	○	○
I have time to refer patients to bike-share.	○	○	○	○	○
It would be a hassle to refer my patients to bike-share through a form in Logician.	○	○	○	○	○
I would consider referring patients to bike-share.	○	○	○	○	○
It is appropriate for a primary care provider to refer a patient to bike-share.	○	○	○	○	○
I worry about my patients' safety if I refer them to bike-share.	○	○	○	○	○
I worry about my personal liability if I refer my patients to bike-share.	○	○	○	○	○

Optional comment

13. We would appreciate any additional information you would like to share about biking in general or this program.

Thank you very much for taking the time to respond to our survey. Your responses will be used to inform our outreach and implementation efforts for the Prescribe a Bike Program.

If you would like to enter the optional raffle one of our $100 Target gift cards and/or request a one-day Hubway pass you will have those options after you hit DONE.

If you do not wish to enter please hit DONE to save your responses and then close out of the raffle window.

100%

Prev Done

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Appendix C2 Letter to Providers Accompanying Survey

Greetings,

Hubway is a bike share system that allows members to use a fleet of 1000+ bikes docked at stations all over Boston, Cambridge, Somerville and Brookline. An annual membership allows an unlimited number of trips, and if trips do not exceed 30-minutes, riders pay no usage fees.

Boston Medical Center (BMC) and the City of Boston are partnering to provide subsidized memberships to low-income Boston residents for just $5/year. Our "Prescribe a Bike" program allows providers to write patients a "prescription" for a subsidized Hubway membership that can be redeemed at the BMC Transcomm office or by calling the city's bike department. All subsidized memberships include a free helmet

We are interested in understanding your thoughts about bicycling in Boston, and about this new program for your primary care patients. The research team from Boston University School of Public Health (BUSPH) and Boston Bikes would appreciate your voluntary participation in the survey below. As a thank you we are offering all respondents a free one-day pass on Hubway AND the option to enter a raffle for one of our $100 Target gift cards.

All responses will be anonymous. Survey responses of individuals will only be available to the study team. Your survey is not linkable to your email address.

The survey will take about 5 minutes to complete. You may decline to answer any questions you choose. You are not required to enter the raffle or request a one-day Hubway pass. Completion and submission of the survey are considered to be implied consent.

If you have any questions about this project or about the survey, please contact Cassie Ryan, RN, MPH cassier@bu.edu at BUSPH or Dr. Alan Meyers at BMC Pediatric Primary Care at alan.meyers@bmc.org or -617-414-4719.

If you would like further information about your rights as a research subject by calling the Office of the Institutional Review Board of Boston University Medical Center at 617-638-7207. https://www.surveymonkey.com...each clinic had a unique link

Thank you in advance for your time. Your opinions and views are important, and we look forward to receiving your responses.

Sincerely,

Alan Meyers, MD

BMC Pediatric Primary Care

Cassie Ryan, RN, MPH

BU School of Public Health

Mari-Lynn Drainoni, PhD

BU School of Public Health

C3 Additional Categorization of Provider Characteristics

	Frequency	Percent
Trainee by Position (n=80)		
Staff	42	53.16
Trainee	37	46.84
Experience in Years after Training (n=80)		
<1 year	33	41.25
1–5 years	17	21.25
6–10 years	13	16.25
>10 years	17	21.25
Commute in miles (n=79)		
within 3 miles	40	50.63
4–10 miles	27	34.18
>10 miles	12	15.19

C4 Univariate statistics for numeric provider characteristics for sample and for non-trainees

Experience in Years	All respondents	Non-trainees
N	**80**	**42**
Mean	7.16	13.29
Standard Deviation	10.34	11.13
Median	2	10
IQR (P25 to P75)	0 to 10	5 to 22
Mode	0	1

Range	0 to 43	0 to 43
Skewness	1.7077	1.0208
Kurtosis	2.3999	0.4061
Shapiro-Wilk (W)	7.1625	0.8915
Shapiro-Wilk (Pr<W)	<0.0001	0.0008
< 1 year	33 (41.25)	1 (2.38)
1– 5 years	17 (21.25)	11 (26.19)
6–10 years	13 (16.25)	12 (28.57
> 10 years	17 (21.25)	18 (42.86)

Clinic sessions per week	**All respondents**	**Non-trainees**
N	79	42
Mean	2.75	3.68
Standard Deviation	2.01	2.05
Median	2	4
IQR (P25 to P75)	1 to 4	2 to 5
Mode	1	1
Range	0.5 to 8	1 to 8
Skewness	0.8301	0.3251
Kurtosis	-0.3188	-0.7043
Shapiro-Wilk (W)	0.8316	0.9298
Shapiro-Wilk (Pr<W)	<0.0001	0.0128
Up to 1/week	37 (46.25)	9 (21.43)
2 to 5/week	33 (41.25)	24 (57.17)
> 5/week	10 (12.50)	9 (21.43)

C5 Trainee status associations and odds ratios with provider characteristics

	n	**% trainee**	**% staff**	**Odds Ratio**	**95% LCI**	**95% UCI**
Gender (female)	79	61.11	62.79	0.9312	0.3742	2.3176
Pediatric Provider	79	48.65	67.44	0.4574	0.1847	1.1327
Experience (up to 5 years)	79	97.3	20.23	83.0769	10.2667	672.2503
Sessions (up to 1/week)	79	75.68	20.93	11.7531	4.1102	33.6076
Commute (up to 5 miles)	78	91.67	53.49	9.5652	2.5421	35.991

C6 Trainee status associations with binary variables

	n	**Test**	**df**	**Statistic**	**p-value**
Gender	79	χ^2	1	0.0235	0.8782
Pediatric Provider	79	χ^2	1	2.8983	0.0887
Experience in years	79	Fisher's Exact	NA	<.0001	<.0001
Sessions per week (3 levels)	79	Fisher's Exact	NA	<0.0001	<0.0001
Commute in miles (3 levels)	78	Fisher's Exact	NA	<0.0001	0.0005

Table of Sessions per Week by Trainee Status (n=80)

Sessions per week	Position: Trainee	Position: Staff
>= 1	28	9
2 to 5	9	25
>5	0	9

CMH 25.6575
Row Mean Scores Differ df=2 P <.0001

C8 Associations using row mean score differences between experience in years and select provider characteristics

	n	df	Statistic	p-value
Gender	79	3	2.9914	0.3929
Pediatric Provider	80	3	7.5073	0.0574
Number of sessions per week (3 levels)	80	3	28.1359	<.0001
Commute in miles (3 levels)	79	3	10.2876	0.0163

C9 Odds ratios between experience of up to or greater than five years with select provider characteristics

	n	% trainee	% staff	Odds Ratio	95% LCI	95% UCI
Gender	79	68.75	51.61	2.0625	0.8121	5.2381
Pediatric Provider	80	89.58	77.42	2.5083	0.7175	8.7688
Sessions (≤ 1/week)	80	61.22	22.58	5.4135	1.9534	15.003
Commute (≤5 miles)	79	81.25	54.84	3.5686	1.2962	9.8251

C10 Associations between commute in miles and select provider characteristics

	n	Test	df	Statistic	p-value
Gender	78	Row Mean Scores	1	0.2613	0.6092
Department	79	Row Mean Scores	3	7.9297	0.0475
Pediatric Provider	79	Row Mean Scores	1	0.0422	0.8373
Position	79	Row Mean Scores	3	20.0494	0.0002
Trainee status	79	Row Mean Scores	1	14.1748	0.0002
Experience in years	79	Nonzero Correlation	1	9.4408	0.0021
Number of sessions per week	79	Nonzero Correlation	1	9.3474	0.0022

C11 Crosstabs and examination for linear trend for sessions per week and trainee status with a commute in miles

Commute in Miles by Sessions per Week (#, %; n=79)

Commute in Miles

	Sessions: <= 1	2 to 5	>5
<3	23	14	3
4 to 10	11	15	1
>10	2	5	5

Nonzero Correlation (df = 1) stat = 9.3474 p=0.0022

Commute in Miles by Trainee Status (#, %; n=79)

Commute in Miles

	Position: Trainee	Staff
<3	26	14
4 to 10	9	18
>10	1	11

CMH Row Mean Scores Differ	df=2	14.2437	p= 0.0008

C12 Odds ratios between experience of up to or greater than five years with select provider characteristics for all providers and for staff providers only

All providers	**Total N**	**% up to 5y experience**		**Odds Ratio**	**95% CI**	
Gender		%female	%male			
	79	67.35	50	2.0625	0.8121	5.2381
Adult provider		% adult	% peds			
	80	57.45	66.67	0.675	0.2673	1.7046
Up to 5 sessions/week	80	<=5	>5			
		81.09	44.19	5.4135	1.9534	15.003
Up to 5 mile commute	79	<= 5 miles	>5 miles			
		69.64	39.13	3.5686	1.2962	9.8251
Staff providers only	**Staff N**	**% up to 5y experience**		**Odds Ratio**	**95% CI**	

Gender		%female	%male			
	43	40.74	12.5	4.8125	0.9072	25.530
Adult provider		% adult	% peds			
	43	34.48	21.41	1.9298	0.4355	8.5511
Up to 5 sessions/week		<=5	>5			
	43	33.33	29.41	1.2	0.2497	5.768
Up to 5 mile commute		<= 5 miles	>5 miles			
	43	30.43	30	1.0208	0.2768	3.7652

C13 Categorizations for provider biking

	Frequency	Percent
Self-identify as a biker(n=80)		
Yes	74	92.5
No	6	7.5
Biking Composite within 12 months (n=78)		
Not a biker	24	30.77
Yes, non-commuting	22	28.21
Yes, includes commuting	32	41.03
Commute by Bike within Past 12 Months (n=78)		
Yes	32	41.03
No	46	58.97
Any bikeshare use (n=80)		
Yes	18	22.5
No	62	77.5
Biking in Boston this year (n=75)		
No	17	22.67
Yes	34	45.33
Not a biker	24	32
Biking both in and out of Boston this year (n=75)		
Yes	34	45.33
No	41	54.67
Only bike outside Boston (n=80)		
Yes	4	5
No	76	95

C14 Associations between provider gender and provider biking (within past 12 months unless otherwise noted)

	n	test	df	stat	p
Composite for biking	77	Fisher's Exact	NA	0.0022	0.0452
Biking for fitness	77	χ^2	2	0.3153	0.8541
Self-identify as biker currently	79	Fisher's Exact	NA	0.3316	1.0000
Any biking	79	χ^2	1	0.0033	0.9542
Biked for commute	77	χ^2	1	4.3015	0.0381
Use of bikeshare ever	79	χ^2	1	1.4312	0.2316
Biked in Boston within past 12 months as YN	74	χ^2	1	2.0671	0.1505
Biked only outside of Boston with past 12 months	79	Fisher's Exact	NA	0.0343	0.0885

C15 Odds ratios for male gender and provider biking

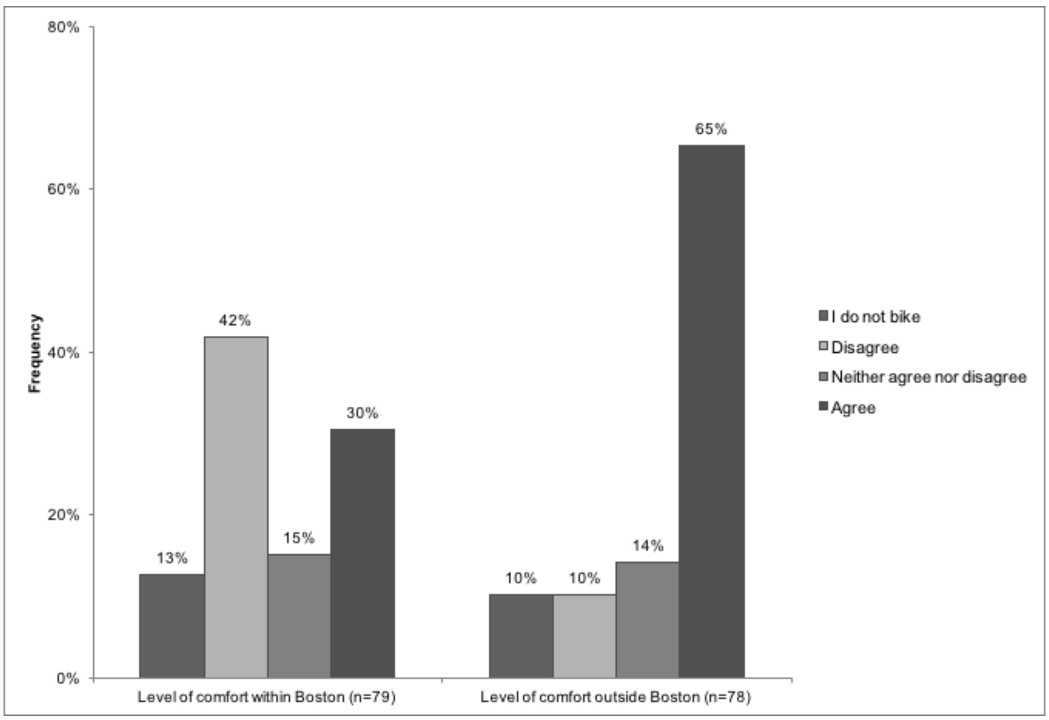
	n	**% males**	**% female**	**OR**	**95% LCI**	**95% UCI**
Self-identify as biker	79	93.33	91.84	1.2444	0.217	7.2457
Biked	79	70	69.32	1.0294	0.3827	2.7686
Biked for commute	77	55.175	31.25	2.7077	1.0441	7.0219
Use of bike-share (ever)	79	30	18.37	1.9048	0.6571	5.5212
Biked in Boston	74	55.56	38.3	2.0139	0.7709	5.261
Biked only outside Boston	79	10	28.57	0.2778	0.724	1.0653

C16 Provider assessments of road safety and own biking comfort

	Frequency	**Percent**
Cars Share the Road Extended (n=80)		
Strongly disagree	16	20.00
Cars safely share the road	35	43.75
Neither agree nor disagree	21	26.25
Agree	8	10.00
Strongly Agree	0	0.00
Cars Share the Road Neutral with yes (n=80)		
Disagree	51	63.75
Do not disagree	29	36.25
Bikes Share the Road Extended (n=80)		
Strongly disagree	12	15
Disagree	31	38.75
Neither agree nor disagree	27	33.75

Agree	9	11.25
Strongly agree	1	1.25
Bikes Share the Road Neutral with yes (n=80)		
Disagree	43	53.75
Do not disagree	37	46.25
I feel safe and comfortable riding in Boston (n=79)		
I do not bike	10	12.66
Not in agreement	33	41.77
Neither agree nor disagree	12	15.19
In agreement	24	30.38
I feel safe and comfortable riding outside Boston (n=78)		
I do not bike	8	10.26
Not in agreement	8	10.26
Neither agree nor disagree	11	14.1
In agreement	51	65.38

C17 Provider level of comfort biking by location



C18 Simple statistics for safety and comfort

	N	Mean	Std Dev	Median	Minimum	Maximum
Cars Safely Share the Road (extended)	80	1.2625	0.89646	1	0	3
Bikes Safely Share the Road (extended)	80	1.45	0.92641	1	0	4
Comfort biking in Boston (full ordinal)	69	1.73913	1.30217	2	0	4

Comfort biking outside Boston (full ordinal)	70	2.75714	0.93925	3	0	4

C19 Intercorrelations for perceptions of road sharing and own comfort biking

	Cars Safely Share the Road	Bikes Safely Share the Road	Comfort biking in Boston	Comfort biking outside Boston
Cars Safely Share the Road	1 80	0.67362 *<.0001* 80	0.78092 *<.0001* 69	0.44566 *0.0001* 70
Bikes Safely Share the Road	0.67362 *<.0001* 80	1 80	0.64189 *<.0001* 69	0.36904 *0.0017* 70
Comfort biking in Boston	0.78092 *<.0001* 69	0.64189 *<.0001* 69	1 69	0.51755 *<.0001* 67
Comfort biking outside Boston	0.44566 *0.0001* 70	0.36904 *0.0017* 70	0.51755 *<.0001* 67	1 70

C20 Associations between biking comfort and perceptions of safe vehicle road sharing behavior using 3-level ordinal variables

	n	test	df	stat	p
I feel safe and comfortable riding in Boston					
Cars Safely Share the Road	69	Fisher's Exact	NA	<.0001	<.0001
	69	CMH χ^2	1	29.341	<.0001
Bikes Safely Share the Road	69	Fisher's Exact	NA	<.0001	<.0001
	69	CMH χ^2	1	25.1313	<.0001
I feel safe and comfortable riding outside Boston					
Cars Safely Share the Road	70	Fisher's Exact	NA	0.0072	0.5975
	70	CMH χ^2	1	3.5014	0.0613
Bikes Safely Share the Road	70	Fisher's Exact	NA	0.0011	0.2045
	70	CMH χ^2	1	3.523	0.0605

C21 Associations between gender and provider perceptions of road safety and own biking comfort

	n	test	df	statistic	p-value
Cars safely share the road	79	Fisher's Exact	NA	0.0027	0.0407
Bikes safely share the road	79	χ^2	2	6.412	0.0405
I feel safe and comfortable riding in Boston	78	χ^2	2	10.1387	0.0063
I feel safe and comfortable riding outside Boston	77	χ^2	2	3.0881	0.2135

C22 Associations between provider characteristics of experience and commute distance with perceptions or road safety and own biking comfort

	n	test	df	statistic	p-value	> 10 years experience	<= 10 years experience
Cars safely share road (Disagree)	80	χ^2	1	3.8544	0.0496	83.33	58.06
Bikes safely share the road (Disagree)	80	χ^2	1	1.5588	0.2118	66.67	50.00
I feel safe and comfortable riding in Boston- No agreement	69	χ^2	1	3.8873	0.0487	86.67	59.26
I feel safe and comfortable riding outside Boston- No agreement	70	χ^2	1	4.6233	0.0315	50	21.43
						% living > 5 miles away	**% living <= 5 miles**
Cars safely share road (Disagree)	79	χ^2	1	0.0819	0.7747	60.87	64.29
Bikes safely share the road (Disagree)	79	χ^2	1	0.112	0.7379	60.87	51.79
I feel safe and comfortable riding in Boston- No agreement	68	χ^2	1	1.3737	0.2412	76.47	60.78
I feel safe and comfortable riding outside Boston- No agreement	69	χ^2	1	2.1034	0.147	41.18	23.08

C23 Correlations between road sharing and own biking comfort with provider characteristics

	Cars Safely Share the Road	Bikes Safely Share the Road	Comfort biking in Boston	Comfort biking outside Boston
EXPERIENCE	-0.09035	-0.08954	-0.06688	-0.27437
Years in practice	*0.4254*	*0.4296*	*0.5851*	*0.0215*
	80	80	69	70

SESSIONS	0.09022	-0.01985	0.10959	-0.11051
Sessions per week	*0.4291*	*0.8621*	*0.3737*	*0.366*
	79	79	68	69
COMMUTE	-0.08547	-0.06055	-0.14337	-0.23115
Commute in Miles	*0.4539*	*0.596*	*0.2435*	*0.056*
	79	79	68	69

C24 Associations between provider biking and perceptions of cars sharing roads safely

	n	**test**	**df**	**statistic**	**p-value**
Disagree that cars share the roads safely with bikes					
Self-identify as biker	80	Fisher's Exact	NA	0.3376	1
Biked within past 12 months	80	χ^2	1	0.1262	0.7224
Bike commute within past 12 months	78	Chi-Square	1	3.8185	0.0507
Biked in Boston within past 12 months	75	Chi-Square	1	2.5145	0.1128
Biked only outside of Boston with past 12 months	80	Chi-Square	1	1.5116	0.2189
Use of bikeshare	80	Chi-Square	1	0.7214	0.3957
Disagree that bikes share the roads safely with cars					
Self-identify as biker	80	Fisher's Exact	NA	0.1185	0.2089
Biked within past 12 months	80	Chi-Square	1	1.0559	0.3041
Bike commute within past 12 months	78	Chi-Square	1	9.8861	0.0017
Biked in Boston within past 12 months	75	Chi-Square	1	8.1318	0.0043
Biked only outside of Boston with past 12 months	80	Chi-Square	1	4.4828	0.0342
Use of bike-share	80	Chi-Square	1	2.0634	0.1509

C25 Odds ratios for provider biking and perceptions of cars sharing roads safely

	n	**non bikers %disagree**	**bikers % disagree**	**OR**	**95% CI**	
Cars do not share the roads safety						
Do not self-identify as biker	80	66.67	63.51	1.1489	0.197	6.692
Have not biked within past 12 months	80	66.67	62.5	1.200	0.438	3.283
Have not bike commuted within past 12 months	78	71.74	50.00	2.5385	0.987	6.527
Have not biked in Boston within past 12 months	75	70.73	52.94	2.1481	0.829	5.565
Have not biked only outside of Boston with	80	60.32	76.47	0.4677	0.136	1.598

past 12 months						
Have not used bike-share	80	61.29	72.22	0.609	0.192	1.925
Bikes do not share the roads safety						
Do not self-identify as biker	80	83.33	51.35	4.7368	0.527	42.532
Have not biked within past 12 months	80	62.5	50.00	1.6667	0.626	4.433
Have not bike commuted within past 12 months	78	67.39	31.25	4.5467	1.725	11.980
Have not biked in Boston within past 12 months	75	68.29	35.29	3.9487	1.507	10.344
Have not biked only outside of Boston with past 12 months	80	47.62	76.47	0.2797	0.082	0.952
Have not used bike-share	80	58.06	38.89	2.1758	0.743	6.365

C26 Associations between provider biking and reported comfort biking in Boston

	n	**test**	**df**	**stat**	**p-value**
Agreement with feeling safe and comfortable biking in Boston					
Self-identify as biker	79	Fisher's Exact	NA	0.1043	0.17
Biked within past 12 months	79	Chi-Square	1	2.588	0.1077
Biked for commute within past 12 months	77	Chi-Square	1	14.1357	0.0002
Biked in Boston within past 12 months	74	Chi-Square	1	10.7992	0.001
Biked only outside of Boston with past 12 months	79	Chi-Square	1	6.1462	0.0132
Use of bikeshare	79	Chi-Square	1	0.0962	0.7565
Agreement with feeling safe and comfortable biking OUTSIDE Boston					
Self-identify as biker	78	Fisher's Exact	NA	0.0012	0.0012
Biked within past 12 months	78	Chi-Square	1	11.9096	0.0006
Biked for commute within past 12 months	76	Chi-Square	1	5.9776	0.0145
Biked in Boston within past 12 months	73	Chi-Square	2	10.4523	0.0054
Biked only outside of Boston with past 12 months	73	Chi-Square	1	6.4298	0.0112
Use of bikeshare	78	Chi-Square	1	1.5879	0.2076

C27 Summary Statistics for Patient Biking Questions for the Original and Post-Imputation Question Sets

Original variables	N	Mean	Std Dev	Median	Min	Max
Patients Can Bike	61	2.09836	0.67589	2	1	4
Patients Have Bike Access	60	1.53333	0.59565	2	0	3
Patients Do Bike	63	1.71429	0.74981	2	0	4
Patients Comfortable Biking	51	1.66667	0.58878	2	1	3
Patients Know Bike Rules	44	1.40909	0.75693	1	0	4
Patient Would Wear Helmet	62	2.17742	0.85936	2	0	4
Patients Would Bike	62	1.93548	0.64961	2	1	4
Patients Can Access Hubway	49	1.81633	0.85813	2	0	4
Patients Would Benefit	78	3.60256	0.63122	4	1	4

Post-Imputation	N	Mean	Std Dev	Median	Min	Max
Patients Can Bike	75	2.0811111	0.644766	2	1	4
Patients Have Bike Access	75	1.6306667	0.6171476	2	0	3
Patients Do Bike	75	1.78000	0.7374628	2	0	4
Patients Comfortable Biking	75	1.7435556	0.5585796	2	1	3
Patients Know Bike Rules	75	1.6225714	0.6905468	1.8333	0	4
Patient Would Wear Helmet	75	2.1115556	0.8127456	2	0	4
Patients Would Bike	75	1.9437778	0.6275206	2	1	4
Patients Can Access Hubway	75	1.8127302	0.7581106	2	0	4
Patients Would Benefit from Biking*	78	3.6025641	0.631217	4	1	4

Appendix C28 psychometrics for questions on patient biking

Measures internal consistency reliability were performed for the set of questions to quantify the degree to which the individual questions related to each other using the Cronbach α correlation coefficient and item-total correlations; the question for benefit was excluded from the analysis because the distribution and correlations were not concordant with the rest of the item set. Raw scores were used because the questions had a common scale.

Cronbach α is based on both the number of items and the intercorrelations between items. For the questions on estimation of own patients' biking the Cronbach α (raw) = 0.8435 which indicates scale reliability or coefficient of consistency among questions. The range of item-total correlation for the rest of the questions ranged from 0.415394 (access to Hubway) to 0.68964 for knowledge of rules. Only removal of access to Hubway would have increased the Cronbach α, and this was a marginal increase.

Factor analysis using an orthogonal rotation was performed to identify latent factors underlying the patient biking questions; again the benefit question was excluded. Two factors were identified using the cumulative proportion of variance explained (factors two and three) ; this decision was supported by visual identification of the scree plot. The total variance explained was 3.834653. Factor three consisted of four variables related to safety and intent. Loadings ranged from 0.61416 (patients would bike) to 0.66039 (patient would wear helmet); the variance explained was 1.96422. Factor two contained the remaining variables related to pragmatics of ability, access and comfort. Loadings were ranged from 0.50821 to 0.70076. Access to Hubway had a low loading on factor one and barely loaded on factor two. The difference in loading for the comfort variable between factors one and two was low (0.5044 and 0.50821). Given the higher item-item correlation of comfort to rules and conceptual basis of the domain, the decision was made to include comfort with the factor one set.

Cronbach Coefficient Alpha	**Alpha**		
Raw	0.8435		
Cronbach Coefficient Alpha with Deleted Variable	**Deleted Variable**	**Raw Variable Correlation with Total**	**Alpha**
I can estimate my patients can bike	PCAN2	0.582023	0.824543
I can estimate my patients have bike access	PACC2	0.598131	0.823049
I can estimate my patients do bike	PDO2	0.55237	0.828538
I can estimate my patients are comfortable biking	PCOM2	0.649545	0.8191
I can estimate my patients know bike rules	PRUL2	0.689464	0.810518
I can estimate my patients would wear a few helmet	PHEL2	0.625079	0.819476
I can estimate my patients would bike	PWOU2	0.566959	0.826445
I can estimate my patients have Hubway access	PACCH2	0.415394	0.847192

Spearman Correlation Coefficients, N = 75 **Prob > |r| under H0: Rho=0**								
	PCAN2	**PACC2**	**PDO2**	**PCOM2**	**PRUL2**	**PHEL2**	**PWOU2**	**PACCH2**
PCAN2	1	0.47315	0.44438	0.47468	0.4551	0.47338	0.43355	0.33068
Patients Can Bike		*<.0001*	*<.0001*	*<.0001*	*<.0001*	*<.0001*	*0.0001*	*0.0038*
PACC2	0.47315	1	0.59402	0.53861	0.55876	0.38897	0.30183	0.44777
Patients Have Bike Access	*<.0001*		*<.0001*	*<.0001*	*<.0001*	*0.0006*	*0.0085*	*<.0001*
PDO2	0.44438	0.59402	1	0.49004	0.48567	0.37536	0.48301	0.17442

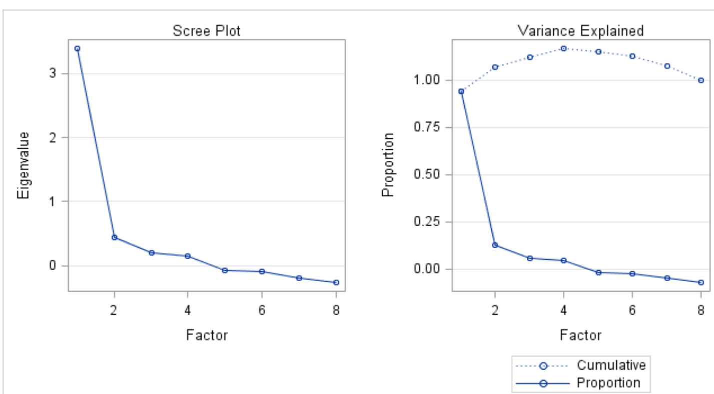
Patients Do Bike	<.0001	<.0001		<.0001	<.0001	0.0009	<.0001	0.1345
PCOM 2	0.47468	0.53861	0.49004	1	0.67322	0.4696	0.44036	0.29033
Patients Comfort able Biking	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	0.0115
PRUL2	0.4551	0.55876	0.48567	0.67322	1	0.58087	0.55017	0.45123
Patients Know Bike Rules	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
PHEL2	0.47338	0.38897	0.37536	0.4696	0.58087	1	0.55563	0.33954
Patient Would Wear Helmet	<.0001	0.0006	0.0009	<.0001	<.0001		<.0001	0.0029
PWOU2	0.43355	0.30183	0.48301	0.44036	0.55017	0.55563	1	0.34933
Patients Would Bike	0.0001	0.0085	<.0001	<.0001	<.0001	<.0001		0.0021
PACC H2	0.33068	0.44777	0.17442	0.29033	0.45123	0.33954	0.34933	1
Patients Can Access Hubway	0.0038	<.0001	0.1345	0.0115	<.0001	0.0029	0.0021	

The FACTOR Procedure		
	Input Data Type	
	Number of Records Read	80
	Number of Records Used	75
	N for Significance Tests	75

Prior Communality Estimates: SMC							
PCAN2	PACC2	PDO2	PCOM2	PRUL2	PHEL2	PWOU2	PACCH2
0.38509	0.49876	0.48529	0.49244	0.56934	0.456398	0.41065	0.298457

Eigenvalues of the Reduced Correlation Matrix: Total = 3.59645003 Average = 0.44955625				
	Eigenvalue	Difference	Proportion	Cumulative
1	3.38944563	2.94423833	0.9424	0.9424
2	0.4452073	0.24248117	0.1238	1.0662
3	0.20272613	0.04438014	0.0564	1.1226
4	0.15834598	0.22299585	0.044	1.1666
5	-0.06464987	0.01997926	-0.018	1.1487
6	-0.08462913	0.10013564	-0.0235	1.1251
7	-0.18476477	0.08046647	-0.0514	1.0737
8	-0.26523124		-0.0737	1
2 factors will be retained by the PROPORTION criterion.				

Scree and Variance Plots



Unrotated Factor Pattern			
		Factor1	Factor2
PRUL2	Patients Know Bike Rules	0.76179	0.14098
PCOM2	Patients Comfortable Biking	0.71589	-0.0141
PHEL2	Patient Would Wear Helmet	0.67923	0.24795
PACC2	Patients Have Bike Access	0.66365	-0.31364
PDO2	Patients Do Bike	0.64618	-0.3497
PCAN2	Patients Can Bike	0.62609	-0.1521
PWOU2	Patients Would Bike	0.60893	0.25407
PACCH2	Patients Can Access Hubway	0.46313	0.23518

PCAN2	PACC2	PDO2	PCOM2	PRUL2	PHEL2	PWOU2	PACCH2
0.41512231	0.53880948	0.53983797	0.51269902	0.60020401	0.52283488	0.43534875	0.26979651

Variance Explained by Each	
Factor	
Factor1	Factor2
1.964223	1.8704292

Final Communality Estimates: Total = 3.834653							
PCAN2	PACC2	PDO2	PCOM2	PRUL2	PHEL2	PWOU2	PACCH2
0.41512	0.5388	0.53983	0.51269	0.60020	0.52283	0.435348	0.269796

C29 Summary statistics for complete question set with composite variables

N=75; nmiss = 5	**Mean**	**Std Dev**	**Min**	**25th Pctl**	**50th Pctl**	**75th Pctl**	**Max**	**Mode**
Patients Can Bike	**2.081**	**0.645**	**1**	**2**	**2**	**2**	**4**	**2**
Patients Have Bike Access	**1.631**	**0.617**	**0**	**1**	**2**	**2**	**3**	**2**
Patients Do Bike	**1.780**	**0.737**	**0**	**1**	**2**	**2**	**4**	**2**
Patients Comfortable Biking	**1.744**	**0.559**	**1**	**1**	**2**	**2**	**3**	**2**
Patients Know Bike Rules	**1.623**	**0.691**	**0**	**1**	**1.833**	**2**	**4**	**2**
Patient Would Wear Helmet	**2.112**	**0.813**	**0**	**2**	**2**	**3**	**4**	**2**
Patients Would Bike	**1.944**	**0.628**	**1**	**2**	**2**	**2**	**4**	**2**
Patients Can Access Hubway	**1.813**	**0.758**	**0**	**1.143**	**2**	**2**	**4**	**2**
Patients Would Benefit from Biking*	**3.603**	**0.631**	**1**	**3**	**4**	**4**	**4**	**4**
Mean score used for imputation	**1.841**	**0.473**	**1**	**1.5**	**1.875**	**2.125**	**3**	**2**
Q11 Comp for safety and patient intent	**1.893**	**0.559**	**1**	**2**	**2**	**2**	**3**	**2**
Q11 Comp for actual patient biking	**1.813**	**0.630**	**0**	**1**	**2**	**2**	**3**	**2**

C30 Intercorrelations for own patient biking variables with composites

	Q11SICOMP	Q11ABCOMP
Q11SICOMP *Safety and Patient Intent Comp*		0.64994 *<.0001*
Q11ABCOMP *Actual Patient Biking Comp*	0.64994 *<.0001*	
PCAN2 *Patients Can Bike*	0.54311 <.0001	
PACC2 *Patients Have Bike Access*	0.5259 <.0001	
PDO2 *Patients Do Bike*	0.53088 <.0001	
PCOM2 *Patients Comfortable Biking*		0.62008 <.0001
PRUL2 *Patients Know Bike Rules*		0.5924 <.0001
PHEL2 *Patient Would Wear Helmet*		0.48183 <.0001
PWOU2 *Patients Would Bike*		0.52483 <.0001
PACCH2 Patients Can Access Hubway	0.41373 0.0002	0.3772 0.0009

C31 Internal Consistency Reliability for Composite Variables

Cronbach Coefficient Alpha

Variables	Alpha
Raw	0.759417

Cronbach Coefficient Alpha with Deleted Variable	Raw Variable Correlation with Total	Alpha
Patients Can Bike	0.55719	0.713629
Patients Have Bike Access	0.612657	0.657813
Patients Do Bike	0.611694	0.658747

Composite on Safety and Intent
Cronbach Coefficient Alpha

Variables	Alpha
Raw	0.806008

Cronbach Coefficient Alpha with Deleted Variable	Raw Variable Correlation with Total	Alpha
Patients Comfortable Biking	0.614011	0.767169
Patients Know Bike Rules	0.708697	0.712982
Patient Would Wear Helmet	0.645504	0.754921

Composite on Actual Patient Biking

C32 Correlations for provider characteristics and patient biking post-imputation

	EXPERIENCE	COMMUTE	SESSIONS
PCAN2	0.20117	0.15358	0.1647
Patients Can Bike	0.0835	0.1914	0.1608
	75	74	74
PDO2	0.06686	0.01217	-0.07089
Patients Do Bike	0.5687	0.9181	0.5484
	75	74	74
PACC2	0.18917	0.1174	0.19927
Patients Have Bike Access	0.1041	0.3192	0.0887
	75	74	74
PWOU2	-0.00681	-0.04478	-0.09316
Patients Would Bike	0.9538	0.7048	0.4298
	75	74	74
PRUL2	0.13203	-0.08608	0.03751
Patients Know Bike Rules	0.2588	0.4658	0.751
	75	74	74
PCOM2	-0.03533	0.068	0.14617
Patients Comfortable Biking	0.7635	0.5648	0.214
	75	74	74
PHEL2	0.20246	0.11959	0.01436
Patient Would Wear Helmet	0.0815	0.3102	0.9034
	75	74	74
PACCH2	0.08542	0.09871	0.13464
Patients Can Access Hubway	0.4662	0.4028	0.2527
	75	74	74
PBEN2	-0.16003	-0.09606	-0.20361
Patients Would Benefit	0.1617	0.406	0.0757
	78	77	77
Q11SICOMP	0.10547	0.02268	0.01617
	0.3678	0.8479	0.8912
	75	74	74
Q11ABCOMP	0.1649	0.10752	0.10871
	0.1574	0.3619	0.3565
	75	74	74

C33 Estimates of patient biking using composite variables by provider biking with odds ratios

Estimate of none to few patients	n	% for provider biking only outside Boston	% for providers not biking only outside Boston	Odds Ratio	95% CI	
Can bike	75	13.33	11.67	1.1648	0.2161	6.2781
Access	75	73.33	28.33	6.9559	1.9442	24.8859
Do bike	75	53.33	26.67	3.1429	0.9807	10.072
Comfortable biking	75	60	12.67	5.4231	1.6305	18.0375
Rules	75	73.33	31.67	5.9342	1.6714	21.069
Helmet	75	26.67	18.33	1.6198	0.4336	6.0518
Would bike	75	13.33	21.67	0.5562	0.1111	2.7838
Hubway access	75	46.67	25	2.625	0.8142	8.4632
Benefit comp	78	0	1.61	NA		
Safety and intent comp	75	26.67	20	1.4545	0.3934	5.3777
Actual biking comp	75	53.33	18.33	5.0909	1.5228	17.0193
Estimate some to all patients	**n**	**% for bike commuting providers**	**% for non-bike commuting providers**			
Can bike	73	90	86.05	1.4595	0.3349	6.3603
Access	73	76.67	51.46	3.1364	1.113	8.8382
Do bike	73	76.67	65.12	1.7602	0.614	5.0458
Comfortable biking	73	83.33	62.79	2.963	0.9457	9.2837
Rules	73	70	51.46	2.2273	0.833	5.9553
Helmet	73	80	79.07	1.0588	0.3327	3.3696
Would bike	73	76.67	81.4	0.751	0.2395	2.3546
Hubway access	73	73.33	67.44		0.4738	3.72
Benefit comp	76	100	97.73	NA		
Safety and intent comp	73	76.67	79.07	0.8697	0.2836	2.6671
Actual biking comp	73	86.67	65.12	3.4821	1.0226	11.8576

C34 Correlations for provider perceptions of road safety and own biking comfort with estimated of patient biking

	Cars share roads	Bikes share roads	Comfort biking in Boston	Comfort biking outside Boston
Patients Can Bike	-0.11034 0.346 75	0.11059 0.3449 75	-0.13309 0.2905 65	-0.26194 0.0336 66
Patients Do Bike	-0.01044 0.9292 75	0.01459 0.9011 75	-0.01623 0.8979 65	-0.06964 0.5785 66
Patients Have Bike Access	0.15509 0.184 75	0.08517 0.4675 75	0.18102 0.149 65	-0.18147 0.1448 66
Patients Would Bike	0.02401 0.838 75	0.10469 0.3714 75	0.08209 0.5156 65	-0.08963 0.4742 66
Patients Know Bike Rules	0.10632 0.364 75	0.16115 0.1672 75	0.1637 0.1926 65	-0.15497 0.2141 66
Patients Comfortable Biking	0.21807 0.0602 75	0.18916 0.1041 75	0.15578 0.2153 65	-0.02975 0.8126 66
Patient Would Wear Helmet	0.00365 0.9752 75	0.11731 0.3162 75	-0.0376 0.7662 65	-0.20252 0.1029 66
Patients Would Benefit	-0.04647 0.6862 78	0.16787 0.1418 78	-0.03179 0.7969 68	-0.02197 0.8578 69
Safety and Intent Composite	0.11623 0.3207 75	0.1853 0.1115 75	0.10751 0.394 65	-0.15282 0.2206 66
Actual Biking Composite	0.00798 0.9458 75	0.07876 0.5018 75	0.03147 0.8035 65	-0.17274 0.1655 66

C35 Cross tabs for provider perceptions of road safety and own comfort biking with own patient biking comfort

		My patients are comfortable (n=75)	
		Some to most	None to few
Cards share roads	Yes	25	3
	No	28	19
Chi-Square	1	7.4724	0.0063
Odds Ratio	5.6548	1.493	21.4181

		My patients are comfortable n=75	
		Some to most	None to few
Bikes share roads	Yes	31	5
	No	22	17
Chi-Square	1	7.9665	0.0048
Odds Ratio	4.7909	1.5368	14.9353

		My patients are comfortable n=65	
		Some to most	None to few
Comfort biking in Boston	Agree	19	4
	Neutral to disagree	28	14
Chi-Square	1	1.8863	0.1696
Odds Ratio	2.375	0.6773	8.3282

		My patients are comfortable n=66)	
		Some to most	None to few
Comfort biking out of Boston	Agree	32	17
	Neutral to disagree	14	3
Chi-Square	1	1.7366	0.1876
Odds Ratio	0.4034	0.1016	1.6013

C36 Associations between provider safety perceptions and biking comfort with own patient comfort biking

Some to most of my patients are comfortable biking	n	test	df	stat	p-value
Cards share the roads	75	Chi-Square	2	8.0927	0.0175
Bikes share the roads	75	Chi-Square	2	8.0675	0.0177
Comfort biking within Boston	65	Chi-Square	2	2.1597	0.3397
Comfort biking outside Boston	66	Fisher's Exact	NA	0.0056	0.0447

C37 Original provider perceived attributes of the RxBike innovation (no re-code)

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Counseling on PA is a Priority (n=80)	**0**	**1**	**1**	**34**	**44**
%	***0***	***1.25***	***1.25***	***42.5***	***55***
I Have Time to Refer (n=80)	**2**	**13**	**27**	**29**	**9**
	2.5	***16.25***	***33.75***	***36.25***	***11.25***
It is a Hassle to Refer in Logician (n=80)	**3**	**35**	**17**	**22**	**3**
	3.75	***43.75***	***21.25***	***27.5***	***3.75***
I Would Worry about Patient Safety (n=80)	**1**	**18**	**19**	**33**	**9**
	1.25	***22.5***	***23.75***	***41.25***	***11.25***
I Would Worry about Liability (n=80)	**9**	**37**	**19**	**12**	**3**
	11.25	***46.25***	***23.75***	***15***	***3.75***
RxBike is an Appropriate Referral (n=80)	**1**	**2**	**8**	**39**	**30**
	1.25	***2.5***	***10***	***48.75***	***37.5***
I would consider RxBike referral (n=80)	**0**	**1**	**6**	**49**	**24**
	0	***1.25***	***7.5***	***61.25***	***30***

C38 Summary statistics for questions on perceived attributes with composites (positive coding) n=80

N= 80	Mean	Std Dev	Variance	Min	25th Pctl	50th Pctl	75th Pctl	Max	Mode
Counseling is a priority	3.513	0.595	0.354	1	3	4	4	4	4
I have time for RxBike referral	2.375	0.973	0.946	0	2	2	3	4	3
Referral to RxBike is not a hassle	2.163	0.999	0.999	0	1	2	3	4	3
I don't worry about patient safety	1.613	1.000	1.000	0	1	1	2	4	1
I do not worry about liability	2.463	1.006	1.011	0	2	3	3	4	3
RxBike Referral Appropriate	3.188	0.813	0.661	0	3	3	4	4	3
Consider RxBike Referral	3.200	0.624	0.390	1	3	3	4	4	3
Process Perceived Attribute Composite	2.825	0.708	0.501	1	2	3	3	4	3
Concern Perceived Attribute Composite	2.250	0.907	0.823	0	2	2	3	4	2

C39 Intercorrelations among questions on perceived attributes

Spearman Correlation Coefficients, N = 80 (Prob > |r| under H0: Rho=0)							
	Counseling is a priority	**I have time for RxBike referral**	**Referral to RxBike is not a hassle**	**I don't worry about patient safety**	**I do not worry about liability**	**RxBike Referral Appropriate**	**Consider RxBike Referral**
Counseling is a priority	1	0.11195	0.20932	-0.01118	0.07439	0.4611	0.16157
		0.3228	*0.0624*	*0.9216*	*0.5119*	*<.0001*	*0.1522*
I have time for RxBike referral	0.11195	1	0.39982	0.02728	-0.06084	0.42245	0.41238
	0.3228		*0.0002*	*0.8102*	*0.5919*	*<.0001*	*0.0001*
Referral to RxBike is not a hassle	0.20932	0.39982	1	-0.12517	-0.08725	0.32215	0.21061
	0.0624	*0.0002*		*0.2686*	*0.4415*	*0.0036*	*0.0608*
I don't worry about patient safety	-0.01118	0.02728	-0.12517	1	0.38991	0.16458	0.15426
	0.9216	*0.8102*	*0.2686*		*0.0004*	*0.1446*	*0.1719*
I do not worry about liability	0.07439	-0.06084	-0.08725	0.38991	1	0.12952	0.21287
	0.5119	*0.5919*	*0.4415*	*0.0004*		*0.2522*	*0.058*
RxBike Referral Appropriate	0.4611	0.42245	0.32215	0.16458	0.12952	1	0.6308
	<.0001	*<.0001*	*0.0036*	*0.1446*	*0.2522*		*<.0001*
Consider RxBike Referral	0.16157	0.41238	0.21061	0.15426	0.21287	0.6308	1
	0.1522	*0.0001*	*0.0608*	*0.1719*	*0.058*	*<.0001*	

C40 Psychometric testing on question set for perceived attributes

Consistency among questions was evaluated with the Cronbach alpha correlation coefficient and Spearman correlation coefficients. The highest correlation among variables was between appropriateness and consider referral (r=0.6308, n=80, p<0.001; r^2 39.79 %). Appropriateness had the highest item-total correlation. Time and hassle correlated with each other, appropriateness, and consider referral. Safety and liability were intercorrelated. Priority of counseling did not correlate with anything except appropriateness. The raw Cronbach alpha was 0.602653, which does not suggest a high degree of reliability as a single scale. The rest of the questions had item total correlations between 0.16349 (liability concerns) and 0.613855 (appropriateness).

Factor analysis using an orthogonal rotation was performed to identify latent factors underlying the question set. Based on the factor loadings and conceptual model of this study the decision was made to create a composite variable for time, hassle, appropriateness, and consideration of referral that will be referred to as Process Perceived Attributes. Consistency among questions was evaluated with the Cronbach alpha correlation coefficient and Spearman correlation coefficients. The highest correlation among variables was between appropriateness and consider referral (r=0.6308, n=80, p<0.001; r^2 39.79 %). Appropriateness had the highest item-total correlation. Time and hassle correlated with each other, appropriateness, and consider referral. Safety and liability were intercorrelated. Priority of counseling did not correlate with anything except appropriateness. The raw Cronbach alpha was 0.602653, which does not suggest a high degree of reliability as a single scale. The rest of the questions had item total correlations between 0.16349 (liability concerns) and 0.613855 (appropriateness).

Factor analysis using an orthogonal rotation was performed to identify latent factors underlying the question set. Based on the factor loadings and conceptual model of this study the decision was made to create a composite variable for time, hassle, appropriateness, and consideration of referral that will be referred to as Process Perceived Attributes. The composite variable was the mean of the scores to each question with positive wording used across the set; the mean was rounded for use as a categorical variable. Counseling was not used for either composite. The two composite variables did not correlate with each other.

Two factors were identified using cumulative proportion of variance explained; this decision was supported by visual identification of the scree plot. Factor one consisted of four variables related to referral process (time, hassle, appropriateness, consideration of referral). Loadings ranged from 0.50742 (hassle) to 0.79504 (appropriateness); the variance explained was 1.7934497. Factor two consisted of only two variables and both related to concerns about outcomes (safety and liability); variance explained was 0.8731069. The variable on propriety of counseling had a negligible loading on either factor.

Based on the factor loadings and conceptual model of this study the decision was made to create a composite variable for time, hassle, appropriateness, and consideration of referral that will be referred to as Process Perceived Attributes. Cronbach alpha testing was repeated for this subset of variables and was 0.72373; item to total correlations ranged from 0.417229 (hassle) to 0.613256 (appropriateness). The composite variable was the mean of the scores to each question with positive wording used across the set; the mean was rounded for use as a categorical variable. The same process was used with the questions about safety and liability for a Concern Perceived Attributes composite. Counseling was not used for either composite. The two composite variables did not correlate with each other.

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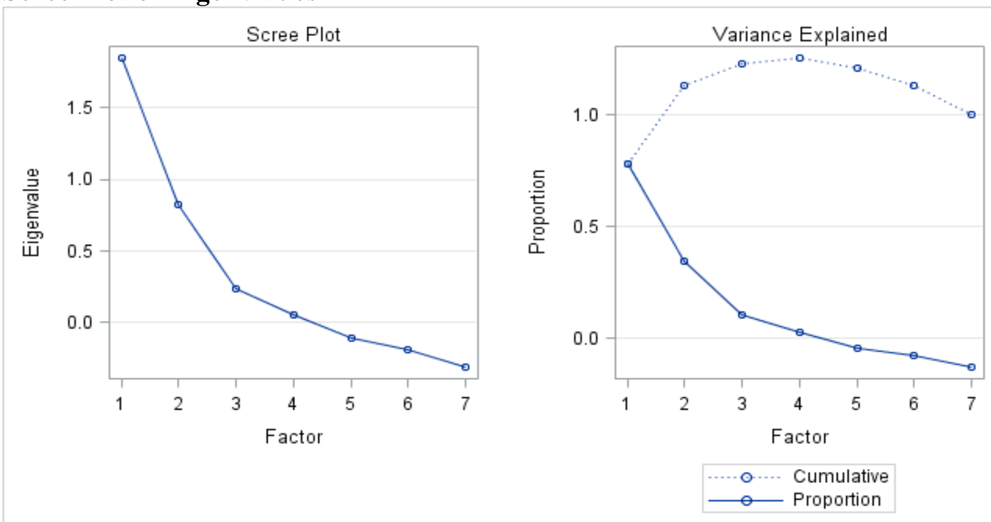
Prior Communality Estimates: SMC						
Q12ICON	Q12IAPP	Q12ITIMP	Q12ICOUNP	Q12IHASSP	Q12IWSAFP	Q12IWLIAP
0.440410	0.5753273	0.355757	0.221494	0.256776	0.273212	0.236024

Eigenvalues of the Reduced Correlation Matrix: Total = 2.35900464 Average = 0.33700066				
	Eigenvalue	Difference	Proportion	Cumulative
1	1.84525531	1.023954	0.7822	0.7822
2	0.82130132	0.58196551	0.3482	1.1304
3	0.23933581	0.18117317	0.1015	1.2318
4	0.05816264	0.1627462	0.0247	1.2565
5	-0.10458356	0.08423177	-0.0443	1.2122
6	-0.18881533	0.12283621	-0.08	1.1321
7	-0.31165154		-0.1321	1
2 factors will be retained by the PROPORTION criterion.				

Scree Plot of Eigenvalues



Variance Explained by Each						
Factor						
Factor1	Factor2					
1.8452553	0.8213013					
Final Communality Estimates: Total = 2.666557						
Q12ICON	Q12IAPP	Q12ITIMP	Q12ICOUNP	Q12IHASSP	Q12IWSAFP	Q12IWLIAP
0.4486326	0.6698554	0.42636971	0.12336186	0.30814195	0.37630069	0.31389441

Root Mean Square Off-Diagonal Partials: Overall = 0.10316792						
Q12ICON	Q12IAPP	Q12ITIMP	Q12ICOUNP	Q12IHASSP	Q12IWSAFP	Q12IWLIAP
0.11865685	0.124877	0.078931	0.13337151	0.0775190	0.08305123	0.0889194
Rotation Method: Varimax						
Orthogonal Transformation Matrix						
	1	2				
1	0.97437	0.22493				
2	-0.22493	0.97437				

Rotated Factor Pattern		Factor1	Factor2
Q12ICON	Consider RxBike Referral	**0.5944**	0.30874
Q12IAPP	RxBike Referral Appropriate	**0.79504**	0.19435
Q12ITIMP	I have time for RxBike referral	**0.65151**	-0.04358
Q12ICOUNP	Counseling is a priority	0.35109	0.00994
Q12IHASSP	Referral to RxBike is not a hassle	**0.50742**	-0.2251
Q12IWSAFP	I don't worry about patient safety	0.05216	**0.61121**
Q12IWLIAP	I do not worry about liability	-0.01137	**0.56015**

Variance Explained by Each						
Factor1	**Factor2**					
1.7934497	**0.8731069**					
Final Communality Estimates: Total = 2.666557						
Q12ICON	**Q12IAPP**	**Q12ITIMP**	**Q12ICOUNP**	**Q12IHASSP**	**Q12IWSAFP**	**Q12IWLIAP**
0.4486326	**0.6698554**	**0.42636971**	**0.12336186**	**0.30814195**	**0.37630069**	**0.31389441**

C41 Correlations for composite variables with complete question set

	Process comp	**Concern comp**
Process composite	1	0.04521 0.6905
Concern composite	0.04521 0.6905	1
Q12ICOUNP ***Counseling is a priority***	0.30103 *0.0067*	0.04324 *0.7033*
Q12ITIMP **I have time for RxBike referral**	0.76935 *<.0001*	-0.02811 *0.8045*
Q12IHASSP **Referral to RxBike is not a hassle**	0.71934 *<.0001*	-0.14254 *0.2072*
Q12IWSAFP **I don't worry about patient safety**	0.04729 *0.677*	0.8533 *<.0001*
Q12IWLIAP **I do not worry about liability**	0.06165 *0.5869*	0.79486 *<.0001*
Q12IAPP **RxBike Referral Appropriate**	0.73655 *<.0001*	0.16529 *0.1429*
Q12ICON **Consider RxBike Referral**	0.67143 *<.0001*	0.19955 *0.076*

C42 Select provider characteristics with perceived attributes

I have time to refer to RxBike	n	test	df	statistic	p-value
Trainee	80	Chi-Square	2	4.0014	0.1352
Up to 10 years experience	80	Chi-Square	2	2.1726	0.3375
Up to 5 mile commute	79	Chi-Square	2	4.1694	0.1243

It is not a hassle to refer to RxBike	n	test	df	statistic	p-value
Trainee	80	Chi-Square	2	1.0666	0.5867
Up to 10 years experience	80	Chi-Square	2	5.0269	0.081
Up to 5 mile commute	79	Chi-Square	2	8.3428	0.0154

I do not worry about liability with referrals	n	test	df	statistic	p-value
Trainee	80	Chi-Square	2	3.1239	0.2097
Up to 10 years experience	80	Fisher's Exact	NA	0.0607	0.9338
Up to 5 mile commute	79	Chi-Square	2	7.3522	0.0253

Composite variable for process PAs	n	test	df	statistic	p-value
Trainee	80	Fisher's Exact	NA	0.017	0.1654
Up to 10 years experience	80	Fisher's Exact	NA	0.012	0.0699
Up to 5 mile commute	79	Fisher's Exact	NA	0.0008	0.0041

Composite variable for concern PAs	n	test	df	statistic	p-value
Trainee	80	Chi-Square	2	1.5662	0.457
Up to 10 years experience	80	Chi-Square	2	1.8081	0.4049
Up to 5 mile commute	79	Chi-Square	2	5.489	0.0643

I think RxBike is an appropriate referral	n	test	df	statistic	p-value
Trainee	80	Fisher's Exact	NA	0.0049	0.0248
Up to 10 years experience	80	Chi-Square	2	15.5046	0.0004
Up to 5 mile commute	79	Fisher's Exact	NA	0.0005	0.0011

I would consider a referral to RxBike	n	test	df	statistic	p-value
Trainee	80	Fisher's Exact	NA	0.1725	1
Up to 10 years experience	80	Fisher's Exact	NA	0.0208	0.0419
Up to 5 mile commute	79	Fisher's Exact	NA	0.4186	1

C43 Associations between ordinal provider characteristics ad strong agreement with appropriateness of referral (3-level)

	n	test	df	statistic	p-value
Experience	80	Fisher's Exact Test	NA	<.0001	0.0322
		Mantel-Haenszel Chi-Square	1	4.7082	0.03
Number of Sessions	80	Fisher's Exact Test	NA	0.0002	0.1074
		Mantel-Haenszel Chi-Square	1	0.6712	0.4126
Commute distance	79	Fisher's Exact Test	NA	<.0001	0.0124
		Mantel-Haenszel Chi-Square	1	1.411	0.2349

C44 Crosstabs with results of testing for associations for provider characteristics and strong agreement with appropriateness of referral

Table of PEDS by Q12IAPPSTRONGnew				
	Strong agreement with appropriateness			
Provider type	**Strongly agree**	**Agree**	**Neutral to disagree**	**Total**
adult	**13**	**25**	**9**	**47**
row %	**27.66**	**53.19**	**19.15**	
peds	**17**	**14**	**2**	**33**
row %	**51.52**	**42.42**	**6.06**	
Total	**30**	**39**	**11**	**80**
Fisher's Exact Test	**NA**	**0.0013**	**0.0264**	
Table of STAFFP by Q12IAPPSTRONGnew				
	Strong agreement with appropriateness			
Staff	**Strongly agree**	**Agree**	**Neutral to disagree**	**Total**
Trainee	**16**	**20**	**1**	**37**
row %	**43.24**	**54.05**	**2.7**	
Staff	**14**	**19**	**10**	**43**
row %	**32.56**	**44.19**	**23.26**	
Total	**30**	**39**	**11**	**80**
Fisher's Exact Test	**NA**	**0.0013**	**0.0264**	
Table of GENDER by Q12IAPPSTRONGnew				
	Strong agreement with appropriateness			
Gender	**Strongly agree**	**Agree**	**Neutral to disagree**	**Total**
female	**20**	**24**	**5**	**49**
row %	**40.82**	**48.98**	**10.2**	
male	**9**	**15**	**6**	**30**
row %	**30**	**50**	**20**	
Total	**29**	**39**	**11**	**79**

Chi-Square	**2**	**1.8793**	**0.3908**	
Table of EXP10 by Q12IAPPSTRONGnew				
	Strong agreement with appropriateness			
Experience (years)	**Strongly agree**	**Agree**	**Neutral to disagree**	**Total**
Up to 10 years	**24**	**34**	**4**	**62**
row %	**38.71**	**54.84**	**6.45**	
Above 10 years	**6**	**5**	**7**	**18**
row %	**33.33**	**27.78**	**38.89**	
Total	**30**	**39**	**11**	**80**
Chi-Square	**2**	**12.8778**	**0.0016**	
Table of COMM5 by Q12IAPPSTRONGnew				
	Strong agreement with appropriateness			
Commute	**Strongly agree**	**Agree**	**Neutral to disagree**	**Total**
within 5 miles	**23**	**30**	**3**	**56**
row %	**41.07**	**53.57**	**5.36**	
>5 miles	**7**	**8**	**8**	**23**
row %	**30.43**	**34.78**	**34.78**	
Total	**30**	**38**	**11**	**79**
Chi-Square	**2**	**11.8207**	**0.0027**	

C45 Crosstabs for gender and select perceived attributes

	Table of GENDER by Q12IWSAFAG		
	Do not worry about safety		
n=79	**Agree**	**Neutral to disagree**	
Female	**20**	**29**	
Male	**17**	**13**	
Chi-Square	**1**	**1.8775**	**0.1706**

	Table of GENDER by Q12IWLIAAG		
	Do not worry about liability		
n=79	**Agree**	**Neutral to disagree**	
Female	**38**	**11**	
Male	**26**	**4**	
Chi-Square	**1**	**1.0052**	**0.3161**

	Table of GENDER by Q12processPAag	
	Process PA Composite	
n=79	**Agree**	**Neutral to disagree**

	Table of GENDER by Q12concernPAag		
	Concern PA Composite		
n=79	**Agree**	**Neutral to disagree**	

Female	**38**	**11**			**Female**	**14**	**35**	
Male	**19**	**11**			**Male**	**18**	**12**	
Chi-Square	**1**	**1.872**	**0.1712**		**Chi-Square**	**1**	**7.6269**	**0.0058**
Odds Ratio	**2**	**0.7351**	**5.4412**		**Odds Ratio**	**3.75**	**1.4388**	**9.7739**

	Table of GENDER by Q12IAPPAG					**Table of GENDER by Q12ICONAG**		
	RxBike is Appropriate Referral					**I would consider RxBike referral**		
n=79	**Agree**	**Neutral to disagree**			**n=79**	**Agree**	**Neutral to disagree**	
Female	**44**	**5**			**Female**	**45**	**4**	
Male	**24**	**6**			**Male**	**27**	**3**	
Fisher's Exact	**NA**	**0.1253**	**0.3164**		**Fisher's Exact**	**NA**	**0.2968**	**1**

C46 Associations between provider perceptions of road sharing and biking comfort with PAs for safety and liability concerns

Concern for patient safety (3-level)	n	test	df	statistic	p-value
Cars share the roads with bikes	80	Chi-Square	2	12.5047	0.0019
Bikes share the roads with cars	80	Chi-Square	2	4.3716	0.1124
Comfort biking within Boston	69	Chi-Square	2	7.3629	0.0252
Comfort biking outside Boston	70	Fisher's Exact	NA	1.284	0.5262
Concern for liability (3-level)					
Cars share the roads with bikes	80	Chi-Square	2	1.284	0.5262
Bikes share the roads with cars	80	Chi-Square	2	2.973	0.2262
Comfort biking within Boston	69	Chi-Square	2	1.4795	0.4772
Comfort biking outside Boston	70	Fisher's Exact	NA	0.0116	0.1626

C47 Crosstabs for perceptions of road sharing and biking comfort with PA for safety and liability concerns

Table of CAROBEYflip by Q12IWSAFYN (n=80)

CAROBEYflip	**Q12IWSAFYN**		
	Neutral to disagree	**Indicate agreement**	**Total**
Yes	20	9	29
No	18	33	51
Total	38	42	80
Chi-Square	1	8.4052	0.0037
Odds Ratio	4.0741	1.5382	10.7905

Table of BIKEOBEYFLIP by Q12IWSAFYN (n=80)

BIKEOBEYFLIP	Q12IWSAFYN: Neutral to disagree	Indicate agreement	Total
Yes	22	15	37
No	16	27	43
Total	38	42	80
Chi-Square	1	3.9481	0.0469
Odds Ratio	2.475	1.0045	6.0979

Table of COMFYBOSAGflip by Q12IWSAFYN (n=69)

COMFYBOSAGflip	Q12IWSAFYN: Neutral to disagree	Indicate agreement	Total
Indicate degree of agreement	17	7	24
Not in agreement	17	28	45
Total	34	35	69
Chi-Square	1	7.1358	0.0076
Odds Ratio	3.932	1.3971	11.0659

Table of COMFYOUTAGflip by Q12IWSAFYN (n=70)

COMFYOUTAGflip	Q12IWSAFYN: Neutral to disagree	Indicate agreement	Total
Indicate degree of agreement	28	23	51
Not in agreement	6	13	19
Total	34	36	70
Chi-Square	1	3.2937	0.0695
Odds Ratio	2.4348	0.9213	6.4346

Table of CAROBEYflip by Q12IWLIAYN (n=80)

CAROBEYflip	Q12IWLIAYN: Neutral to disagree	Indicate agreement	Total
Yes	25	4	29
No	40	11	51
Total	65	15	80
Chi-Square	1	0.7337	0.3917
Odds Ratio	1.7188	0.4931	5.9913

Table of BIKEOBEYFLIP by Q12IWLIAYN (n=80)

BIKEOBEYFLIP	Q12IWLIAYN Neutral to disagree	Indicate agreement	Total
Yes	33	4	37
No	32	11	43
Total	65	15	80
Chi-Square	1	2.8481	0.0915
Odds Ratio	2.8359	0.8179	9.8333

Table of COMFYBOSAGflip by Q12IWLIAYN (n=69)

COMFYBOSAGflip	Q12IWLIAYN Neutral to disagree	Indicate agreement	Total
Indicate degree of agreement	22	2	24
Not in agreement	37	8	45
Total	59	10	69
Chi-Square	1	2.0838	0.1489
Odds Ratio	3.0698	0.6306	14.9432

Table of COMFYOUTAGflip by Q12IWLIAYN (n=70)

COMFYOUTAGflip	Q12IWLIAYN Neutral to disagree	Indicate agreement	Total
Indicate degree of agreement	47	4	51
Not in agreement	14	5	19
Total	61	9	70
Chi-Square	1	12.3006	0.0005
Odds Ratio	8.0781	2.2522	s

C48 Correlations between perceived attributes and provider estimates of patient biking

	Q12processPAc	Q12concernPAc	Q12IAPP	Q12ICON
PCAN2 *Patients Can Bike*	0.07917 *0.4996* 75	0.03933 *0.7376* 75	-0.02421 *0.8366* 75	0.06915 *0.5555* 75
PDO2 *Patients Do Bike*	0.13952 *0.2325* 75	-0.03348 *0.7755* 75	0.06096 *0.6034* 75	0.10361 *0.3764* 75
PACC2 *Patients Have Bike Access*	0.00048 *0.9967* 75	-0.0702 *0.5495* 75	-0.12075 *0.3021* 75	-0.00894 *0.9393* 75
PWOU2 *Patients Would Bike*	0.12842 *0.2722* 75	0.06657 *0.5704* 75	0.05088 *0.6646* 75	0.24832 *0.0317* 75
PRUL2 *Patients Know Bike Rules*	0.19603 *0.0919* 75	-0.0129 *0.9125* 75	0.02683 *0.8192* 75	0.03248 *0.782* 75
PCOM2 *Patients Comfortable Biking*	0.05765 *0.6232* 75	0.13584 *0.2452* 75	-0.01382 *0.9063* 75	0.04842 *0.6799* 75
PHEL2 *Patient Would Wear Helmet*	0.15694 *0.1787* 75	-0.107 *0.3609* 75	0.05036 *0.6678* 75	0.11756 *0.3151* 75
PBEN2 *Patients Would Benefit*	0.10242 *0.3722* 78	0.18587 *0.1033* 78	0.29133 *0.0097* 78	0.33205 *0.003* 78
Q11SICOMPc	0.20576 *0.0766* 75	0.00595 *0.9596* 75	0.11188 *0.3393* 75	0.19675 *0.0907* 75
Q11ABCOMPc	-0.06551 *0.5766* 75	0.02436 *0.8357* 75	-0.17746 *0.1277* 75	0.00127 *0.9914* 75

C49 Associations between patient biking composites and provider perception of appropriateness of RxBike with consideration of referral

	n	test	df	stat	p-value
Patient biking safety and intent composite x strong agreement with appropriateness	75	Fisher's Exact	NA	0.0188	0.1237
Actual biking composite for patient biking x strong agreement with appropriateness	75	Fisher's Exact	NA	0.0057	0.0228
Patient biking safety and intent composite x strong agreement with consider referral	75	Fisher's Exact	NA	0.0062	0.0242
Actual biking composite for patient biking x strong agreement with consider referral	75	Fisher's Exact	NA	0.0139	0.0441

C50 Crosstabs for estimation of patient biking with level of agreement to consider referral

Many to most of patients can bike (n=75)

	Appropriateness **Strongly agree**	**Agree**	**Neutral to disagree**
Many to most	6	2	5
None to some	23	35	4
Chi-Square	2	13.078	0.0014

Many to most of patients have bike access (n=75)

	Appropriateness **Strongly agree**	**Agree**	**Neutral to disagree**
Many to most	2	1	1
None to some	27	36	8
Fisher's Exact	NA	0.1112	0.4491

Many to most of patients have Hubway access (n=75)

	Strongly agree	**Agree**	**Neutral to disagree**
Many to most	8	3	1
None to some	21	34	8
Fisher's Exact	NA	0.0115	0.0882

Patient safety and intent composite (n=75)

	Appropriateness **Strongly agree**	**Agree**	**Neutral to disagree**
Many to most	6	2	0
None to some	23	35	9
Fisher's Exact	NA	0.0188	0.1237

Patient actual biking composite (n=75)

	Appropriateness **Strongly agree**	**Agree**	**Neutral to disagree**
Many to most	3	1	3
None to some	26	36	6
Fisher's Exact	NA	0.0057	0.0228

C51 Crosstabs, testing for association, and odds ratios for provider biking with strong agreement with consider referral

Biker	**Consider referral** **Do not strongly agree**	**Strongly agree**	**Total**
No	5	1	6
%	83.33	16.67	
Yes	51	23	74
%	68.92	31.08	
Total	56	24	80
Fisher's Exact	NA	0.3051	0.6627
Odds Ratio	2.2549	0.2492	20.4065

Bike commuting	**Consider referral** **Do not strongly agree**	**Strongly agree**	**Total**
No	38	8	46
%	82.61	17.39	
Yes	17	15	32
%	53.13	46.88	
Total	55	23	78
Chi-Square	1	7.89	0.005
Odds Ratio	4.1912	1.4945	11.7537

Biked this year	Consider referral Do not strongly agree	Strongly agree	Total
No	19	5	24
%	79.17	20.83	
Yes	37	19	56
%	66.07	33.93	
Total	56	24	80
Chi-Square	1	1.3719	0.2415
Odds Ratio	1.9514	0.6305	6.0396

Boston biking	Consider referral Do not strongly agree	Strongly agree	Total
Yes	21	13	34
%	61.76	38.24	
No	33	8	41
%	80.49	19.51	
Total	54	21	75
Chi-Square	1	3.232	0.0722
Odds Ratio	0.3916	0.1389	1.1044

Biked out of Boston only	Consider referral Do not strongly agree	Strongly agree	Total
No	42	21	63
%	66.67	33.33	
Yes	14	3	17
%	82.35	17.65	
Total	56	24	80
Chi-Square	1	1.5686	0.2104
Odds Ratio	0.4286	0.1108	1.6573

C52 Crosstabs for provider perceptions of safety and comfort with strong agreement for consider referral

Cars share the roads	Intended uptake Do not strongly agree	Strongly agree	Total
Not in agreement	38	13	51
row%	*74.51*	*25.49*	
col%	*67.86*	*54.17*	
Neutral	15	6	21
row%	*71.43*	*28.57*	
col%	*26.79*	*25*	
In agreement	3	5	8
row%	*37.5*	*62.5*	
col%	*5.36*	*20.83*	
Total	56	24	80
Mantel-Haenszel Chi-Square	1	3.1461	0.0761

Bikes share the roads	Intended uptake Do not strongly agree	Strongly agree	Total
Not in agreement	35	8	43
row%	*81.4*	*18.6*	
col%	*62.5*	*33.33*	
Neutral	17	10	27
row%	*62.96*	*37.04*	
col%	*30.36*	*41.67*	
In agreement	4	6	10
row%	*40*	*60*	
col%	*7.14*	*25*	
Total	56	24	80
Mantel-Haenszel Chi-Square	1	7.451	0.0063

Comfort biking in Boston	Strong agreement with appropriateness: Strongly agree	Agree	Neutral to disagree	Total
Not in agreement	11	29	5	45
row%	24.44	64.44	11.11	
col%	50	70.73	83.33	
Indicate degree of agreement	11	12	1	24
row%	45.83	50	4.17	
col%	50	29.27	16.67	
Total	22	41	6	69
Mantel-Haenszel Chi-Square	1	3.5177	0.0607	

Comfort biking outside Boston	Strong agreement with appropriateness: Strongly agree	Agree	Neutral to disagree	Total
Not in agreement	4	12	3	19
row%	21.05	63.16	15.79	
col%	18.18	27.91	60	
Indicate degree of agreement	18	31	2	51
row%	35.29	60.78	3.92	
col%	81.82	72.09	40	
Total	22	43	5	70
Mantel-Haenszel Chi-Square	1	2.8469	0.0915	

C53 Technical summary and supporting data for explanatory models

Explanatory model for provider perceived appropriateness of the RxBike Program using logistic regression

The models were initially built using a backwards selection method with inclusion of variables shown to be associated with the outcomes of interest in the unadjusted analyses.

This approach did not yield a model with more than one independent variable. In the second round, forward selection was performed based on results of unadjusted analyses, presence and strength of associations in the initial model building, and the theoretical framework.

Each variable was examined as a potential confounder for the other covariates. If a variable was associated with both another predictor and the outcome then the variable was a potential confounder; failing to adjust for the confounding variable could bias assessment of covariate main effects. Change in unadjusted beta coefficient of more than 10% with adjustment for the potential confounding variable was used as a threshold for considering a variable to be a potential confounder. There was evidence that failure to include estimate of patient biking would lead to underestimation of the gender effect and overestimation of the commute effect. Failure to include commute distance also resulted in a lower estimate of the gender effect on appropriateness.

	Commute distance and gender	**Commute distance and patient biking**	**Gender and patient biking**	**Final model**
Model inputs				
Commute ≥ 5 miles	6.806 (1.447, 32.013)	6.437 (1.327, 31,224)		7.411 (1.413,38.864)
Many to most patients bike composite‡		7.323 (1.108, 48,396)	6.663 (1.130,39.268)	7.081 (1.069, 46.905)
Male gender	3.772 (0.791,17.977)		3.205 (0.691, 14.862)	3.947 (0.747,20.861)
Effects (Wald χ2)				
Model (Global)	7.9142 (df = 2, p = 0.0191)***	8.5893 (df = 2, p = 0.0136)***	6.6878 (df=2, p=0.0353)***	9.6309 (df=3, p=0.022)***
Commute distance	5.8932 (df = 1, p= 0.0152)***	5.3408 (df =1, p = 0.0208)***		5.6129 (df = 1, p = 0.0178)***
Patient biking composite		4.2701 (df = 1, p = 0.0388)***	4.3901 (df = 1, p = 0.0361)***	4.117 (df=1, p=0.0425)***
Male gender	2.7758 (df = 1, p = 0.0957)**		2.2153 (df=1, p = 0.1366)***	2.6126 (df=1, p= 0.106)*
N	73	73	73	73
Pseudo R2	0.2303	0.2547	0.1756	0.3175
c-statistic	0.78	0.775	0.736	0.817
** <.15, ** <.10, *** <.05*				
ǂ reference group is none to some of patients				

After exclusion of observations for which there was not complete data on all listed covariates, 54 (70.12%) providers indicated lack of strong agreement with consider referral and 23 (28.97%) indicated strong agreement (n=77). The model is described below.

Log [p/(1-p)] $= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$

Logit of not agreeing with appropriateness = -3.9323 + 2.0030 (commute > 5 miles) + 1.9574 (estimate none to some patients bike) + 1.3730 (male gender)

Technical Summary

<u>Global Test</u>

Global H_0: There is no association between lack of agreement with appropriateness of RxBike as a primary care referral and any of the predictors.

Global H_1: There is an association between lack of agreement with appropriateness of RxBike as a primary care intervention and at least one of the predictors.

Level of significance = 0.05

Estimates of interest

Global test Wald χ^2 9.6309, df = 3, p=0.0220

Conclusion: Reject the null hypothesis. There is evidence of an association for lack of agreement with appropriateness and at least one of the predictors in the model.

Interaction Testing
H_0: There is no association between the outcome of lack of agreement with appropriateness of RxBike and the interactions between gender and commute, gender and patient biking, and commute and patient biking.
H_1: There is an association between the outcome of lack of agreement with appropriateness of RxBike and at least one of the interactions listed above.
Level of significance = 0.05
Estimates of interest (n=73)
Wald $\chi^2$for interaction of gender and commute, adjusted for patient biking:
0.2600, df = 1, p=0.6101
Wald $\chi^2$for interaction of gender and patient biking, adjusted for commute:
0.0744, df = 1, p=0.7850
Wald $\chi^2$for interaction of commute and patient biking, adjusted for gender:
0.1332, df = 1, p=0.7152
Conclusion: Do not reject the null hypothesis. There is no evidence for any of the three interactions listed above.

Main Effects Testing
Commute H_0: There is no association for commute of greater than 5 miles with lack of agreement with appropriateness, adjusting for estimate of patient biking and gender.
Commute H_1: There is an association for commute of greater than 5 miles with lack of agreement with appropriateness, adjusting for estimate of patient biking and gender.
$\beta_{commute}$ = 2.0030 (SE = 0.8455), p=0.0178
Odds ratio for commute of > 5 miles = 7.411 (95% CI 1.413, 38.864)
Conclusion for commute effect: Reject the null hypothesis. There is evidence of an association for commute of greater than 5 miles with lack of agreement with appropriateness, adjusting for estimate of patient biking and gender.

Estimate of patient biking H_0: There is no association for estimate of patient biking with lack of agreement with appropriateness, adjusting for commute of greater than 5 miles and gender.
Estimate of patient biking H_1: There is an association for estimate of patient biking with lack of agreement with appropriateness, adjusting for commute of greater than 5 miles and gender.
$\beta_{\text{estimate of patient biking}}$ = 1.9574 (SE = 0.9647), p = 0.0425
Odds ratio for none to some patients bike = 7.081 (95% CI 1.069, 46.905)
Conclusion for estimate of patient biking effect: Reject the null hypothesis. There is evidence of an association for estimate of patient biking with lack of agreement with appropriateness, adjusting for commute of greater than 5 miles and gender.

Gender H_0: There is no association for gender with lack of agreement with appropriateness, adjusting for commute of greater than 5 miles and estimate of patient biking.
Gender H_1: There is an association for gender with lack of agreement with appropriateness, adjusting for commute of greater than 5 miles and estimate of patient biking.
β_{gender} = 1.3730 (SE = 0.8494), p= 0.1060
Odds ratio for male gender 3.947 (95% CI 0.747,20.861)

Conclusion for gender effect: Do not reject the null hypothesis as there is insufficient evidence to support an association for gender with lack of agreement with appropriateness, adjusting for commute of greater than 5 miles and estimate of patient biking.

Examination of the standardized beta coefficients shows the strongest effect was for commute of greater than 5 miles (standardized beta = 0.5034), followed by male gender (standardized beta 0.3730), and low estimate of patient biking (0.3199).

<u>Goodness of Fit</u>
Goodness of fit was assessed as model calibration and outcome discrimination ability.
H_0 for calibration: There is no difference between the observed and expected values for the appropriateness outcome.
Level of significance = 0.05
Hosmer-Lemeshow test of goodness-of-fit χ^2statistic = 0.4603, df = 2, p= 0.7944
C-statistic = 0.817
Conclusion: Do not reject the null hypothesis for calibration; there is evidence that the model was able to predict the appropriateness outcome. The model also demonstrated high degree of discrimination between agreement with appropriateness and lack of agreement as the outcome variable.

	Coefficient	**Standard error**	**Std β**	**Odds ratio**	**95% CI for OR**	
Constant	-3.9323	0.9483				
Model inputs						
Commute ≥ 5 miles	2.003**	0.8455	0.5034	7.411	1.413	38.864
Many to most patients bike composite‡	1.9574**	0.9647	0.3199	7.081	1.069	46.905
Male gender	1.373*	0.8494	0.373	3.947	0.747	20.861
Effects	**Wald χ2**	**df**	**p-value**			
Model (Global)	9.6309	3	0.022			
Commute	5.6129	1	0.0178			
Patient biking composite	4.117	1	0.0425			
Male gender	2.6126	1	0.106			
N	73					
Pseudo R2	0.3175					
Hosmer-Lemeshow χ2 (df, p-value)	0.4603	2	0.7944			
c-statistic	0.817					
** <.15, ** <.05*						
ǂ reference group is none to some of patients						

Results
In the final model, the outcome of lack of agreement with appropriateness was predicted by the covariates of commute of more than 5 miles, male gender, and estimate that many to most of the provider's own patients were bikers. The model demonstrated evidence of calibration and a high level of discrimination, there was no evidence of interaction for the covariate pairs. In the logistic regression analysis there was evidence of association between commute distance and lack of agreement with appropriateness. Providers with longer commutes had 7.4 times the odds of

not agreeing with RxBike appropriateness compared to providers living within 5 miles of BMC, controlling for estimates of patient biking and gender.
There was evidence of a significant association between estimates of patient biking lack of agreement with appropriateness. Providers with lower estimates of patient biking had 7.081 times the odds of not agreeing with RxBike appropriateness compared to providers estimating that many to most of their patients biked, controlling for estimates of commute distance and gender.
Results suggest that male providers had increased odds of not agreeing with RxBike appropriateness, while controlling for commute distance and estimates of patient biking. The association between gender and the outcome of appropriateness did not reach the apriori level of statistical significance. The p-value for the Wald χ^2approached significance, which suggests that the analysis may have lacked power detect a true association for gender and appropriateness (n=73). Male providers had higher odds of not agreeing with appropriateness compared to female providers when controlling for commute distance and estimate of patient biking.
In unadjusted analyses, females had equal likelihood of biking this year, but lower likelihood of biking in Boston when compared to male providers. Female gender was strongly associated with more negative perceptions of road safety and provider comfort biking. Female agreement with appropriateness was 93.18% compared to79.31% for males. For these reasons the inclusion of gender in the logistic regression is supported as provider biking practices and safety perceptions would be expected to impact provider perceptions of attributes of the RxBike program and decisions about patient referral.

C54 Unadjusted analyses for variables in model

Commute	**Appropriateness**		
	Neutral to disagree	**Indicate agreement**	**Total**
>5 miles	**6**	**15**	**21**
row %	***28.57***	***71.43***	
within 5 miles	**3**	**49**	**52**
row %	***5.77***	***94.23***	
Total	**9**	**64**	**73**
Fisher's Exact Test			
Table Probability (P)	**0.0124**		
Two-sided Pr <= P	**0.0141**		
		LCI	**UCI**
Odds Ratio	**6.5333**	**1.4552**	**29.3314**
Patient biking	**Appropriateness**		
	Neutral to disagree	**Indicate agreement**	**Total**
None to Some	**3**	**4**	**7**
row%	***42.86***	***57.14***	
Many to Most	**6**	**60**	**66**
row%	***9.09***	***90.91***	
Total	**9**	**64**	**73**

Fisher's Exact Test			
Table Probability (P)	**0.0328**		
Two-sided Pr <= P	**0.0361**		
		LCI	**UCI**
Odds Ratio	**7.5**	**1.3482**	**41.7224**
Gender	**Appropriateness**		
	Neutral to disagree	**Indicate agreement**	**Total**
Male	**6**	**23**	**29**
row%	***20.69***	***79.31***	
Female	**3**	**41**	**44**
row%	***6.82***	***93.18***	
Total	**9**	**64**	**73**
Fisher's Exact Test			
Table Probability (P)	**0.0648**		
Two-sided Pr <= P	**0.1423**		
		LCI	**UCI**
Odds Ratio	**3.5652**	**0.814**	**15.6144**

C55 Technical summary and supporting data for consider referral

Explanatory model for provider consideration of patient referral to the RxBike Program using logistic regression

In the initial model, the covariates were dichotomized bike commuting within the past year, ordinal agreement with appropriateness of referral (strong agreement, agreement, neutral with disagreement) and gender. Initial analyses indicated significant confounding from both gender and appropriateness on the other variables. There was evidence of association between provider perception of appropriateness of RxBike referral and lack of strong agreement with consider RxBike referral. Results suggest that female providers had increased odds of not strongly agreeing with RxBike consider referral while controlling for RxBike appropriateness and bike commuting, but the association between gender and the outcome did not reach the apriori level of statistical significance. Additional analyses revealed an interaction effect for bike commuting and gender, only after removal of bike commuting and gender as covariates.

Logit of not strongly agreeing with consideration of referral = -3.5844 + 4.9699 (agree with appropriateness) + 4.5950 (neutral or disagree with appropriateness) + 1.8713 (not a bike commuter) + 1.9304 (female gender).

In the new model, the outcome was log odds of not strongly agreeing with consider referral was modeled with the independent variables for dichotomized strong agreement with appropriateness of referral and the composite variable for gender and biking.

Each variable was examined as a potential confounder for the other covariates. If a variable was associated with both another predictor and the outcome then the variable could be a potential confounder; failing to adjust for the confounding variable could bias assessment of covariate main effects. Change in unadjusted beta coefficient of more than 10% with adjustment for the potential confounding variable was used as a threshold for considering a variable to be a potential confounder.

Adjusting the model for appropriateness resulted in a higher estimate on the effect of female non commuting status on consider referral; adjustment for gender-bike commuting decreased the effect of appropriateness. Additional examination using the covariates for dichotomized strong agreement with appropriateness, gender and bike commuting showed that the confounding gender was greater than confounding by bike commuting

	Appropriateness	***Appropriateness, provider biking, and gender***	***Appropriateness and the gender-bike commuting interaction***	***Final model***
Model inputs				
Do not strongly agree with appropriateness	*38.330 (9.201, 159.681)*	*132.188 (12.498, >999.999)*	*74.766 (12.262, 455.880)*	*130.705 (12.051, >999.999)*
Female non bike commuter ǂ				*45.422 (2.827, 729.849)*
Female bike commute ǂ				*6.816 (0.411, 113.137)*
Male non bike commuter ǂ				*6.087 (0.372,99.674)*
Not a bike commuter		*6.458 (1.157, 36.058)*		
Female gender		*7.143 (0.789, 64.633)*		
Bike commute-gender interaction[§]			*11.166*	
Effects (Wald $\chi 2$)				
Model (Global)	*25.0828 (df= 1, p < 0.0001)*	*18.0957 (df=3, p=0.0004)*	*21.8968 (df=2, p<0.0001)*	*18.2307 (df=4, p = 0.0011)*
Do not strongly agree with appropriateness	*25.0828 (df= 1, p < 0.0001)*	*16.4729 (df=1, p <0.0001)*	*21.8775 (df = 1, p < 0.0001)*	*16.0521 (df = 1, p < 0.0001)*
Gender-bike commute composite				*8.0063 (df=3, p=0.0459)*
Bike commute		*4.5190 (df=1, p=0.0335)*		
Female gender		*3.0609 (df=1, p=0.0802)*		
Bike commute-gender interaction			*7.0129 (df=1, p = 0.0081)*	
N	*77*	*77*	*77*	*77*
Pseudo R2	*0.5509*	*0.6768*	*0.6491*	*0.6768*
c-statistic	*0.861*	*0.939*	*0.919*	*0.939*
**<.05, ** <0.01*				
ǂ reference group is male bike commuters				
§ female non bike commuters versus all others				

After exclusion of observations for which there was not complete data on all listed covariates, 54 (70.12%) providers indicated lack of strong agreement with consider referral and 23 (28.97%) indicated strong agreement (n=77). The model is described below.
Log [p/(1-p)] = $\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$
Logit of lacking strongly agreement with consideration of referral = 0.7369 + 2.4365 (no strong agreement with APP) + 1.9306 (female not bike commuting) + 0.0339 (female bike commuting) - 0.0792 (male non bike commuter)

Technical Summary

<u>Global Test</u>
Global H_0: There is no association between lack of strong agreement with consider referral to RxBike and any of the predictors.
Global H_1: There is an association between lack of strong agreement with consider referral to RxBike and any of the predictors.
Level of significance = 0.05
Estimates of interest
Global test Wald χ^2 18.2307 , df = 4, p=00011
Conclusion: Reject the null hypothesis. There is evidence of an association between lack of strong agreement with consider referral to RxBike and at least one of the predictors.

<u>Interaction Testing</u>
H_0: There is no association between the outcome of lack of strong agreement with consider referral to RxBike and the interaction between strong agreement with appropriateness of referral and the composite variable for gender-bikecommuting.
H_1: There is an association between the outcome of lack of strong agreement with consider referral to RxBike and the interaction between strong agreement with appropriateness of referral and the composite variable for gender-bikecommuting.
Level of significance = 0.05
Estimates of interest
Wald $\chi^2$for strong agreement with appropriateness of referral and the composite variable for gender-bikecommuting = 0.0366, df = 2, p=0.9982
Conclusion: Do not reject the null hypothesis. There is no evidence for interaction of strong agreement with appropriateness of referral and the composite variable for gender-bikecommuting

<u>Main Effects Testing</u>
Strong appropriateness of referral H_0: There is no association between strong agreement for appropriateness of referral with lack of strong agreement with consider RxBike referral, adjusting for the gender-bikecommuting composite.
Strong appropriateness of referral H_1: There is an association between strong agreement for appropriateness of referral with lack of strong agreement with consider RxBike referral, adjusting for the gender-bikecommuting composite.
Wald $\chi^2_{\text{appropriateness}} = 16.0531$, df = 1, p< 0.0001
$\beta_{\text{do not strongly agree with appropriateness versus strongly agree}} = 2.4365$ (SE = 0.6081), p < 0.0001
Odds ratio $_{\text{do not strongly agree with appropriateness versus strongly agree}}$ = 130.705 (95% CI 12.051, >999.99)
Conclusion for appropriateness of referral: Reject the null hypothesis. There is evidence of an association between strong agreement for appropriateness of referral with lack of strong agreement with consider RxBike referral, adjusting for the gender-bikecommuting composite.

Gender-bikecommuting composite H_0: There is no association between the gender-bikecommuting composite with lack of strong agreement with consider RxBike referral, adjusting for strong agreement with appropriateness of referral.
Gender-bikecommuting composite H_1: There is an association between the gender-bikecommuting composite with lack of strong agreement with consider RxBike referral, adjusting for strong agreement with appropriateness of referral.
Wald $\chi^2_{\text{gender-bikecommuting composite}} = 8.0063$, df = 3, $p< 0.0459$
Conclusion for appropriateness of referral: Reject the null hypothesis. There is evidence of an association for the gender-bikecommuting composite with lack of strong agreement with consider RxBike referral, adjusting for strong agreement with appropriateness of referral.
Contrasts for gender-bikecommuting composite
Contrasts for gender-bikecommuting composite H_0: There is a no difference in odds of lack of agreement with consider referral for all categories of the gender-bikecommuting composite, adjusting for strong agreement with appropriateness of referral.
Contrasts for gender-bikecommuting composite H_1: There is a difference in odds of lack of agreement with consider referral for at least one category of the gender-bikecommuting composite, adjusting for strong agreement with appropriateness of referral.
$\beta_{\text{female non bike commuter}} = 1.9306$ (SE = 0.7523), p = 0.0103
Odds ratio $_{\text{female non bike commuter versus male bike commuter}}$ = 45.422 (95% CI 2.827, 729.849)
$\beta_{\text{female bike commuter}} = 0.0399$ (SE = 0.7954), p = 0.9660
Odds ratio $_{\text{female bike commuter versus male bike commuter}}$ = 6.816 (95% CI 0.411, 113.137)
$\beta_{\text{male non bike commuter}} = - 0.0792$ (SE = 0.9141), p = 0.9310
Odds ratio $_{\text{male non bike commuter versus male bike commuter}}$ = 6.087 (95% CI 0.372, 99.674)
Conclusion for contrasts for gender-bikecommuting composite: Reject the null hypothesis. The odds for lack of strong agreement with consider referral is higher for the female non bike commuters compared to the male bike commuters, controlling for strong agreement with appropriateness of referral.

Examination of the standardized beta coefficients shows the strongest effect was for lack of strong agreement with appropriateness of referral (standardized β 1.3008) followed by female non bike commuters (standardized β 0.8213), female bike commuters (standardized β 0.0119) and male non bike commuters (standardized β -0.0269). The categories of gender and biking were compared to male bike commuters.

Goodness of Fit
Goodness of fit was assessed as model calibration and outcome discrimination ability.
H_0 for calibration: There is no difference between the observed and expected values for the outcome of consider referral.
Level of significance = 0.05
Hosmer-Lemeshow test of goodness-of-fit χ^2statistic = 1.6547, df = 5, p= 0.8946
C-statistic = 0.939
Conclusion for model calibration: Do not reject the null hypothesis for calibration; there is evidence that the model was able to predict the consider referral outcome. The model demonstrated high degree of discrimination between strong agreement with consider referral and lack of agreement as the outcome variable.

Fisher's Exact text for Gender- Bike Commute Composite 0.0002, p= 0.0297

	Coefficient	**Standard error**	**Std β**	**Odds ratio**	**95% CI for OR**	
Constant	-3.9323	0.9483				
Model inputs						
Commute ≥ 5 miles	2.003**	0.8455	0.5034	7.411	1.413	38.864
Many to most patients bike composite‡	1.9574**	0.9647	0.3199	7.081	1.069	46.905
Male gender	1.373*	0.8494	0.373	3.947	0.747	20.861
Effects	**Wald χ2**	**df**	**p-value**			
Model (Global)	9.6309	3	0.022			
Commute	5.6129	1	0.0178			
Patient biking composite	4.117	1	0.0425			
Male gender	2.6126	1	0.106			
N	73					
Pseudo R2	0.3175					
Hosmer-Lemeshow χ2 (df, p-value)	0.4603	2	0.7944			
c-statistic	0.817					
** <.15, ** <.05*						
‡ reference group is none to some of patients						

Results

In the final model, the outcome of lack of strong agreement with consider referral was predicted by the covariates strong agreement for appropriateness of referral and the gender-bike commuting composite. The model demonstrated evidence of calibration and a high level of discrimination, there was no evidence of interaction between the two independent variables.

In the controlled analyses, there was evidence of association between strong provider perception of appropriateness of RxBike referral and lack of strong agreement with consider RxBike referral.

There was also evidence of association between the gender-bike commuting composite variable of and lack of strong agreement with consider RxBike referral, with adjustment for appropriateness rating. Only the contrast between the female non bike commuters and the male bike commuters was shown to increase likelihood of not endorsing strong agreement, when controlling for appropriateness; females had 45 times the odds of not agreeing. In the unadjusted analysis the highest proportions for not strongly agreeing with strongly consider referral were for the female non bike commuters and lowest for male bike commuters. Results suggest that bike commuters have higher strong agreement with consider referral, regardless of gender. Tabulation of the four levels of the gender-bike commute composite with strong agreement with appropriateness resulted in small cell sized, these were further decreased after separating by strong agreement with consideration of referral. This analysis was not powered to *allow conclusions about the relative difference in likelihood of referral for bike commuting females or non bike commuting males.*

C56 Unadjusted analyses for variables in model for consider referral

Gender	**Consider referral**		
	Do not strongly agree	Strongly Agree	Total
Female	36	12	48
row%	*75*	*25*	
Male	18	11	29
row%	*62.07*	*37.93*	
Total	54	23	77
	df	**Value**	**Prob**
Chi-Square	1	1.443	0.2296
		LCI	**UCI**
Odds Ratio	1.8333	0.678	4.9573
Bike commuting	**Consider referral**		
	Do not strongly agree	Strongly Agree	Total
No	38	8	46
row%	*82.61*	*17.39*	
Yes	16	15	31
row%	*51.61*	*48.39*	
Total	54	23	77
	DF	**Value**	**Prob**
Chi-Square	1	8.4936	0.0036
		LCI	**UCI**
Odds Ratio	4.4531	1.5771	12.5738

Appropriateness	**Consider referral**		
	Do not strongly agree	Strongly Agree	Total
Do not strongly agree	46	3	49
row%	*93.88*	*6.12*	
Strongly agree	8	20	28
row%	*28.57*	*71.43*	
Total	54	23	77
	DF	**Value**	**Prob**
Chi-Square	1	36.277	<.0001
		LCI	**UCI**
Odds Ratio	38.3333	9.2013	159.6993
Gender-Bike Commute Composite	**Consider referral**		
	Do not strongly agree	Strongly Agree	Total
Female non-bikecomm	28	5	33
row%	*84.85*	*15.15*	
Female bikecomm	8	7	15
row%	*53.33*	*46.67*	
Male non-bikecomm	10	3	13
row%	*76.92*	*23.08*	
Male bikecomm	8	8	16
row%	*50*	*50*	
Total	54	23	77
Fisher's Exact Test			
Table Probability (P)	0.0002		
Pr <= P	0.0297		

Appendix D: Chapter Four

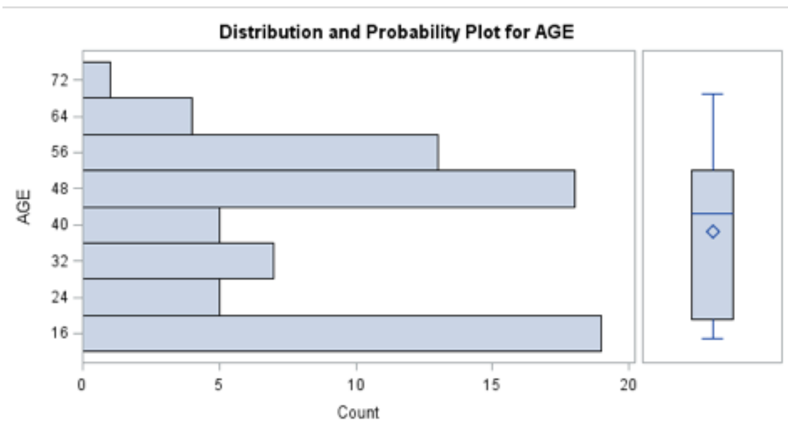
D1 Additional descriptive statistics for referrals to RxBike from 2013–2015 (n=72)

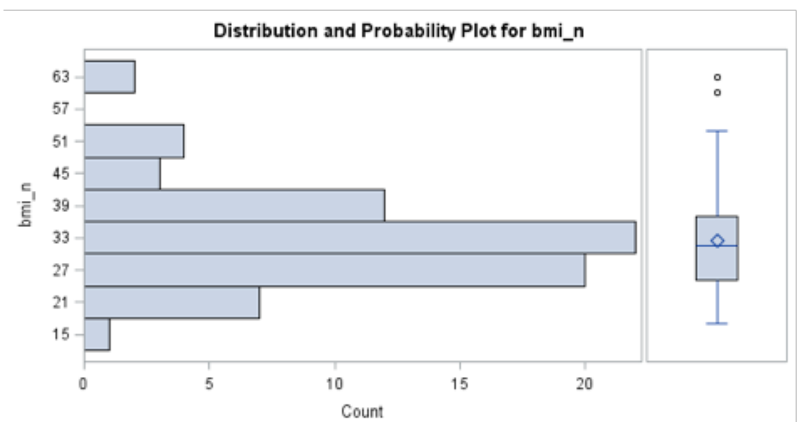
	Frequency	Percent
Neighborhood (n=60)		
Allston-Brighton	0	0.00
Back Bay	1	1.67
Charlestown	0	0.00
Dorchester North	12	20.00
Dorchester South	17	28.33
East Boston	1	1.67
Fenway	0	0.00
Hyde Park	3	5.00
Jamaica Plain	3	5.00
Mattapan	3	5.00
Roslindale	1	1.67
Roxbury	9	15.00
South Boston	2	3.33
South End	8	13.33
West Roxbury	0	0.00
Clinic site		
Adolescent clinic	8	11.11
Cardiology	4	5.56
Infectious disease	20	27.78
Family medicine	1	1.39
Adult internal medicine*	12	16.67
Hematology/oncology	2	2.78
Infusion unit	1	1.39
Inpatient	1	1.39
Pediatrics	14	19.45
Pediatric infectious disease	2	2.78
Urology	1	1.39
Women's Health	6	8.33
Month		
January	0	0.00
February	0	0.00
March	9	12.50
April	8	11.11
May	8	11.11
June	9	12.50
July	18	25.00
August	4	5.56
September	7	9.72
October	6	8.33
November	2	2.78
December	1	1.39
EMR Used		
EPIC	13	18.06
Logician	59	81.94

D2 Univariate statistics and testing for normality for age in years and BMI in m^2/kg

Age in years				BMI in m^2/kg			
N	72	**Missing**	0	**N**	71	**Missing**	1
Mean	38.53	**Variance**	272.0837	**Mean**	32.52	**Variance**	84.8523
Std Dev	16.4950	**Std Error**	1.9439	**Std Dev**	9.2115	**Std Error**	1.0932
Min	15	**Max**	69	**Min**	17	**Max**	63
Median	42.5	**Mode**	19	Median	31.51	Mode	33
25th Pctl	19	**75th Pctl**	52	**25th Pctl**	25.08	**75th Pctl**	37
Skew	-0.1142	**Kurtosis**	-1.5204	**Skew**	1.0471	**Kurtosis**	1.5103
Tests for Normality				**Tests for Normality**			
Test	**Statistic**			**Test**	**Statistic**		
Shapiro-Wilk		0.889983	<0.0001	**Shapiro-Wilk**		0.935892	0.0013

D3 Distributions for age in years and BMI in m^2/kg





D4 Cross tabs and testing for associations for provider characteristics and year (2014–2015)

	Adult provider	Pediatric provider	Total
2014	43	9	52
2015	5	14	19
Total	48	23	71

	df	statistic	p-value
χ^2	1	20.1949	<.0001

	Trainee	Staff	Total
2014	10	42	52
2015	1	18	19
Total	11	60	71

	statistic	p-value
Fisher's Exact Test	0.1174	0.267

D5 Cross tabs and testing for associations for patient characteristics and year (2014–2015)

	up to age 24	25–44	45 and above	Total
2014	9	12	31	52
2015	14	1	4	19
Total	23	13	35	71

	df	statistic	p-value
CMH χ^2	1	15.6862	<.0001

	Female	Male	Total
2014	22	30	52
2015	12	7	19
Total	34	37	71

	df	statistic	p-value
χ^2	1	2.4241	0.1195

D6 Distribution of patients by BMI category for 2014–2015 (n=70)

	Underweight	Normal weight	Overweight	Obese	Extreme obesity	Total
2014	3	9	6	22	11	51
row%	*5.88*	*17.65*	*11.76*	*43.14*	*21.57*	*100*
2015	0	4	6	8	1	19
row%	*0*	*21.05*	*31.58*	*42.11*	*5.26*	*100*
Total	3	13	12	30	12	70
row %	*4.29*	*18.57*	*17.14*	*42.86*	*17.14*	*100*

D7 Odds of referral for an obese patient by provider type and patient gender

	Obese	Not obese	Total
Adult	32	15	47
row %	*68.09*	*31.91*	
Pedi/adolescent	10	13	23
row %	*43.48*	*56.52*	
Total	28	42	70
row%	*60.00*		
	Odds ratio	**95% CI**	
Adult provider	2.7733	0.9926	7.749

	Obese	Not obese	Total
Female	26	8	34
row%	*76.47*	*23.53*	
Male	16	20	36
row%	*44.44*	*55.56*	
Total	42	28	70
row%	*60.00*	*40.00*	
	Odds ratio	**95% CI**	
Female patient	4.0625	1.4509	11.3749

D8 Descriptive statistics for the neighborhoods of BMC patients referred to RxBike of those referrals living in Boston (n=61)

		Frequency	Percent
Neighborhood poverty			
	Worse than Boston	30	49.18
	Same as Boston	25	40.98
	Better than Boston	6	9.84
Neighborhood unemployment			
	Worse than Boston	42	68.85
	Same as Boston	16	26.23
	Better than Boston	3	4.92
Neighborhood rental cost-burden			
	Worse than Boston	42	68.85
	Same as Boston	13	21.31
	Better than Boston	6	9.84
Neighborhood linguistic isolation			
	Worse than Boston	21	34.43
	Same as Boston	34	55.74
	Better than Boston	6	9.84
Neighborhood low level of education			
	Worse than Boston	34	55.74
	Same as Boston	9	14.75
	Better than Boston	18	29.51

Neighborhood premature birth rate		
Bottom 25% (worst performance)	30	49.18
2nd quartile	23	37.70
3rd quartile	4	6.56
Top quartile (best performance)	4	6.56
Neighborhood diabetes mortality rate		
Bottom 25% (worst performance)	30	49.18
2nd quartile	18	29.51
3rd quartile	11	18.03
Top quartile (best performance)	2	3.28
Neighborhood diabetes admission rate		
Bottom 25% (worst performance)	39	63.93
2nd quartile	17	27.87
3rd quartile	3	4.92
Top quartile (best performance)	2	3.28
Neighborhood homicide rate		
More than 1.5x Boston rate	42	70.00
Close to Boston rate	17	28.33
Less than half Boston rate	1	1.67
Neighborhood mental health hospitalization rate		
More admits than Boston	35	57.38
Same admits as Boston	22	36.07
Fewer admits than Boston	4	6.56
Neighborhood chronic disease mortality index		
More deaths than Boston	27	44.26
Same deaths as Boston	14	22.95
Fewer deaths than Boston	20	32.79
Neighborhood chronic disease hospitalization index		
More admits than Boston	45	73.77
Same admits as Boston	9	14.75
Fewer admits than Boston	7	11.48
Neighborhood poor birth outcome score		
High score (disadvantage)	29	47.54
Moderate score	24	39.34
Low score (advantage)	8	13.11
Self-reported Black race/ethnicity		
Less than half of Boston	4	6.56
About the same as Boston	12	19.67
More than 1.5x Boston	45	73.77
Self-reported White race/ethnicity		
Less than half of Boston	42	68.85
About the same as Boston	16	26.23
More than 1.5x Boston	3	4.92
Self-reported Latino race/ethnicity		
Less than half of Boston	4	6.56
About the same as Boston	44	72.13
More than 1.5x Boston	13	21.31

D9 Provider comments from survey

Q6 Commute Comment

- I use the commuter train, and then walk from Back Bay
- 3–4 miles
- soon moving closer

Q7 Own Biking Comment

- i am afraid of riding in traffic; used to ride on minute man trail before my daughter was born.
- I ride a stationary bike
- I don't feel safe riding to work. I have seen 3 bike accidents involving cars over the last 2 years alone.
- Cambridge, where I live
- I am afraid of being killed in traffic or I would ride my bike to work
- too dangerous to ride in Boston
- previously biked to work for a 1 months - stopped due to discomfort riding in traffic
- i do not know how to ride
- i do not know how to ride a bike

Q8 Bikeshare use

- plan to start once move is completed

Q9 Feel safe biking

- Need bike lanes!
- I have been to other areas where the bike paths are separated physically from cars. I feel that biking in dedicated bike paths or in less congested areas is much safer.
- I am a little scared of the idea of biking in Boston city limits.
- I usually do not bike outside of Boston
- i probably would not feel safe

Q10 cars and bikes

- Bicyclist , do not follow rules of transient

Q11 Beliefs about patients biking

- I also have many disabled patients, and elderly patients, who would have problems with bicycles.
- A good portion of my patients are older, overweight and have physical limitations
- my patients are all less than 16 so not eligible

Q12 Beliefs on own practice

- I also have many Spanish speaking patients and wonder if there are materials in Spanish.
- Would I be liable if I referral pt to exercise in a gym and they injured themselves? It would be the same.
- is the physician liable if someone gets into an accident after using the bike share?
- if we have to print a form off logician, the logistics of printing forms is time consuming.
- A great program but mostly shodu be taken out of the hands of providers and not burden then with additional task in alreayd busy clinic. I suggest having the patient primed when they

enter the PCP office wuith a form that they woudl have already filled out that the MD simply has to sign off on
• i referred my first patient yesterday

General comments
• I would also like to have access to this program. My pcp is in family medicine.
• I am very enthused about the idea of Hubway (both for myself - I use the service regularly) and for my patients. My main concern is the current distribution of hubway stations which favors the central parts of Boston to the exclusion of the Southern neighborhoods (Roxbury, Dorchester, Mattapan, Roslindale, etc) where 3 of my patients reside. I was shocked, for example, to realize that Upham's corner is the southern4 docking station in Dorchester. I suspect I personally will be more likely to consider referring when I am more confident that there is adequate service in the neighborhoods where my patients live.
• good idea - would be best if we could flag 2one and they did the calling and followup with the patient. also would want pt to get bike helmet and safety reminders.
• The easier you can make the referral link, the better. Also, 3 of my patients are French or Creole or Spanish-speaking, so they would need culturally appropriate educational material
• I enjoy biking for recreation and wish I had more time to do it.
• Given the other demands placed on primary care physicians, I often forget to discuss the bike share program. I wonder if there would be another way to educate patients outside of the primary care visit. Could it be done in the waiting room, mailers to patients, tables in the 1st floor of Shapiro etc.
• I have referred patients using the current referral form in Logician, but it is cumber2 to go through Letters, etc. to find it. A better process would be welcome.
• The exercise benefits are modest and the hazards of riding a bicycle in heavy traffic outweigh any benefits for me.
• As a PCP, I already cannot meet expectations to deliver preventive care, nutrition advice, mental health screening, survive logician and meaningless use, oh...yeah, take care of illness? and are you serious- refer to Bike Share through Logician? Why do docs have to everything?
• do the form in EPIC. otherwise you will have to train folks again in Feb
• I just need to shoe horn it into a session that is already overbooked with prevention discussions and running over schedule. But worthy and will try.
• I think it would be great but I do worry about safety bicycling in Boston - mainly due to the drivers but also lack of knowledge on the part of 2 bicyclists
• I actually hadn't thought about liability until reading the last question. Can this be addressed at 2 point in the future?
• Riding in Boston remains a risky activity, have direct knowledge of deaths related to bike riding in Boston, and the issue of physician liability is real.
• BMC employees should get a discount as well!!
• This is a fantastic program!
• it would be great if health leads or jump rope clinic could do this
• I do not bike in Boston because I feel unsafe in traffic. I have biked in other cities where I felt much safer.

Appendix E: Chapter Five

E1 How does neighborhoods disadvantage of Boston riders (2012–2015) from study one compare to patients referred by BMC (2014–2015)

	% regular riders	% subsidized riders	% BMC referrals
n	1,166,227	90,158	*61*
Neighborhood disadvantage			
More linguistically isolated households	21.73	31.45	*34.43*
More adults without a high school diploma	8.09	15.3	*55.74*
Higher unemployment rate	4.76	15.8	*68.85*
More residents with income below poverty level	55.17	69.65	*49.18*
More housing units with rent burden	27.25	33.37	*68.85*
Health indicators			
Bottom quartile for premature birth	3.71	10.43	*49.18*
Bottom quartile for diabetes mortality	3.71	10.43	*49.18*
Bottom quartile for diabetes hospitalizations	4.76	15.5	*63.93*
More mental health admits	54.58	64.88	*57.38*
More chronic disease mortality	8.99	14.51	*44.26*
More chronic disease admissions	4.89	16.2	*73.77*
More negative birth outcomes*	24.07	23.58	*47.54*
More than 1.5x homicide rate*	9.65	23.09	*70.00*
Racial/ethnic composition			
%Blacks >1.5x Boston	4.89	16.2	*73.77*
% Whites >1.5x Boston	39.44	22.86	*4.92*
% Latino >1.5x Boston	6.41	13.98	*21.23*

*sample size for homicide BMC = 60, subsidized = 61.663, regular = 575,352 ; sample size for poor birth outcome: BMC 61, subsidized = 89,966 , regular = 1,162,554

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CURRICULUM VITAE

Kathleen M. Ryan, B.A., B.S.N., R.N., M.P.H., Ph.D. candidate
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Education

- **Boston University** School of Public Health Boston, PhD in Health Services Research, anticipated May 2016
- **Boston University** School of Public Health Boston, MA Masters in Public Health, May 2003
- **Boston University** School of Public Health Boston MA, Certificate in Maternal and Child Health, May 1999
- **Columbia University** School of Nursing New York, NY, Bachelor of Science in Nursing, 1994, Dean's List
- **College of the Holy Cross** Worcester, MA, B.A. Psychology, 1991, Magna Cum Laude

Additional coursework in education, science, statistics and accounting at Wheelock College, Boston College, Northeastern University, University of Massachusetts and Harvard Extension School

Teaching Experience

Teaching associate, Boston University School of Public Health

- Introduction to Health Policy and Management
  - Summer 2012–2015 and Spring 2014–2016
  - Core course for the masters in Public Health Program
  - Introduced new elements to course: online post-class assessments, sessions in computer room for team assignments, web conference exam review, structured in class group work
  - Ongoing course revision to incorporate progress of health reform
  - Teaching assistant in Fall only 2011–2015
- Introduction to Public Health
  - Spring and Fall 2013–present
  - Elective for undergraduate students
  - Received Boston University School of Public Health Teaching Award, Fall 2015

Adjunct instructor, Boston University Metropolitan College and College of Communications

- Introduction to the American Health Care System for Health Communications
- Spring 2013 to present
- Online course through Distance Learning

Previous Grant Activities

2006–December 2009 Nurse Coordinator, Centers for Disease Control, Resource Center

2007–2009 Co-Investigator and Evaluator, New England Genetics Collaborative Innovative Project

2004–2005 Medical Advisor, **Lawrence J. and Anne Rubenstein Charitable Foundation;**

2003 –2005 Project Director, HRSA/MCHB Sickle Cell and Newborn Screening Grant

2002–2003 Educational Coordinator, HRSA/MCHB Sickle Cell and Newborn Screening Grant

Professional Experience

2011 – 2014, Staff RN, Ambulatory **Neurology, Children's Hospital Boston**

2010 – 2011 Project Manager/Health Scientist, Validating and Classifying VA Readmissions for Quality Assessment, Center for Organization Leadership and Management (COLMR), VA Boston Healthcare System

2003 – 2009 Program Coordinator/Staff Nurse II, Children's Hospital Boston Ambulatory Hematology Program

2003–2004 Pediatric Nurse, Centrus Home Care, Plymouth, MA

1997– 2003 Program Coordinator, PainFree Pediatrics Program, Boston Medical Center

1999–2006 Coordinator, New England Pediatric Sickle Cell Consortium

2000–2002 Special Projects, Pediatric Hematology Program, Boston Medical Center

1997–2000 Clinical Coordinator, Pediatric Hematology Program, Boston Medical Center

Fall 2001 Boston Public Health Commission. Walk this Way Campaign

1996–1997 Staff Nurse, Pediatric Primary Care, Boston Medical Center

1994–1996 Staff Nurse, Pediatric Inpatient Unit, Boston City Hospital/ Boston Medical Center

Additional Training and Awards

Teaching Award, Boston University School of Public Health, Fall 2015

Teaching Doctoral Students to Teach, Spring 2012

Evidence-Based Practice Fellowship Children's Hospital Boston Department of Nursing, 2008–2009.

Collaborative Institutional Training Initiative Certification 2009–present.

Responsible Conduct of Research Training, Boston University Office of Research Compliance, 2012.

Child Health Policy Training, Office of Government Relations, Boston Children's Hospital, 2012.

Anne G. Hargeaves Award for Nursing Excellence, Boston Medical Center, 1999

Community Activities

Boston Cares, Friday Night Supper Club, 2013–present

- Board of directors 2015–present

Bridge over Troubled Water Medical Outreach Van, July 2011– Present

The Hole in the Wall Gang Camp Ashford Connecticut, 1996– Present

Next Step Program, Cambridge MA, 2004 – 2010

March of Dimes Massachusetts Chapter Community Grant Reviewer, 2005– 2009

Children's AIDS Program, Boston, MA 1991–1992

Boston City Hospital Inpatient Child Life Program, 1990–1992

Sickle Cell Collaborative, Member, (2000–2007 formerly known as Sickle Cell Savers)

Selected Presentations

- Prescribe a Bike: Reducing Income-Based Disparities in Bike Access for Health Promotion and Active Transport through Primary Care, accepted for Academy Health Poster June 2016.
- Nursing Considerations for Children with Special Health Care Needs in the Camp Setting, Society of Pediatric Nurses, March 2016
- Reducing Income-Based Disparities in Bike Access for Health Promotion and Active

Transport through Primary Care, New England Walk-Bike Summit, September 2015

- Nursing Care of the Pediatric Sickle Cell Patient in the Stem Cell Transplant Setting, Hematology/Oncology. August 2009.
- Sickle Cell Disease. Advanced Concepts in Pediatric Hematology Full-Day Conference (open to participants from outside the institution). Children's Hospital Boston Medicine Patient services. March 2009.
- Nursing Care of the Pediatric Sickle Cell Patient in the Intensive Care Unit, Hematology/Oncology. April 2009.
- Inpatient Nursing Care of Pediatric Patients with Sickle Cell Disease. Children's Hospital Boston New Graduate Orientation Program, Hematology/Oncology. August 2006–present.
- Immunizations for the Child with Sickle Cell Disease. On-line computer based learning module for nurses. Children's Hospital Boston. September 2005–present.
- Nursing Care in Sickle Cell Disease: Pediatric Perspectives. Presentation. Annual Sickle Cell Disease Association of America Meeting. Baltimore, MD. September 2005.
- Sickle Cell in the Educational Setting: School Nurse Perspective. Boston Public School Nurses. March 2005. www.nepscc.org/primarycare.html.
- Nursing Management of Children and Adolescents with Sickle Cell Disease in the Emergency Department. Children's Hospital Boston Emergency Department Nursing Orientation. 2005 – present.
- Comprehensive Care for Children and Adolescents with Sickle Cell Disease. Presentations at community health centers and pediatric practices in the Boston area. 2005–2006. www.nepscc.org/primarycare.html.
- Newborn Screening for Hemoglobin Traits and Diseases. Presentations at community health centers, hospital-based clinics and pediatric practices in the Boston area. 2005–2006. www.nepscc.org/newbornscreen.html.
- Nursing Grand Rounds. Perspectives in Pediatric Procedural Pain. University of Massachusetts Medical Center. April 2002.
- Pediatric Resident Retreat. Pre-procedural anesthetics for pediatric patients. Workshop. University of Massachusetts Medical Center. January 2003.
- Palliative Care Grand Rounds. Procedural Pain in Pediatrics. Massachusetts General Hospital. January 2003.
- Workshop Assistant. Topical anesthetics for procedural pain in children. American Academy of Pediatrics. October 2001 Annual Meeting.

<u>Publications</u>

- Ryan, CR, Foltz, K. Prescribe-a-Bike Program Improves Public Health Equity and Transportation Access in Boston, Federal Highways Administration Fostering Livable Communities Newsletter, October 2015
- Mull, HJ, Burgess JF, Borzecki AM, Ryan KM, Rosen AK. Comparison of Medical Chart Review Methods: Can an Electronic Abstraction Tool Improve Data Quality? Academy Health Poster. 2011.
- Oyeku SO, Feldman HA, Ryan KM, Muret-Wagstaff S, Neufeld EJ. Primary Care Clinicians' Knowledge and Confidence about Newborn Screening for Sickle Cell Disease: Randomized Assessment of Educational Strategies. Journal of the national Medical Association, Accepted for Publication, 2009.

- Kubicek B, Gerson H. Ryan KM. Preparing for adult health care navigation: A look down the road for young adults with Sickle Cell Disease. Abstract and Poster, December 2008. New England Regional Genetics Group Annual Meeting.
- Sprinz P et al. Adolescents with Sickle Cell Disease: Clinical Data from the New England Pediatric Sickle Cell Consortium.Abstract and poster April 2006. Annual sickle cell meeting National Health, Lung, Blood Institute.
- Nursing Care in Sickle Cell Disease: Pediatric Perspectives. Presentation. Annual Sickle Cell Disease Association of America Meeting. Baltimore, MD. September 2005.
- Oyeku SO, Feldman HA, Ryan KM, Muret-Wagstaff S, Neufeld, EJ. Clinician Knowledge and Confidence about Newborn Screening for Sickle Cell Disease: Randomized Assessment of Educational Strategies. Abstract accepted for National Sickle Cell Disease Program. April 2005.
- Oyeku, SO, Feldman, HA, Ryan, KM, Muret-Wagstaff, S, Neufeld, EJ. Primary Care Provider Knowledge and Confidence about Newborn Screening for Sickle Cell Disease. Abstract accepted for Pediatric Academic Society Meetings May 2004.
- Ryan KM, Oyeku SO, Renfroe J, Heeney M, Neufeld EJ. Newborn Screening to Comprehensive Sickle Cell Care. Sickle Cell Disease Association of America Annual Meeting. Abstract and poster, September 2004.
- Kubicek B, Ryan K, Oyeku S. Retreat programming for adolescents and young adults with sickle cell disease. Abstract and Plenary Presentation. SCDAA September 2004.
- Oyeku SO, Ryan KM, Sprinz P, Space S. Muret-Wagstaff S, Neufeld, EJ. Community Provider Education and Newbo Screening and Sickle Cell Disease. Sickle Cell Disease Association of America Annual Meeting. Abstract and poster, September, 2003.
- Kharasch SJ, Ryan KM, Mehta S, Capozzi M, Zuckerman B. Pharmocologic interventions for selected procedures performed in an emergency department. Pediatric Academic Society. Abstract and Poster Accepted for May 2003.
- Sham JM, Ryan KM. Reducing pediatric pain during ED procedures with a nurse driven protocol: An urban pediatric emergency department's experience. Journal of Emergency Nursing. April 2003.
- Ryan KM, Sham JM. Erase pediatric pain. Nursing Spectrum. December 6(24). 2002.
- Kharasch S, Ryan KM, Tien I, Sham JM, Myers A, Cimo S, Smith L, Zuckerman B. A "PainFree Pediatrics" program: quality improvement evaluation. Pediatric Academic Society. 2002 Platform Presentation.
- Sham JM, Ryan KM. PainFree Pediatrics: Clinical Pearls. Pain Management for Vulnerable Populations. Boston Medical Center Pain Quality Assurance Program. May 2002.
- Lawrence PR, Ryan KM, Harney KM. Sickle cell disease in children: providing comprehensive care for a chronic condition. Advance for Nurse Practitioners 2000. 8(5): 48–55.
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