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Correlates of Awareness and Use of the Hubway Bike Share Program and the Association with Weight Status

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CORRELATES OF AWARENESS AND USE OF THE HUBWAY BIKE SHARE

PROGRAM AND THE ASSOCIATION WITH WEIGHT STATUS

A Thesis Presented

by

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ABSTRACT

CORRELATES OF AWARENESS AND USE OF THE HUBWAY BIKE SHARE PROGRAM AND THE ASSOCIATION WITH WEIGHT STATUS

August 2015

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Objective: The purpose of this study was to examine the correlates of awareness and use of the Hubway bike share program and assess the relationship between use and rates of overweight or obesity. Methods: Two-hundred, fifty-six students, faculty, and staff from the University of Massachusetts Boston (UMB) participated in this cross-sectional study. Participants completed an on-line survey during the fall of 2014 that assessed socio-demographics, behavioral and physical activity characteristics, Hubway awareness, and use of Hubway and personal bikes. Multivariable regression models were conducted to evaluate associations between socio-demographic and behavioral factors, and Hubway awareness, use, and the relationship with weight status. Results: Living in a Hubway community, owning a bicycle, and not exclusively commuting to UMB via car had statistically significant positive associations with awareness of the Hubway program. Two variables, living in a Hubway community and bike ownership, had positive associations with bike share use. Finally, Hubway use was associated with a 60% decreased odds of being overweight or obese (OR= .40; 95% CI= .17, .93). Conclusion: Additional promotional efforts may be necessary to address relatively low rates of awareness and bike share use at UMB. Further studies are needed to identify correlates associated with bike share awareness and use and to determine the potential health benefits to users.

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CHAPTER 1

INTRODUCTION AND SPECIFIC AIMS

Regularly performing physical activity (PA), while limiting sedentary time, can provide significant health benefits to people of all ages and fitness levels. These health benefits can include reduction in the risk of developing cardiovascular disease, type 2 diabetes, hypertension, some forms of cancer, and other chronic conditions (Lee et al. 2012; Wannaamethee & Sharper 2002; United States Department of Health and Human Services (USDHHS) 2008). Although regular PA is a critical component of a healthy lifestyle, a majority of Americans do not meet the national recommendations for weekly PA. Adults are expected to perform at least 150 minutes of moderate or 75 minutes of vigorous PA or a combination of the two each week. National studies using self-report data have shown the adherence to PA recommendations among adults is between 30 and 60% (Carlson, Fulton, Schoenborn, & Fleetwood 2010), whereas national surveillance studies objectively measuring PA with accelerometers has shown this percentage to be less than 5% (Troiano et al. 2008).

Healthy People 2020, which outlines public health goals for the U.S., identifies a number of objectives related to PA (Healthy People 2020). One of these objectives is to increase the proportion of bicycle trips taken by adults, specifically increasing the proportion of trips under five miles. Increasing the amount of short utilitarian bike trips has the potential to contribute to overall PA levels, while also providing health benefits to users. These benefits include higher levels of aerobic fitness and decreased risk for cardiovascular disease and all-cause mortality (deHartog, Boogaard, Nijland, & Hoek 2010; Dill 2009; Gordon-Larsen et al. 2009; Hamer, & Chida 2007; Woodcock, Givoni, & Morgan 2013). In the U.S. taking these utilitarian trips via bicycle has become more accessible and practical as many cities have launched public bike share programs in the past seven years. These programs provide bicycles for rent to annual subscribers or individuals who buy daily passes for a fee. Users pick up a bike at one of many docking stations around a city and then drop off the bike at any other station at the completion of their ride. Studies conducted in Europe have shown that bike share programs can provide significant health benefits to users, while also lowering carbon emissions as more people switch from driving cars to cycling (Rojas-Rueda, de Nazelle, Tainio, & Nieuwenhuijsen 2011). In the United States and Canada, several studies have assessed the correlates of bike share use in North American cities (Fuller 2011 et al.; Fishman, Washington, & Haworth 2013; Pucher, Buehler, & Seinen 2011). These studies have shown that users tend to be younger, well-educated males located near college campuses (Fishman et al. 2013; Pucher et al. 2011). Through these studies on bike sharing some data on user profiles has been obtained, however additional research is needed to understand why certain individuals or groups are more or less likely to use bike share programs.

A relatively new bike share program that has not been well researched is Boston's Hubway bike share system. Launched in 2011, Hubway has provided bicycles to 12,500 annual subscribers and over 88,000 day pass users who together have logged over 2.7 million bicycle trips (Hubway 2015). Currently, Hubway has 140 docking stations and 1,300 bicycles in Boston, Cambridge, Brookline, and Somerville. Two of these stations are located on or near the University of Massachusetts Boston (UMB) campus; one near the UMB Campus Center and the other at the JFK-UMass T station (i.e., public transit station with trains, commuter rail, and buses). However, little is known about use of these two stations by members of the UMB community or the factors that may be associated with awareness and use of the Hubway system in general. Since many college students and young professionals live in Boston, it is important to better understand the correlates of awareness and use on a college campus in the Boston area. In addition, the potential health benefits of Hubway to the UMB community have not been well examined; specifically how Hubway use may contribute to healthier weight status.

Specific Aims

The goal of this study was to determine correlates of awareness and use of Hubway among the UMB community, as well as to evaluate the relationship between use of the program and weight status. To accomplish this, a survey was developed and administered to students, faculty, and staff. The survey assessed socio-demographics and other factors potentially correlated with awareness and utilization of the Hubway system. The two primary aims of the study were the following:

Aim 1: Examine correlates of awareness and use of Hubway among the UMB community.

Aim 2: Determine the relationship between Hubway use and weight status.

In addition, this study included two exploratory aims:

Aim 3: Examine the correlates of helmet use by respondents reporting Hubway or personal bicycle use.

Aim 4: Determine the characteristics and correlates of bicycle accidents among members of UMB community who use Hubway or their own bicycles.

This study was expected to provide evidence on the demographics of Hubway users among UMB students, staff, and faculty. This information could potentially be used by policy makers in public health, urban planning, and transportation to further develop and market Hubway. These results could also be used to identify segments of the university population that are not using Hubway or being reached by promotional efforts. The study was also expected to determine if a significant association exists between use of Hubway and rates of overweight or obesity.

CHAPTER 2

BACKGROUND AND SIGNIFICANCE

Health Benefits of Physical Activity

Engaging in regular physical activity (PA) has been shown to provide significant health benefits to youths and adults (USDHHS 2008). In the United States, recommendations call for adults to engage in 150 minutes of moderate or 75 minutes of vigorous physical activity each week, or an equivalent combination of the two (USDHHS 2008). People who are able to reach these recommendations can decrease their risk of developing obesity, cardiovascular disease, high blood pressure, type 2 diabetes, colon and breast cancers, and other non-communicable health conditions (Wannaamethee et al. 2002; Lee et al. 2012; USDHHS 2008). This reduction in risk is accomplished through a variety of physiological mechanisms such as lowering lipid levels, improved blood pressure control, and the anti-inflammatory effects of physical activity (Hamer, & Chida. 2008; Warburton, Nicol, & Bredin 2006). Other benefits of PA that have been observed include increased mobility, improved cognitive function, and an overall increase in quality of life (Penedo, & Dahn 2005). Although the health benefits of regular PA are well established, a majority of adults in the U.S. are not reaching the national guidelines for PA, placing them at increased risk for a number of serious health problems.

Insufficient levels of PA has contributed to the current obesity epidemic. Currently, more than 1/3 of the U.S. adult population or approximately 78 million people are considered obese and approximately 70% are overweight or obese (CDC 2014; Flegal, Carroll, Kit, & Ogden 2010). In 2008 it was estimated that obesity treatments alone cost 147 billion U.S. dollars (Finkelstein, Trogdon, Cohen, & Dietz 2009). This represents a serious financial burden on obese individuals and the health care system in general. The upward trend in obesity rates is associated with decreased levels of PA (Ladabaum, Mannalithara, Myer, & Singh 2014). Between 1988 and 2010, people reporting no leisure-time physical activity increased from 19% to 52% among women and from 11% to 44% among men (Ladabaum et al. 2014). This trend is particularly troubling, as occupational PA has also been decreasing over the past five decades (Church, Thomas, & Tudor-Locke 2011). Over the last few decades obesity rates have been increasing in the U.S. and there is strong evidence that this trend is linked to increasing levels of insufficient PA in the population.

Prevalence of Physical Activity in U.S.

The percentage of U.S. adults reaching the 150 minutes per week goal for PA has been estimated between 30 and 60% (Carlson et al. 2010). However these estimates are based on self-report methods, which tend to produce results much higher than estimates based on objective assessment methods, such as accelerometry (Luke, Dugas, Durazo-Arvizu, Cao, & Cooper 2011; Tucker, Welk, & Beyler 2011). Studies measuring physical activity through the use of accelerometers place the percentage of adults meeting PA guidelines at less than 10% (Luke et al. 2011; Troiano et al. 2007; Tudor-Locke, Brashear, Johnson 2010; Tucker et al. 2011). These surveillance data demonstrate how widespread the inactivity problem is in the United States.

There are some segments of the population that tend to be more inactive leading to increased risks for disease. Age has been shown to have a strong inverse relationship with activity levels (Carlson et al. 2010). As people age, they tend to become less physically active. Activity levels begin to decrease during adolescence and continue to decrease through old age. Another PA pattern seen in the U.S. is the differences that exists between genders. In general, females tend to display lower rates of physical activity than males (Carlson et al. 2010). Individuals who are more highly educated are also more likely to reach PA recommendations. In general, Caucasians have been found to be more physically active than African-American or Hispanic adults in the U.S. (Carlson et al. 2010). These racial and ethnic differences in PA are consistent with higher rates of obesity, cardiovascular disease, and type 2 diabetes that have been observed in African-American and Hispanic populations (Shay et al. 2013; CDC Fact Sheet 2011).

Health Benefits of Active Commuting

In part due to decreasing levels of PA found in the U.S., active commuting has been promoted as a way to increase adherence to PA recommendations and decrease chronic disease burden. Active commuting, either walking or cycling, is an alternative to traveling via automobile to work, school, or for other utilitarian purposes (e.g., running errands, getting to social events, etc.). Active commuting can also be a part of a multimodal trip where walking and cycling are combined with the use of public transportation. In the U.S., attempts have been made to increase short walking and bicycle trips made for utilitarian purposes. Objectives PA-13 and PA-14 of Healthy People 2020 focus on increasing the proportion of short trips taken by either walking or cycling (Healthy People 2020). These objectives call for increasing the amount of walking trips that are one mile or less and the proportion of cycling trips under five miles for adults. Research has shown rates of active commuting are increasing, however a majority of this growth seems to come from increased walking not cycling (Pucher, Buehler, Maerom, & Bauman 2011). Instead of using an automobile, walking or cycling for these short trips could contribute to weekly PA requirements and thereby provide health benefits to individuals who make the switch to more active forms of commuting.

There have been relatively few studies assessing the extent to which cycling contributes to individuals meeting PA guidelines. One study conducted in Portland, Oregon, found that almost sixty percent of study participants were meeting the 150 minutes per week of moderate PA recommendation just from cycling (Dill 2009). A majority of these rides were for utilitarian purposes, highlighting the possibility that short utilitarian bicycle trips could replace some automobile trips in the U.S. (Dill 2009). Although only one study, these findings demonstrate the possibility of U.S. adults using cycling as a form of active commuting, which is consistent with Healthy People 2020 objectives.

Several studies in Europe have quantified the health benefits of cycling as a form of active commuting (de Hartog et al. 2010; Rojas-Rueda et al. 2011). In the Netherlands it was found that between three to fourteen months of life could be gained on average if individuals shifted their main mode of transportation from cars to bicycles (de Hartog et al. 2010). In that study researchers assessed the risks of urban bike riding (e.g., accidents and injuries) along with the expected health benefits of using cycling as a form of active commuting. It was found that the potential for significant health benefits outweighed the risks associated with bicycling in an urban environment (de Hartog et al. 2010).

The health benefits and contribution of walking or cycling to meeting PA guidelines has been studied more closely than cycling alone, especially in Europe. In France, a study attempted to assess the contribution of active commuting to daily PA (Chaix et al. 2014). On average participants spent almost two hours a day commuting and 31% of energy expended and 33% of all moderate and vigorous PA performed over seven days came from commuting. These results clearly show the potential active commuting has to affect the amount of PA being performed.

People who choose to use some form of active commuting instead of driving an automobile have displayed some positive health outcomes. In two review papers from the United Kingdom (UK) and one cross-sectional study conducted in the U.S., it was found that individuals who actively commute to work via walking or cycling displayed lower triglycerides levels, blood pressure, insulin levels, and an overall reduced rate of obesity and cardiovascular disease (Gordon-Larsen et al. 2009; Hamer et al. 2007; Kelly et al. 2014). Individuals who actively commute to work also displayed higher levels of aerobic fitness (Gordon-Larsen et al. 2009). In an international review paper including twenty-one studies from Europe, Asia, and North America, it was found that people who completed 11.5 MET hours per week of walking or cycling could see a 10% reduction in the risk for all-cause mortality (Kelly et al. 2014). These results are similar to the findings from a 2007 meta-analysis from the UK which concluded that an increase in active commuting was associated with an 11% reduction in the risk of developing cardiovascular disease (Hamer et al. 2007). Of note, this review found a greater reduction in risk for women than men.

In addition to providing health benefits to apparently healthy individuals, some research has shown that individuals with chronic conditions can also obtain positive changes in their health status by increasing the amount they actively commute. A simulation study from the UK generated scenarios with increased active commuting and decreased car use, and determined it was possible to reduce disease burden with the largest estimated health benefits for individuals with ischemic heart disease (Woodcock et al. 2013). Overall, existing evidence on walking or cycling for utilitarian purposes has shown the potential to positively influence health and health-related outcomes like cardiovascular risk.

History of Bike Sharing Internationally and in the U.S.

Although bike sharing is a relatively new phenomena in the U.S., it has been common in Europe for decades. Bike share programs provide bicycles for rent to annual subscribers or individuals who buy daily passes for a fee. Users pick up a bike at one of many docking stations around a city and then drop off the bike at any other station at the completion of their ride. The first bike share program was implemented in Amsterdam in 1965. However problems, such as thefts, occurred early on and the program ended quickly (DeMaio 2009). It was not until 1995 that the first large-scale bike share program was implemented in Copenhagen, Denmark. Programs continued to be implemented in

Europe with varying success over the next ten years. However, according to some reports, it was not until a bike share program was implemented in Lyon, France in 2005 did transportation officials and others see the potential impact of bike sharing programs. After seeing the impact of the Lyon program, a bike share system was launched in Paris in 2007. This program's success in a large city paved the way for the development of programs outside of Europe. In 2008, programs began in Brazil, China, South Korea, and the U.S. (DeMaio 2009). The number of bike share systems globally has increased dramatically from 120 programs in 2009 to about 300 programs in 2013 (Fishman et al. 2013). Currently many of the largest bike share systems in the world are located in China. The programs in Wuhan and Hangzhou, China, have 70,000 and 65,000 bikes, respectively (Fishman et al. 2013). The program in Hangzhou has an estimated 172,000 trips taken every day (Shaheen, Zhang, Martin, & Guzman, 2011).

The first modern bike share program in a major U.S. city was launched in 2008 in Denver, Colorado (though smaller, short-lived programs appeared in the U.S. prior to 2000). Since then approximately 30 new programs have been implemented across the U.S. including in New York City, Boston, San Francisco, Chicago, and many others. Currently the largest bike share system in the U.S. is New York City's Citi Bike.

Physical Activity and Health-Related Benefits of Bike Sharing

In recent years, the implementation of bike share programs in many U.S. cities has made active commuting a more realistic option for some adults (Shaheen, Martin, Cohen, Chan, & Pogodzinsk 2014). Although limited, there is some evidence that increasing bike share usage as a form of transportation can lead to health benefits (Rojas-

Rueda et al. 2011; Stewart, Johnson, & Smith 2011; Shaheen et al. 2014). In a survey conducted with bike share users in Washington DC, about a third of respondents reported lower levels of stress and that they had lost weight since beginning to use the program (Shaheen et al. 2014). A study in Barcelona, Spain, estimated that with an increase in bike share use, about 12 deaths a year could be avoided from the increase in PA alone, while also providing population wide benefits by reducing carbon dioxide emissions due to decreased car usage. (Rojas-Rueda et al 2011). Similarly, researchers have also estimated that the Montreal BIXI bike share program decreased greenhouse gases by 3 million pounds in one year from people using their program instead of driving (DeMaio 2009). It was also reported that the bike share program in Lyon, France helped to reduce carbon dioxide pollution by approximately 18 million pounds between 2005 and 2009 (DeMaio 2009).

Bike share programs may also be able to provide health benefits to individuals at-risk of chronic disease. In Minnesota, the local bike share program attempted to increase the amount of cycling trips taken in a low-income community. Results showed that bike share users from low-income neighborhoods were taking trips on average for 22 minutes, providing more than two-thirds of their daily recommended PA (Stewart, Johnson, & Smith 2013). These results demonstrate that bike share programs could be an effective way to increase daily PA among healthy users and people in vulnerable populations.

Correlates of Bike Share Use

Recently, researchers have examined socio-demographic and environmental characteristics of bike share users in North America (Fishman et al. 2013; Fuller et al.

2011; Shaheen 2012). This information is needed to determine who is using these programs, but also to determine who is not using these programs so that promotional efforts can be made to increase use in these populations. The most common reason for using bike share programs in Montreal and Washington DC was to travel to and from work or school (Fishman et al. 2013; Fuller et al. 2011; Shaheen 2012). Studying one of the most popular programs in North America, the BIXI bike share program in Montreal, Canada, it was observed that its users tended to be younger (18-24 years old), college educated, living within 250 meters of a docking station, and used cycling as their primary form of transportation to work (Fuller et al. 2011). Similarly, a study of bike share users in Washington DC determined that users tended to be young white males, with higher employment rates and education levels (Fishman et al. 2013). In that study it was also found that a majority of individuals used bike share to get from one public transit station to another. Although limited research has been conducted focusing on the use of bike share in conjunction with other modes of transport, these findings begin to provide evidence into why bike share users choose to use the programs.

Two studies of Montreal's BIXI bike share program have shown that one of the most consistent environmental correlates of bike share use is living within close proximity of a docking station (Bachand-Marleau, Lee, & El-Geneidy 2012; Fuller et al. 2011). One hypothesis of this research was that living within close proximity of a docking station increases the number of exposures to the program, and therefore may influence the likelihood of using the program.

Although bike share programs continue to expand, there is some evidence that only certain segments of the population are using them. As mentioned previously, users tend to be young, white males with higher socio-economic levels (Fuller et al. 2011; Fishman et al. 2013). In fact, almost all growth in cycling in general in North America has come from men aged 25-64 (Pucher et al. 2011). As this group generally tends to be more physically active than other segments of the adult population, additional efforts may need to be made to increase bike share usage among older, less active and at-risk populations.

Bicycle Helmet Use

Wearing a bicycle helmet is an effective way to prevent head injuries sustained during cycling accidents. However relatively few studies have compared the rates of helmet use on personal bikes and while using bike share. One study from Washington, DC may show that bike share users are less likely to wear helmets than private bike riders (Kraemer, Roffenbender, & Anderko 2012). Over 70% of private bike riders in Washington, DC who commute to work, reported wearing helmets when they ride. This was significantly different than the 33% of bike share users who reported helmet use (Kraemer et al. 2012). It has also been seen that age has a positive association with helmet use (Ross, Ross, Raham, & Cataldo 2010; Ritter, & Vance 2011). In a population of undergraduate college students, only 12% of students reported wearing helmets while cycling (Ross et al. 2010). Although there is some evidence that younger individuals and bike share users, wear bicycle helmets less frequently than older private bike riders, more research is needed to determine if this pattern is generalizable to the population as a whole.

Bicycle Accidents and Injuries in the U.S.

Bicycle safety is a serious concern for many potential riders and may affect their decision to use bike share programs. Unfortunately bike accidents that result in injuries occur fairly frequently. In the U.S., over 60,000 people are estimated to be treated annually at emergency departments for non-fatal cyclist injuries involving a motor vehicle (Haileyesus, Annest, & Dellinger 2007). The number of bicycle accidents is most likely higher, as many accidents do not require medical attention. This underreporting is apparent in a study looking at bike messengers in Boston, MA (Dennerlein & Meeker 2002). Seventy percent of messengers sustained at least one injury that forced them to miss days of work. Bone fractures, dislocations, sprains, and strains were the most common injuries sustained in these accidents (Dennerlein et al 2002).

Another related issue that researchers continue to explore is perceived bicycle safety. Anxiety surrounding riding a bicycle through busy city streets is often viewed as a potential barrier to bike share usage (Fishman et al. 2012a). If active commuting, and specifically bike share use is to become more prevalent in the United States, the issues surrounding perceived safety and bicycle accidents must be addressed.

Efforts have been made to determine whether the increase in bike share programs is leading to an increase in bicycle accidents. At least one study has shown that bike share users are at no more risk of bicycle accidents than private bike riders (Fuller et al. 2013). Two studies in Europe assessed the positive health benefits of cycling compared to the potential risk of cycling accidents (de Hartog et al. 2010; Rojas-Rueda et al. 2011). Researchers estimated that increasing the amount of users of the Bicing bike share program in Barcelona, Spain would lead to a slight increase in the amount of bicycle-related deaths each year. However, when compared to the health benefits gained from using the program, the ratio of positive benefits to negative effects was found to be 77:1 (Rojas-Rueda et al. 2011). A study from the Netherlands found the benefits of cycling were about nine times greater than the risks (deHartog et al. 2010). As bike usage and bike share membership continues to grow in North America, it will become important to improve the built environment for riding. Improving a city's riding infrastructure, should be the focus of public health policy makers to ensure rider safety and alleviate any anxieties surrounding riding on crowded city streets (Hoffman. Lambert, Peck, & Mayberry 2010).

Conclusion

In the U.S., adherence to PA recommendations is low. Insufficient levels of physical activity increases the risk for many serious chronic health conditions and diseases including cardiovascular disease and type 2 diabetes. One way to potentially increase population-levels of PA is through the promotion of active commuting. Walking or cycling instead of taking an automobile for short utilitarian trips has been found to be an effective way to increase PA and improve health. Active commuting by bicycle has become more accessible since the implementation of bike share programs across the U.S. Although research is limited, these programs have the potential to contribute significantly to daily PA and provide significant health benefits to their users. Therefore it is important that future research focus on bike share's contribution to health-related outcomes, as well as the correlates associated with program use and awareness.

CHAPTER 3

METHODS

The purpose of this study was to assess demographic and behavioral correlates of awareness and use of the Hubway bike share program among faculty, staff, and students at UMB and the association between bike share use and being either overweight or obese. Participants were asked to complete a brief on-line survey about their usual PA and commuting patterns, knowledge and utilization of the Hubway bike share program, and factors that influence their use of the system. This study also assessed bicycle safety issues among the UMB community; specifically, frequency of bicycle accidents and rates of helmet use. Potential correlates of helmet usage and bicycle accidents were also examined in exploratory analyses. A convenience sample of participants was recruited from among students, faculty, and staff at UMB.

Study Design

This study used a cross-sectional design in which the participants were asked to complete the survey one time. The survey was conducted on-line using SNAP survey software (Snap Surveys, 210 Commerce Way, Suite 200, Portsmouth, NH 03801, USA). The survey was implemented in late October 2014 and continued through the end of

December 2014. Multiple methods of recruitment was used to reach as many potential participants as possible. Both electronic (e-mail) and face-to-face recruitment were utilized.

Hubway Bike Share Program

The Hubway bike share program was launched in 2011 in Boston, MA. It is overseen by Boston Bikes, an organization within the mayor's office. Currently, Hubway has approximately 1,300 bikes at 140 docking stations in the Greater Boston area. Hubway currently operates in the communities of Boston, Cambridge, Brookline, and Somerville. Two stations are located on or near the UMB campus. During the fall of 2014 one station was located in front of the UMB Campus Center, while the other was located at the JFK/UMass T-station. As of August 2014, Hubway riders were averaging over 43,000 trips per week and 175,000 trips per month. Since its launch, Hubway users have logged over 2.7 million trips. Hubway currently has over 12,500 annual members and sells over 88,000 day passes a year.

Characteristics of Students, Faculty and Staff at UMB

The student population of UMB provides a unique opportunity to study a diverse group of people from various cultures and socio-economic backgrounds. At UMB there are over 16,000 students; 76% are undergraduates. Fifty-nine percent of students are female and 41% are male. The student body is made up of 56% Caucasians and 44% from minority groups; 16% African-American, 12% Asian, 12% Hispanic, and 4% other.

There are over 1,100 faculty (602 full-time and 571 part-time) at UMB. The faculty is 53% female and 47% male. The racial/ethnic composition of UMB faculty is

67% Caucasian and 33% from minority groups, 7.5% Asian, 4% African-American, 3% Hispanic.

The staff of UMB were also recruited to participate in the study. There are over 1,600 staff members (1,191 full-time (73%) and 431 part-time). The staff is categorized as, professional staff (55%), classified staff (40%), and executive/administrative (5%). Sixty percent of the staff are female and 40% are male. Sixty percent of the UMB staff is Caucasian, 12% African-American, 8% Asian, and 6% Hispanic. (UMB Office of Institutional Research 2013)

Participants and Recruitment

The target population for this study were students, faculty, and staff at UMB. The requirements for participation were: 1) having a valid UMB email address, 2) can read and comprehend English, 3) willing and able to give informed consent. There were no restrictions based on age, gender, race/ethnicity, or current physical activity levels. Prior knowledge or use of Hubway were also not required for participation.

In order to obtain a large number of participants, several different recruiting methods were utilized. The first method used was mass e-mail. An e-mail was sent to all UMB faculty (n~1000) that briefly described the study and provided a link to the on-line survey. A week after the initial email was sent, a follow-up email was distributed in an attempt to increase the response rate.

Emails were also sent to all undergraduate and graduate students in the College of Nursing and Health Science (n~1147). Two emails were sent a week apart to maximize response rates. This email also briefly described the study and provided a link to the on-line survey.

In an attempt to increase the amount of participants, a second method of recruiting was used. A table was set up in a highly trafficked area of the UMB Campus Center, where students, faculty, and staff were recruited as they walked by. Laptops were provided so that participants could take the survey immediately. They were also given the option of providing an email address and having the survey link emailed directly to them. This form of recruiting was done to reach members of the UMB community that were not contacted through email.

To incentivize participation, individuals who completed the survey were able to enter their name into a random drawing for a $25 gift certificate. A total of ten gift certificates were available in the drawing, totaling $250.

Bike Share Survey

The survey was created using the SNAP Survey Software. This software allowed for surveys to be created and then accessed on-line by study participants. The survey was created from prior physical activity and bike share studies as well as unique questions assessing factors surrounding Hubway and UMB (Boston Bike Survey, 2013; Bike and Pedestrian Crash Survey: Nashville Metropolitan Planning Organization, November 2009, Milton, Bull, & Bauman 2010). The survey consisted of 44 questions covering six main areas: 1) socio-demographics, 2) routine physical activity and commuting pattern, 3) awareness and use of Hubway, 4) potential facilitators or barriers to bike share use, 5) helmet use, and 6) bicycle accidents.

Socio-demographic items included age, gender, race, ethnicity, education level, home zip code, and employment status. The routine PA and commuting pattern section assessed participants' current level of PA and how they commute to and from the UMB campus. The utilization of Hubway was determined by asking the participant about their use of the program ever, use in the past year, and use in the past month. This included trips taken around UMB, but also throughout the greater Boston area. Survey questions also assessed awareness and general knowledge about bike share programs, including the location of Hubway stations. Facilitators and barriers items were used to identify the reasons people use or avoid bike share programs. These included safety concerns, convenience, health reasons, cost, etc. Helmet usage was assessed for both bike share riders and those who use their own private bicycle. In addition, survey items assessed the amount of cycling accidents, cause(s) of the accident (e.g., collision with a motor vehicle, pedestrian, other cyclist), severity and type of injuries.

Upon completion of the survey, participants were asked to provide contact information if they wanted to be entered into a drawing for a gift card. Participants were also asked if they would be willing to participate in future bike share research and if so, provide contact information including their name and email address at the end of the survey.

Dependent Variables

For primary Aims 1 and 2, three dependent variables were examined: awareness of Hubway, including stations by UMB; use of Hubway, and weight status. Hubway awareness was classified as a dichotomous (yes/no) outcome. The awareness dependent variable was defined as the respondent reporting being aware of Hubway and also knowing the location of the two docking stations near the UMB campus. Exploratory analysis was also done to determine general awareness of Hubway as well as the term bike share. Both general Hubway and bike share awareness outcomes were also considered dichotomous (yes/no) variables.

Hubway use was assessed by determining the participants that had ever used Hubway in the past. The use of Hubway was considered a dichotomous (yes/no) outcome.

For Aim 2, weight status was determined by using participants BMI values. Participants provided their height and weight, which was used to determine their BMI (kg/m^2). Individuals with a BMI $\geq$ 25.0 were classified as overweight/obese, and participants with BMI $<$ 25.0 were classified as normal/underweight group. Weight status was a dichotomous outcome: overweight/obese versus normal/underweight.

For exploratory Aim 3, the dependent variable was helmet use. The participants were asked how often they used a helmet when using Hubway or personal bikes. Frequency of helmet use was assessed via a five point Likert scale: always, often, sometimes, rarely, and never. A dichotomous variable (yes/no) was created for helmet use. Those who reported always or often wearing helmets were considered helmet users, while those who report wearing helmets sometimes, rarely, or never were considered non-helmet users. This was used to determine the correlates associated with helmet use among the UMB community. Helmet use was also evaluated for any differences between Hubway and private bike users.

For exploratory Aim 4, the dependent variables was the amount of cycling accidents. Only accidents occurring in the last two years were included when determining the prevalence of bicycle accidents among the UMB community. A dichotomous outcome variable was created for bicycle accidents (at least one accident/no accident).

Independent Variables

For Aim 1, which focused on awareness and use of Hubway, a number of demographic and behavioral factors were examined as independent variables. Age, gender, race, Hispanic/Latino descent, and status at UMB were evaluated as potential correlates of awareness and use. Race was considered a dichotomous variable comparing white participants with those from all other racial groups. Status at UMB was also a dichotomous outcome with students being compared to both faculty and staff.

Typical commute pattern was also considered an independent variable. Those reporting exclusively driving to UMB were compared to those who incorporated any other mode of commute. This could have included public transportation, walking, or cycling or a multi-modal commute utilizing multiple methods. Participants provided a home zip code and if that corresponded to a zip code for Boston, Brookline, Cambridge, or Somerville (all communities where Hubway stations are located), then the person was classified as living in a Hubway community (yes/no). Owning a personal bicycle was assessed, as well as the amount of trips taken in the past year. Owning a personal bicycle was also considered a dichotomous (yes/no) outcome variable. Participants were also asked how many days per week they perform at least 30 minutes of moderate intensity PA. PA days per week will be included in the analysis as a continuous variable.

Statistical Analysis

All statistical analyses were conducted using SAS software (Version 9.4. Copyright © 2015 SAS Institute Inc.). Univariate statistics (means, frequencies, etc.) were used to summarize all study variables. Differences in means and frequencies by gender, age, race, ethnicity, and status at UMB (student, faculty or staff) were assessed using t tests and chi square tests. The a priori level was set at $p < 0.05$. Multiple logistic regression was used to examine factors associated with awareness and use of Hubway (Aim 1), assess the relationship between Hubway use and weight status (Aim 2), and examine the correlates of helmet use (Aim 3) and bicycle accidents (Aim 4).

A hierarchal modeling approach was used to evaluate all study aims. Regression modelling was done in three steps: 1) age-adjusted, 2) socio-demographic model, 3) socio-demographic + behavioral variables model.

Aim 1: Examine correlates of awareness and use of Hubway among the UMB community. Multiple logistic regression was used to determine factors associated with both awareness and use of Hubway. The independent variables of age, gender, race, ethnicity, PA level, typical commute pattern, and place of residence were evaluated as potential correlates.

Aim 2: Determine the relationship between Hubway use and weight status. Multiple logistic regression was used to determine if past Hubway use was associated with overweight/ obesity. The independent variables of age, gender, race, ethnicity, PA level, typical commute pattern, and place of residence were evaluated as potential correlates.

Aim 3: Examine the correlates of helmet usage by respondents reporting use of Hubway or use of personal bicycles. Helmet use was scored on a five point Likert scale: always, often, sometimes, rarely, and never. To determine whether there is a difference in associations for individuals who only use Hubway and those who also use personal bicycles, we will classify cyclists as "Hubway only" or "personal bike only."

Aim 4: Determine the correlates of bicycle accidents in the last two years for members of the UMB community. The presence of accidents was considered a categorical variable (at least one accident/no accidents). Multiple logistic regression was used to identify statistically significant correlates of bicycle accidents.

Potential Problems and Alternative Strategies

There were two main challenges to conducting this study: 1) recruitment, and 2) obtaining a sufficient sample of respondents who had used Hubway. In terms of recruitment, we experienced challenges including being unable to email the entire student population and a low survey response rate from faculty. Due to recruitment challenges, it was decided to recruit a convenience sample of the UMB community using two different methods. Both electronic (i.e., email requests) and face to face recruitment were used. Two emails were sent to faculty and two emails were sent to students in the College of Nursing and Health Sciences to maximize the response rate. All recruiting efforts were done in an attempt to get enough completed surveys to produce significant findings.

CHAPTER 4

MANUSCRIPT:

CORRELATES OF AWARENESS AND USE OF THE HUBWAY BIKE SHARE PROGRAM AND THE ASSOCIATION WITH WEIGHT STATUS

Objective: The purpose of this study was to examine the correlates of awareness and use of the Hubway bike share program and assess the relationship between use and weight status. **Methods:** Two-hundred, fifty-six students, faculty, and staff from the University of Massachusetts Boston (UMB) participated in this cross-sectional study. Participants completed an on-line survey during the fall of 2014 that assessed socio-demographics, behavioral and physical activity characteristics, Hubway awareness, and use of Hubway and personal bikes. Multivariable logistic regression models were conducted to evaluate associations between socio-demographic and behavioral factors and Hubway awareness and use; and between Hubway use and overweight/obesity. **Results:** Living in a Hubway community, owning a personal bicycle, and not exclusively commuting to UMB via car had statistically significant positive associations with awareness of the Hubway program. Living in a Hubway community and bike ownership, had positive associations with use.

Finally, Hubway use was associated with 60% decreased odds of being overweight or obese (OR= .40; 95% CI= .17, .93). **Conclusion:** Additional promotional efforts may be necessary to address low rates of awareness and use of bike share at UMB. Prospective studies are needed to identify factors that predict bike share awareness and use in urban areas and to determine the direction of relationship between bike share use and weight status.

Introduction

Historically, the focus within physical activity (PA) promotion has been on leisure time activity. Despite the importance of physical activity for the prevention and control of obesity and other chronic diseases and conditions, less than 5% of the U.S. adolescents and adults are sufficiently active according to accelerometer-based assessments.[3,4] Therefore current national public health objectives, such as those contained within Healthy People 2020, also emphasize PA performed to get to and from destinations; in other words, active transportation.[5]

One form of active transportation, utilitarian cycling, has the potential to increase the adherence rates to national PA recommendations. A study in Portland, OR, found that almost 60% of commuter cyclists were meeting weekly recommendations for moderate-intensity PA just through utilitarian cycling.[11]

A number of studies have provided a strong health-related rationale for focusing on active commuting and specifically transportation-related cycling.[6-9] One study evaluating rates of active commuting internationally found that countries with the lowest rates of active commuting generally displayed the highest rates of obesity.[9] Of the 17 countries included in this study, the U.S. had the lowest levels of active commuting and the highest rates of obesity. Other studies have shown that walking or cycling to work is associated with lower triglycerides levels, blood pressure, insulin levels, reduced rates of obesity and cardiovascular disease, and higher levels of aerobic fitness.[6-8] It has also been estimated that regular walking or cycling to work is associated with about a 10% reduction in risk for cardiovascular disease and all-cause mortality.[7,8] Studies specifically focusing on commuter cycling have also reported health benefits. A systematic review from the Netherlands estimated that individuals switching from driving to commuter cycling could see between 3 and 14 months of life gained, when evaluating the potential health benefits of PA compared to the risks of cycling in an urban environment.[10] Despite evidence for the health benefits of utilitarian forms of cycling, few studies have specifically focused on the potential health benefits of bike share programs.

One approach for increasing rates of commuter cycling is through the development and promotion of bike share programs. Public bike share programs provide bicycles to rent for a small fee, which can then be picked up and then returned to any docking station in the bike share system. Bike share programs have been operating in Europe for decades, however the first modern bike share program in the U.S. only opened in 2008 in Denver, CO.[12] Since then approximately thirty other programs have been launched across the U.S. Although the number of programs in the U.S. has increased rapidly, few studies have examined the factors associated with either awareness or use of bike share programs or the association between bike share use and health outcomes like weight status.

A current gap in the evidence base on bike share programs pertains to the correlates of awareness and use of programs. This information is critical for designing effective interventions and public health policy aimed at promoting bike share use. Studies have shown that bike share users tend to be younger (18-24 years old), white, and have higher education levels and employment rates.[16,17] Research has also shown the most common reason for using bike share programs was getting to and from work or school, with a majority of trips being part of a multi-modal commute including some form of public transportation.[16-19] One established environmental correlate of bike share use is proximity to a docking station.[17,20] Research on the BIXI bike share program in Montreal, Canada showed that living within 250 meters of a station significantly increased the likelihood of using the program.[17]

There is currently limited research suggesting that bike share programs could contribute to overall PA levels and may be related to positive health benefits. Researchers in Minneapolis, MN found that bike share users in low-income communities took an average trip duration of 22 minutes, or approximately two-thirds of their recommended daily PA.[13] A study from Barcelona, Spain, estimated that with an increase in bike share usage, about twelve deaths a year could be avoided from increasing PA alone, while also lowering carbon dioxide emissions in the city from decreased car usage.[14] In another study, bike share users in Washington, DC reported losing weight and lowering their levels of stress after using the program.[15]

Given the limited evidence on awareness, use, and potential health benefits of bike share programs, this cross sectional study was designed to focus on Hubway, a bike share program in the Boston area that was launched in 2011. Hubway has shown steady growth in utilization with over 2.7 million trips recorded by spring 2015. Despite this growth, little is known about the correlates of both awareness and use of Hubway or the potential benefits in terms of users' weight status. Therefore, the aims of this study were: 1) to examine the correlates of awareness and use of Hubway by students, faculty, and staff at the University of Massachusetts Boston (UMB); and 2) to examine associations between Hubway use and being overweight or obese.

Methods

Study Design

A cross-sectional survey was conducted to assess awareness and utilization of the Hubway bike share program by students, faculty and staff at UMB during the fall of 2014. The focus on UMB provided an opportunity to study a diverse urban campus with close access to two Hubway docking stations. One station is located at the JFK/UMASS public transportation station approximately one mile from campus, which is used by anyone commuting to UMB via public transportation. At the time of the survey, a second Hubway station was located across the street from the UMB Campus Center.

Participants and Recruitment

The target population for this study consisted of students, faculty, and staff at UMB. Inclusion criteria were: 1) holds a valid UMB email address, 2) can read and comprehend English, 3) willing and able to give informed consent. There were no restrictions based on age, gender, race/ethnicity, current PA levels, or prior knowledge or use of Hubway. Two primary methods of recruitment were utilized: 1) multiple e-mail contacts; and 2) face-to-face contact in the UMB Campus Center. Two emails (initial and follow-up) were sent to all UMB faculty (n~ 1000) and both undergraduate and graduate students in the College of Nursing and Health Sciences (n~1147) requesting their participation in the study. The email included a brief description of the study and a link to the online survey. A follow-up email was sent about one week after the initial email to increase the response rate.

Face-to-face recruitment was conducted for two full days during the fall semester. A table was set up in the UMB Campus Center with two laptop computers and a sign advertising the study. The table was managed by two of the co-authors. Students, faculty, and staff who passed by were asked if they would like to participate in a brief on-line survey. Interested individuals who met inclusion criteria were given the option to take the survey immediately or provide their email address and be sent the link to the online survey. Recruitment began in October 2014 and continued until the survey was closed in December 2014.

When participants clicked on the link to the survey, they were first brought to an informed consent page. Their continued participation after reading this page indicated their consent. To incentivize participation, individuals who completed the survey were able to enter a drawing for a $25 gift card. All study procedures, instruments, and materials were approved by the UMB Institutional Review Board.

At the end of the data collection phase, there were 301 partial and completed surveys submitted online. After checking for data completeness, 45 partially completed surveys were excluded from the analysis. The final analytic sample consisted of 256 individuals.

Survey Instrument

The on-line survey was created using the SNAP Survey Software (Snap Surveys, 210 Commerce Way, Suite 200, Portsmouth, NH 03801, USA). The survey consisted of 44 questions that assessed: 1) socio-demographics, 2) awareness and utilization of Hubway, 3) routine PA and commuting pattern, 4) facilitators and barriers to bike share use, 5) bicycle helmet use, and 6) bicycle accidents. New survey items were developed, as well as adapted from previous physical activity and bike share surveys.

Dependent Variables

Awareness and utilization of Hubway were considered binary outcome variables (yes/no). Awareness was defined as having answered "yes" to knowing about Hubway, and correctly reporting the locations of the two Hubway docking stations around UMB. Use was defined as having ever used Hubway in the past (yes/no). Separate items assessed use of Hubway anytime in the past, in the past year, and in the past month.

Respondents provided their height and weight, which was converted to body mass index (BMI) values (kg/m^2). A binary outcome was created, combining overweight and obese individuals into one group (BMI $\geq$ 25.0), while a BMI $<$ 25.0 was classified as underweight/normal weight.

Independent Variables

Socio-demographic and behavioral variables were examined as potential correlates of Hubway awareness and use. Socio-demographic variables included age, gender, race, Hispanic/Latino ethnicity, location of their home, and status at UMB (i.e. student, faculty, and staff). Respondents were asked to provide their home zip code in order to determine whether they lived in the Hubway communities of Boston, Cambridge, Somerville, and Brookline.

Behavioral variables included the mode of commuting to UMB, frequency of PA per week, and whether or not the respondent owned a bicycle. Individuals who exclusively drove a vehicle to campus were compared to those who used other forms of commuting including public transportation, walking, and cycling. To assess PA levels, participants were asked how many days per week they performed at least thirty minutes of moderate or vigorous PA (0-7 days). Respondents who reported that they owned a personal bike were asked how many times they had used their bike in the past year.

Statistical Analysis

All statistical analysis was done using SAS software (Version 9.4. Copyright © 2015 SAS Institute). Univariate statistics (means, frequencies, etc.) were used to summarize all study variables. Multiple logistic regression was used to assess associations between socio-demographics and behavioral factors and both awareness and use of Hubway. Multiple logistic regression was also used to determine the association between use of Hubway and overweight/obesity. Three regression models were run for each outcome: 1) age-adjusted, 2) socio-demographics, 3) socio-demographics and behavioral variables.

Results

Socio-Demographic Characteristics of Survey Respondents

Demographic characteristics for the overall sample (N=256) and stratified by UMB status are reported in Table 4.1. The average age of participants was 32.4 years old, with students making up 72% (n=185) of the overall sample. Females accounted for a majority of participants compared to males (69% versus 31%). A majority of respondents were white (62.1%). Other racial groups included African-American or black (13.3%), Asian (10.6%), and other (14.1%). These results are consistent with the student population of UMB, where a majority of individuals are white (56%) and female (59%). Also, approximately 8% of respondents were Hispanic/Latino, and about 39% of participants lived in a community where Hubway operates.

Commuting and Physical Activity Characteristics of Survey Respondents

The most common mode of commuting to and from UMB was driving, with almost 60% of respondents reporting at least some driving as part of their typical commute. Public transportation (48.8%) was the second most common mode of travel. Less than 30% of respondents reported incorporating walking or cycling into their commute to UMB.

On average, both students and faculty/staff were physically active about three days per week. Almost 26% of participants were overweight and 16.4% were obese. Overall, the average BMI was 25.4, which was also similar between students and faculty/staff. Approximately 52% of respondents reported owning a personal bicycle. In the past year, these respondents took an average of 55.5 trips on their bikes.

Table 4.1: Socio-demographic, commuting, and behavioral characteristics of survey respondents at the University of Massachusetts Boston

	Overall N=256	**Students n= 185**	**Faculty/staff n= 71**
Gender % (n)			
Male	30.9 (79)	25.4 (47)	45.1 (32)
Female	69.1 (177)	74.6 (138)	54.9 (39)
Age in years (SD)	32.4 (13.8)	26.4 (8.3)	48.0 (13.0)
Race % (n)			
White	62.1 (159)	54.1 (100)	83.1 (59)
African American	13.3 (34)	17.3 (32)	2.8 (2)
Asian	10.6 (27)	11.4 (21)	8.5 (6)
Other	14.1 (36)	17.3 (32)	5.6 (4)
Hispanic % (n)	8.2 (21)	10.3(19)	2.8 (2)
Living in Hubway area % (n)	39.1(100)	37.8 (70)	42.3(30)
Mode of Commuting to UMB			
% (n)	59.8 (153)	63.2 (117)	50.7(36)
Drive	48.8 (125)	43.2 (80)	63.4 (45)
Public Transport	22.3 (57)	24.3 (45)	16.9 (12)
Walk	7.4 (19)	2.2 (4)	21.1(15)
Cycle			
BMI (SD)[a]	25.4 (5.3)	25.3 (5.6)	25.7 (4.6)
Weight Status[b] % (n)			
Underweight/healthy	57.4 (147)	57.8 (107)	56.3 (40)
Overweight/obese	42.6 (109)	42.2 (78)	43.7 (31)
PA days/week (SD)	3.2 (2.1)	3.1 (2.1)	3.4 (1.8)
Owns private bike % (n)	52.0 (133)	44.3 (82)	71.8 (51)
Aware of Hubway and station locations % (n)			
Yes	33.6 (86)	27.0 (50)	50.7 (36)
No	66.4 (170)	73.0 (135)	49.3 (35)
Ever used Hubway[c] % (n)			
Yes	12.9 (33)	10.8 (20)	18.3 (13)
No	87.1 (223)	89.2 (165)	81.7 (58)

[a] BMI- in kg/m2

[b] Weight status: Used BMI values to classify weight status. BMI ≥ 25.0 considered to be overweight or obese. BMI < 25.0 considered underweight/normal weight

[c] Reported use of Hubway anytime in the past

Facilitators and Barriers to Hubway Use

Participants reporting any Hubway use were asked why they use the program. The three most common reasons were for recreation/leisure (60.6%), running errands

(33.3%), and getting to work (27.2%). Individuals who had never used the program were asked why they do not use Hubway, and the most common responses were fear (40.5%), lack of interest (33.1%), station availability (32.4%), cost (25.7%), and uses own bike (24.3%).

Correlates of Hubway Awareness

Correlates of Hubway awareness are shown in Table 4.2. In age-adjusted analyses, living in a Hubway community, being UMB faculty or staff, not exclusively commuting via car, and owning a personal bicycle all showed positive, statistically significant associations with awareness of Hubway. In a multivariable model including all demographic and behavioral variables, three of these four variables remained statistically significant: living in an area with Hubway stations, not exclusively commuting via car, and owing a bike.

Individuals living in one of the communities where Hubway operates were 2.01 times more likely to display awareness of Hubway than those living in other communities (OR= 2.01, 95% CI = 1.10, 3.67). Mode of commuting to and from campus had the strongest association with awareness of Hubway. Respondents who used public transportation, walked, or cycled as part of their commute to UMB were 3.2 times more likely to be aware of Hubway than those who reported only driving to campus (OR= 3.2, 95% CI= 1.6, 6.2). Another correlate positively associated with awareness was owning a personal bicycle. Bike owners were 2.27 times as likely to be aware of Hubway, compared to those who did not own a bike (OR= 2.27, 95% CI= 1.27, 4.45).

Table 4.2: Demographic and behavioral correlates of Hubway awareness (n=256)

	Age-adjusted			**Demographic model**			**Demographic and behavioral model**		
	OR	95% CI		OR	95% CI		OR	95% CI	
Age				1.00	.97	1.03	1.00	.98	1.04
Gender									
Female	1.00			1.00			1.00		
Male	.85	.47	1.51	.79	.42	1.46	.67	.35	1.29
Race									
White	1.00			1.00			1.00		
Minority	.73	.41	1.29	.81	.44	1.48	.81	.43	1.55
Hispanic									
No	1.00			1.00			1.00		
Yes	1.75	.70	4.38	2.03	.79	5.24	2.27	.84	6.10
UMB status									
Student	1.00			1.00			1.00		
Faculty/staff	**3.54**	**1.55**	**8.06**	**3.16**	**1.34**	**7.45**	2.19	.89	5.35
Living in Hubway area									
No	1.00			1.00			1.00		
Yes	**2.46**	**1.43**	**4.23**	**2.27**	**1.30**	**3.96**	**2.01**	**1.10**	**3.67**
Commuting Type									
Drives only	1.00						1.00		
Other modes	**3.51**	**1.94**	**6.36**				**3.19**	**1.63**	**6.22**
Frequency of PA/week	1.05	.92	1.19				.94	.81	1.09
Owns personal bike									
No	1.00						1.00		
Yes	**1.93**	**1.11**	**3.33**				**2.27**	**1.27**	**4.45**

Correlates of Hubway Use

The results of the regression analysis for Hubway use is shown in Table 4.3. In age-adjusted and multivariable models, living in a Hubway community and owning a bike had statistically significant positive associations with use of Hubway. The strongest relationship was found for personal bike owners, who were 3.09 times more likely to have used Hubway in the past than non-bike owners (OR= 3.09, 95% CI= 1.27, 7.52). . Participants living in a Hubway community were 2.34 times more likely to have used the program, compared to those living outside these areas (OR=2.34, 95% CI = 1.04, 5.27).

Association between Bike Share Use and Overweight/Obesity

As shown in Table 4.4, Hubway use had a statistically significant inverse association with the likelihood of being overweight/obese, after controlling for socio-demographic variables. Survey respondents who reported any past Hubway use had a 60% lower likelihood of being overweight/obese when compared to non-Hubway users (OR= .40; 95% CI= .17, .93). There was no association between personal bike ownership and being overweight/obese (OR = .98, 95% CI= .57, 1.69; data not shown).

Table 4.3: Demographic and behavioral correlates of Hubway use (n=256)

	Age adjusted			**Demographic model**			**Demographic and behavioral model**		
	OR	95% CI		OR	95% CI		OR	95% CI	
Age				1.00	.97	1.04	1.00	.96	1.04
Gender									
Female	1.00			1.00			1.00		
Male	.89	.39	2.01	.87	.38	2.00	.78	.33	1.87
Race									
White	1.00			1.00			1.00		
Minority	.87	.39	1.93	.94	.41	2.15	1.17	.48	2.83
Hispanic									
No	1.00			1.00			1.00		
Yes	1.24	.34	4.54	1.34	.36	5.00	1.29	.33	4.96
UMB status									
Student	1.00			1.00			1.00		
Faculty/staff	1.98	.67	5.85	1.71	.56	5.21	1.46	.47	4.61
Living in Hubway area									
No	1.00			1.00			1.00		
Yes	**2.16**	**1.03**	**4.56**	2.05	.96	4.35	**2.34**	**1.04**	**5.27**
Commuting Type									
Drives only	1.00						1.00		
Other modes	1.36	.63	2.91				1.04	.44	2.47
Frequency of PA/week	1.07	.89	1.20				1.00	.82	1.22
Owns personal bike									
No	1.00						1.00		
Yes	**2.69**	**1.18**	**6.18**				**3.09**	**1.27**	**7.52**

Discussion

This study of students, faculty and staff at an urban university found significant positive associations between Hubway users and personal bike owners as well as those who live in communities where Hubway operates. These two variables, as well as commuting to the UMB campus via public transportation, walking, or cycling, were also found to have significant positive associations with Hubway awareness. It was also seen that Hubway use had an inverse association with the likelihood of being overweight or obese. The magnitude of this association was fairly strong with Hubway users having a 60% lower likelihood of being overweight or obese than non-users.

Table 4.4:Association between Hubway use and overweight/obesity

	OR	**95% CI**	
Age	**1.03**	**1.01**	**1.06**
Gender			
Female	1.00		
Male	1.67	.94	2.97
Race			
White	1.00		
Minority	1.10	.63	1.94
Hispanic			
No	1.00		
Yes	1.07	.42	2.74
UMB status			
Student	1.00		
Faculty/staff	.58	.25	1.33
Living in Hubway area			
No	1.00		
Yes	.79	.47	1.36
PA frequency/week	.96	.84	1.09
Ever used Hubway			
No	1.00		
Yes	**.40**	**.17**	**.93**

In multivariable models, no socio-demographic variables showed significant associations with either awareness or use of Hubway. These findings are not consistent with previous research on correlates of bike share use. Previous studies assessing demographic correlates of bike share use have found that users tend to be younger, white, male, and have higher socio-economic status.[16,17,21] Even though two-thirds of Hubway users in the present study were white, race was not associated with use. It not clear why gender and age were not associated with either awareness or bike share use, though a lack of variability in the sample may have contributed to these null findings. Income or socioeconomic status was not assessed in this study. Also, UMB is an urban commuter university, unlike other universities in the Boston area where most students live on or near campus. Therefore, the lack of associations for demographic factors should be viewed with some caution as it may not be generalizable to other urban universities, even in the Boston area.

Respondents who lived in a Hubway community (e.g., Boston, Brookline, Cambridge, and Somerville) were significantly more likely to be aware of and use Hubway than those living outside of these area. These results are not unexpected since those residing in areas where Hubway operates would have additional opportunities to be exposed to and use the system, including taking short trips around their homes and potentially as part of a commute to UMB. These results are also generally consistent with findings from studies of other North American bike share systems which have shown users tend to live within an inner urban area, within 250-m of a docking station, and closer to work than non-users.[16,17,20,22]

Owning a personal bike was also positively associated with both awareness and use of Hubway. This finding is similar to other studies which found that bike share members were more likely to own and use personal bikes than non-members.[16,17,23,24] As this population (bike owners) already has interest and experience with cycling, they are likely to have more confidence in their cycling abilities and may be more aware of current cycling-related programs and news. Prior experience and confidence may be especially important for engaging in cycling in an urban setting like Boston. This study found the most common reason for choosing not to use Hubway was fear (40.5%). This is consistent with previous studies that have shown that safety concerns are a major barrier for bike share participation, commuter cycling, and active transportation in general.[24-28] In an Australian study researchers determined that positive attitudes towards cycling and perceived behavioral control increased the odds of cycling for transport and for recreation.[28] An individual's perceived ability to cycle, and specifically to be safe are critical factors to address if bike share programs are to gain more widespread adoption.

Since bike share programs have the potential to increase the number of individuals who actively commute, it is important to understand how typical commute pattern is associated with bike share awareness. Assessing bike share programs around the globe, one study found that a majority of bike share trips included some form of public transportation.[16] Given that one Hubway docking station is located at a public transportation station within a mile of campus, there is the potential for Hubway to be used as part of a multi-modal active commute to UMB. Even though over 70% of respondents were familiar with Hubway, only about a third were both aware of the Hubway program and correctly reported the two station locations near UMB. This suggests that additional promotional efforts, including signs directing people towards the stations may be needed. As this study showed, individuals who only drove to campus were less likely to be aware of Hubway and the docking stations around UMB than those who incorporated public transportation, walking, or cycling into their commute.

As noted, use of the Hubway bike share system was associated with a greatly reduced odds of being overweight or obese. To our knowledge this may be the first study to document an inverse relationship specifically between bike share use and weight status. An international study on active commuting and weight status found that the countries with the highest rates of active commuting tended to have the lowest rates of obesity, although this study did not specifically focus on bike share use.[9] Similarly, a comprehensive analysis of city, state, and international data consistently showed that higher levels of walking and cycling to work were associated with lower obesity and diabetes rates and higher rates of meeting PA guidelines.[29] Collectively, findings from the present study and previous research demonstrates the potential for utilitarian cycling and bike share use to positively influence overweight and obesity rates.

One strength of this study is the relatively few other studies that have identify correlates of awareness of bike share programs, as well as demonstrate an association between bike share use and weight status. Another strength was that UMB provided a unique opportunity to study a diverse urban campus where a majority of students and faculty live off campus. With a large number of commuters driving or using public transportation, there seems to be potential for a large percentage of the UMB students, faculty, and staff to become active commuters.

One limitation of this study is the cross-sectional design, which makes it impossible to determine the direction of the relationship between bike share use and weight status. This design prevents us from determining whether bike share use leads to improvements in weight status or that leaner and more fit individuals are choosing to use bike share more. Another limitation is the self-report measures of bike share use; which have not been tested for reliability and validity. The use of a convenience sample and low response rate were also potential limitation of this study, although demographic characteristics of our sample were fairly consistent with the make-up of the university.

In conclusion, use of the Hubway bike share system was associated with decreased odds of being overweight or obese among the population of an urban university. Bike share use appears to have the potential to influence health related outcomes like obesity rates. On this campus awareness and use of bike share are fairly low, indicating a potential opportunity for bike share programs and urban universities to work together and come up with creative ways to promote these programs as healthy alternatives to driving. Future research should continue to evaluate factors associated with awareness and use of bike share programs, as well as the potential health benefits.

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CHAPTER 5

RESULTS FROM EXPLORATORY ANALYSES

Commuting Pattern of Survey Respondents

Results for commuting behavior stratified by students and faculty/staff is shown in Table 5.1. Most respondents reported having a commute to the UMB campus that was greater than 30 minutes (78.4%), while only 7.8% of participants had a commute of less than 15 minutes. The time of day participants came to UMB was split fairly evenly, with 48.8% of participants getting to campus before 9 am and 51.2% arriving after 9 am. The average number of days commuting to campus was 3.6 days per week. This was consistent for both students and faculty/staff.

Table 5.1: Commuting pattern of UMB faculty/staff and students during fall 2014

	Overall	**Students**	**Faculty/Staff**
Average duration of commute to UMB % (n)			
< 15 minutes	7.8 (20)	10.8 (20)	0.0 (0)
15-30 minutes	13.7 (35)	14.1 (26)	12.9 (9)
31-45 minutes	30.6 (78)	31.9 (59)	27.1 (19)
46-60 minutes	27.8 (71)	24.3 (45)	37.1 (26)
60+ minutes	20.0 (51)	18.9 (35)	22.9 (16)
Time of commute to UMB % (n)			
Before 9am	48.8 (125)	49.2 (91)	47.9 (34)
After 9 am	51.2 (131)	50.8 (94)	52.1 (37)
Average days/week at UMB (SD)	3.6 (1.42)	3.6 (1.49)	3.5 (1.26)

Awareness of Bike Share and Hubway

Full results for awareness of Hubway, bike share, and station locations is shown in Table 5.2. Over 70% of the sample answered “Yes” when asked if they knew about Hubway. A smaller percentage of students reporting being aware of Hubway than faculty/staff (63.8% vs. 88.7%). Participants were also asked about station locations near the UMB campus. Although 76% of participants were aware of the Hubway station located at the UMB campus center, only 55% correctly reported the location of the docking station at the JFK/UMass MBTA-stop. The percentage of faculty/staff and students who were aware of the Hubway station near the JFK/UMass MBTA-stop was fairly similar; 60.3% and 52.5% respectively. A greater difference in the awareness of the docking station near the UMB Campus Center was seen between these groups. Approximately 92% of faculty/staff reported they were aware of the docking station near the Campus Center, compared to 67.8% of students.

When a stricter definition of awareness was used, awareness of Hubway and the location of the two docking stations, only 33.6% were considered aware. Only 27% of students were considered aware using this stricter definition, compared to 50.7% of faculty/staff.

Compared to the high proportion of participants who were aware of Hubway (about 70%), only 49.2% were aware of the term bike share. Over three-quarters of faculty/staff reported knowing about bike share programs, while only 38.4% of students answered “Yes” to the same question.

Table 5.2: Awareness of Hubway bike share program by the UMB community

	Overall	Students	Faculty/Staff
Knows about bike share % (n)			
Yes	49.2 (126)	38.4 (71)	77.5 (55)
No	50.8 (130)	61.6 (114)	22.5 (16)
Knows about Hubway[a] % (n)			
Yes	70.7 (181)	63.8 (118)	88.7 (63)
No	29.3(75)	36.2 (67)	11.3 (8)
Aware of Hubway and station locations[b] % (n)			
Yes	33.6 (86)	27.0 (50)	50.7 (36)
No	66.4 (170)	73.0 (135)	49.3 (35)
Aware of JFK station[c] % (n)			
Yes	55.3 (100)	52.5 (62)	60.3 (38)
No	8.3 (15)	8.5 (10)	7.9 (5)
Don't know	36.5 (66)	39.0 (46)	31.8 (20)
Aware of UMB station[c] % (n)			
Yes	76.1 (137)	67.8 (80)	91.9 (57)
No	2.8 (5)	4.2 (5)	0.0(0)
Don't know	21.1 (38)	28.0 (33)	8.1 (5)
Aware of home station[c] % (n)			
Yes	32.2 (58)	28.8 (34)	38.7 (24)
No	57.2 (103)	61.0 (72)	50.0 (31)
Don't know	10.6 (19)	10.2 (12)	11.3 (7)
Walk time to station by home[d] % (n)			
<5 minutes	24.1 (14)	20.6 (7)	29.2 (7)
5-9 minutes	41.4 (24)	41.2 (14)	41.7 (10)
10-15 minutes	22.4 (13)	20.6 (7)	25.0 (6)
16-30 minutes	6.9 (4)	8.8 (3)	4.2 (1)
>31 minutes	3.5 (2)	5.9 (2)	0.0(0)
Don't know	1.7 (1)	2.9 (1)	0.0 (0)

[a] Simplest measure of awareness
[b] Most stringent measure of awareness
[c] Station location only asked of participants who reported being aware of Hubway
[d] Walk time only asked of participants who reported being aware of Hubway and aware of station near their home

In addition to awareness of Hubway stations around the UMB campus, awareness of Hubway near the participant's home was also assessed. About a third of participants reported having a Hubway station near their home. Among these individuals, almost 80% of all stations were located less than a 15 minute walk from their home.

Use of Hubway

Approximately 13% of respondents reported having ever used Hubway anywhere in the past. Among these participants, only 15% had ever used Hubway around UMB, with a majority of use (87.8%) occurring elsewhere in the Boston area. In fact, only five participants had used Hubway around UMB in the past year. The most common duration for a Hubway trip was reported to be between 16 and 30 minutes (53.1%), with only 25% of trips lasting longer than 30 minutes. Data on use of Hubway around UMB and Boston in general as well as trip duration can be found in Table 5.3.

Table 5.3: Utilization of Hubway and personal bicycles[a]

	Overall	Students	Faculty/Staff
Ever used Hubway % (n)			
Yes	12.9 (33)	10.8 (20)	18.3 (13)
No	87.1 (223)	89.2 (165)	81.7 (58)
Ever used Hubway at UMB % (n)			
Yes	15.2 (5)	5.0 (1)	30.8 (4)
No	84.9 (28)	95.0 (19)	69.2 (9)
Used in past year at UMB % (n)	15.2 (5)	5.0(1)	30.8(4)
Used in past month at UMB % (n)	6.1(2)	0.0(0)	15.4(2)
Used Hubway anywhere else in Boston % (n)			
Yes	87.8 (29)	95.0 (19)	76.9 (10)
No	12.1 (4)	5.0 (1)	23.1 (3)
Used anywhere else in Boston in past year % (n)	63.6 (21)	75.0 (15)	46.2 (6)
Used anywhere else in Boston in past month % (n)	6.1 (2)	5.0 (1)	7.7 (1)
Typical Hubway trip duration % (n)			
1-15 minutes	21.9 (7)	15.0 (3)	33.3 (4)
16-30 minutes	53.1 (17)	50.0 (10)	58.3 (7)
31-45 minutes	6.3 (2)	10.0 (2)	0.0 (0)
46-60 minutes	15.6 (5)	25.0 (5)	0.0 (0)
60+ minutes	3.1 (1)	0.0 (0)	8.3 (1)

[a] All Hubway utilization questions were only asked of individuals who reported ever using Hubway in the past. Usage rates for past year and past month were based off of this total (n=33)

As seen in Table 5.4, the most common reasons for using Hubway recreation/leisure (60.6%), running errands (33.3%), getting to work (27.2%), and to exercise (18.2%). The most commonly reported reasons for not using Hubway were fear (40.5%), lack of interest (33.1%), station availability (32.4%), and cost (25.7%) (See Table 5.4).

Personal Bike Use

Descriptive statistics for personal bike use can be found in Table 5.5. Overall, 52% of respondents reported owning a personal bicycle. A much higher percentage of faculty/staff owned bikes compared to students (71.8% vs. 44.3%). The average number of trips taken on personal bikes in the past year was 55.5 trips, with faculty/staff taking slightly more trips (62.2 trips), than students (51.2 trips).

Table 5.4: Facilitators and barriers to Hubway use

	Overall	**Students**	**Faculty/Staff**
Reasons for using Hubway[a] % (n)			
Get to school	6.1 (2)	10.0 (2)	0.0 (0)
Get to work	27.2 (9)	0.0 (0)	0.0 (0)
To/from public transport	15.2 (5)	5.0 (1)	30.8 (4)
Social events	15.2 (5)	15.0 (3)	15.4 (2)
Run errands	33.3 (11)	30.0 (6)	38.5 (5)
Exercise	18.2 (6)	20.0 (4)	15.4 (2)
Recreation/Leisure	60.6 (20)	65.0 (13)	53.9 (7)
Reasons for not using Hubway[b] % (n)			
Interest	33.1 (49)	40.8 (40)	18.0 (9)
Bike availability	7.4 (11)	11.2 (11)	0.0 (0)
Station availability	32.4 (48)	36.7 (36)	24.0 (12)
Health reasons	.7 (1)	1.0 (1)	0.0 (0)
Cost	25.7 (38)	31.6 (31)	14.0 (7)
Fear	40.5 (60)	42.9 (42)	36.0 (18)
Can't ride	3.4 (5)	3.1 (3)	4.0 (2)
Uses own bike	24.3 (36)	15.3 (15)	42.0 (21)

[a] Reasons for using Hubway was only asked of participants reporting past Hubway use
[b] Reasons for not using were only asked of individuals reporting no prior history of Hubway use

Table 5.5: Percentage of respondents who own a personal bicycle and amount of trips taken in past year

	Overall	**Students**	**Faculty/Staff**
Own a personal bike % (n)	52.0(133)	44.3 (82)	71.8 (51)
Amount of trips on personal bike during past year (SD)	55.5 (78.2)	51.2 (79.5)	62.2 (78.7)

Helmet Use

Results for helmet use stratified by students and faculty/staff are displayed in Table 5.6. Helmet use was assessed for both use on Hubway and while riding a personal bike. Helmet use was assessed on a 5-point Likert scale: always, often, sometimes, rarely, never. Although Hubway officially requires all users to wear a helmet when using the system, rates of helmet use were lower on Hubway than personal bikes. More Hubway users reported “never” wearing a helmet (42.4%) than “always” wearing one (36.4%). In contrast 57.9% of personal bike owners reported “always” wearing a helmet, and only 17.3% reported they “never” wore a helmet. Full results for helmet usage rates stratified by students and faculty/staff can be found in Table 5.6.

Rates of helmet use also differed between faculty/staff and students. Seventy percent of students who used Hubway reported wearing helmets “rarely” or “never” compared to just 30.8% of faculty/staff. During private bike use, 32.9% of students reported “rarely” or “never” wearing helmets, whereas only 5.9% of faculty/staff wore helmets at this rate. It is important for Hubway to address the low helmet usage rates among its users, as helmets are a cheap and reasonable way to increase bicycle safety and decrease serious injuries. Hubway has recently begun to place helmet rental machines at some docking stations around the city, in an attempt to increase rates of helmet usage.

Table 5.6: Helmet use among Hubway users and personal bikes owners

	Overall	Students	Faculty/Staff
Use of helmet on Hubway[a] %(n)			
Always	36.4 (12)	15.0 (3)	69.2 (9)
Often	6.1 (2)	10.0 (2)	0.0 (0)
Sometimes	3.0 (1)	5.0 (1)	0.0 (0)
Rarely	12.1 (4)	15.0 (3)	7.7 (1)
Never	42.4 (14)	55.0 (11)	23.1 (3)
Use of helmet on personal bike[b] %(n)			
Always	57.9 (77)	41.5 (34)	84.3 (48)
Often	11.3 (15)	13.4 (11)	7.8 (4)
Sometimes	8.3 (11)	12.2 (10)	2.0 (1)
Rarely	5.3 (7)	7.3 (6)	2.0 (1)
Never	17.3 (23)	25.6 (21)	3.9 (2)

[a] Helmet usage on Hubway only asked of participants reporting past Hubway use
b Helmet use on personal bike only asked of participants reporting personal bike ownership

Frequency of Accidents and Severity of Injuries

Data on frequency of accidents and severity of injuries can be seen in Table 5.7. Roughly 12% of participants (n=31) who reported using Hubway or a personal bike were involved in a cycling related accident within the past two years. Almost half of those who reported an accident, were involved in at least two accidents over the same time span. Approximately 90% of accidents resulted in minor injuries that did not need medical attention. The remaining accidents required at least some medical attention, with 6.4% of injuries considered serious and requiring an Emergency Room visit or hospitalization. Frequency of accidents and severity of injuries can be found in Table 5.7.

Correlates of Bike Share Awareness

Correlates of bike share awareness can be found in Table 5.8. In both age-adjusted and multivariable logistic regressions, students (compared to faculty/staff) and being non-white were negatively associated with awareness of the term bike share. In the final regression model, faculty/staff were 3.3 times more likely to have answered “yes” to knowing about bike share than students (OR=3.30, 95% CI= 1.36, 8.01). Survey respondents from racial minority groups were 50% less likely to be aware of the term bike share than those who were White (OR= .50, 95% CI= .28, .92). No other variables were associated with general bike share awareness in either age-adjusted or fully-adjusted models.

Table 5.7: Frequency of bicycle accidents and severity of injuries within past two years

	Overall	Students	Faculty/staff
Accidents in the past 2 years[a] %(n)			
0	43.4 (111)	38.4 (71)	28.2 (40)
1	6.6 (17)	6.5 (12)	7.0 (5)
2	3.5 (9)	2.7 (5)	5.6 (4)
3	.8 (2)	.5 (1)	1.4 (1)
4+	1.2 (3)	1.1 (2)	1.4 (1)
Severity of injuries[b] % (n)			
Minor (no attention)	90.3 (28)	90.0 (18)	90.9 (10)
Minor (some attention)	3.2 (1)	5.0 (1)	0.0 (0)
Serious (emergency room visit)	3.2 (1)	5.0 (1)	0.0 (0)
Serious (hospitalized)	3.2 (1)	0.0 (0)	9.1 (1)

[a] Accidents in past two years only asked of participants reporting some form of cycling (n=142)
[b] Severity of injuries only asked of participants reporting at least one accident in the past two years (n=31)

Correlates of Hubway Awareness

Age-adjusted and fully-adjusted logistic regression models were performed to examine associations between demographic and behavioral variables and a less conservative measure of Hubway awareness; answering "yes" or "no" to knowing about Hubway. In age-adjusted models, faculty/staff members, living in a Hubway community, and commuting to UMB using any other mode than only driving were found to have positive, statistically significant associations with awareness. In the fully-adjusted model (with demographic and behavioral variables), only faculty/staff status and living in a Hubway community remained as statistically significant correlates. Faculty/staff were over three times more likely to be aware of Hubway than students (OR= 3.65, 95% CI= 1.16, 11.54). Respondents living in a Hubway community were over four times as likely to be aware of the program than individuals living in other communities (OR= 4.39, 95% CI= 2.15, 8.95). The results of the less conservative measure of awareness can be found in Table 5.9.

Table 5.8: Correlates of bike share awareness (n=256)

	Age-adjusted			**Demographic model**			**Demographic and behavioral model**		
	OR	95% CI		OR	95% CI		OR	95% CI	
Age				1.01	.99	1.04	1.02	.99	1.05
Gender									
Female	1.00			1.00			1.00		
Male	1.24	.70	2.19	1.30	.72	2.38	1.38	.75	2.56
Race									
White	1.00			1.00			1.00		
Minority	**.53**	**.31**	**.92**	**.56**	**.32**	**.99**	**.50**	**.28**	**.92**
Hispanic									
No	1.00			1.00			1.00		
Yes	.78	.30	1.99	.84	.32	2.22	.88	.33	2.25
UMB status									
Student	1.00			1.00			1.00		
Faculty/staff	**4.05**	**1.75**	**9.36**	**3.38**	**1.43**	**7.97**	**3.30**	**1.36**	**8.01**
Living in Hubway area									
No	1.00			1.00			1.00		
Yes	1.54	.91	2.61	1.43	.83	2.48	1.39	.78	2.48
Commuting Type									
Drive alone	1.00						1.00		
Other	1.50	.89	2.55				1.19	.66	2.15
PA days/week	.98	.86	1.11				.92	.80	1.05
Owning a personal bike									
No	1.00						1.00		
Yes	1.06	.62	1.79				.94	.52	1.68

Table 5. 9: Correlates of Hubway awareness (n=256)

	Age-adjusted			**Demographic model**			**Demographic and behavioral model**		
	OR	95% CI		OR	95% CI		OR	95% CI	
Age				1.00	.97	1.03	1.01	.97	1.04
Gender									
Female	1.00			1.00			1.00		
Male	.94	.51	1.72	.89	.46	1.73	.86	.43	1.70
Race									
White	1.00			1.00			1.00		
Minority	.64	.36	1.13	.65	.36	1.20	.69	.36	1.32
Hispanic									
No	1.00			1.00			1.00		
Yes	.94	.36	2.47	.96	.35	2.67	1.00	.35	2.83
UMB status									
Student	1.0			1.00			1.00		
Faculty/staff	**4.92**	**1.74**	**13.91**	**4.31**	**1.43**	**13.02**	**3.65**	**1.16**	**11.54**
Living in Hubway area									
No	1.00			1.00			1.00		
Yes	**4.30**	**2.22**	**8.33**	**4.26**	**2.16**	**8.37**	**4.39**	**2.15**	**8.95**
Commuting Type									
Drive only	1.00						1.00		
Other	**2.21**	**1.26**	**3.87**				1.44	.76	2.73
PA days/week	1.00	.88	1.14				.92	.79	1.07
Owning a private bike									
No	1.00						1.00		
Yes	1.58	.90	2.77				1.88	.99	3.58

Correlates of Cycling

Results for the correlates of cycling can be found in Table 5.10. An overall outcome measure for cycling was created based on any reported use of the Hubway bike share program or a personal bike. In age-adjusted models and models that adjusted for demographic and behavioral variables, being from a racial minority group had a statistically significant, negative association with cycling in general. Also, PA frequency was positively and significantly associated with this outcome. Non-white participants were 55% less likely to do any kind of cycling than white participants (OR=.45, 95% CI=

.26, .79). It was also found that each one day increase in weekly frequency of PA was associated with a 15% increased odds of engaging in some type of cycling (OR= 1.15, 95% CI= 1.01, 1.32).

Table 5.10: Correlates of cycling in general [a] (n=256)

	Age-adjusted			Demographic model			Demographic and behavioral model		
	OR	95% CI		OR	95% CI		OR	95% CI	
Age				1.01	.99	1.04	1.02	.99	1.05
Gender									
Female	1.00			1.00			1.00		
Male	1.15	.65	2.01	1.31	.73	2.36	1.24	.67	2.29
Race									
White	1.00			1.00			1.00		
Minority	**.40**	**.23**	**.68**	**.39**	**.23**	**.68**	**.45**	**.26**	**.79**
Hispanic									
No	1.00			1.00			1.00		
Yes	.84	.34	2.09	.93	.36	2.41	.88	.34	2.27
UMB status									
Student	1.00			1.00			1.00		
Faculty/staff	1.73	.77	3.87	1.50	.65	3.46	1.52	.64	3.64
Living in Hubway area									
No	1.00			1.00			1.00		
Yes	.78	.47	1.31	.75	.44	1.27	.75	.43	1.32
Commute type									
Drive alone	1.00						1.00		
Other	.86	.51	1.44				.78	.44	1.40
PA days/week	**1.19**	**1.05**	**1.34**				**1.15**	**1.01**	**1.32**

[a] Cycling in general was defined as any participant who reported either past Hubway use or personal bike ownership.

Correlates of Bicycle Helmet Use

Table 5.11 shows the results of logistic regression models in which demographic and behavioral variables were examined as potential correlates of helmet use. Every one-year increase in age was associated with a 9% higher odds of wearing a bicycle helmet (OR= 1.09 95% CI= 1.03, 1.15). Being of Hispanic/Latino descent was also significantly and positively associated with wearing a helmet (OR=13.65, 95% CI= 1.35, 138.02). Despite the fact that a much higher percentage of personal bike users wore helmets, as compared to Hubway users, type of cycling (Hubway vs. personal bike use) was not associated with helmet use in logistic regression models.

Table 5.11: Correlates of bicycle helmet use[a] (n=142)

	Age-adjusted			**Demographic model**		
	OR		95% CI	OR		95% CI
Age				**1.09**	**1.03**	**1.15**
Gender						
Female	1.00			1.00		
Male	1.22	.50	2.94	.98	.37	2.61
Race						
White	1.00			1.00		
Minority	.64	2.26	1.54	.56	.21	1.47
Hispanic						
No	1.00			1.00		
Yes	8.70	.99	76.62	**13.65**	**1.35**	**138.02**
UMB status						
Student	1.00			1.00		
Faculty/staff	2.62	.68	10.17	3.27	.80	13.48
Bike type						
Private bike user	1.00			1.00		
Hubway user	.65	.26	1.66	.51	.18	1.45

[a] Use of helmets only asked of participants reporting some form of cycling

Correlates of Bicycle Accidents

In both age-adjusted and fully-adjusted models, no demographic or behavioral variables were associated with bicycle accidents. The odds of being in an accident were not different for Hubway or personal bike riders. The lack of associations may in part be due to the low number of accidents reported (31 of 142 people who reported doing some type of cycling).

Table 5.12: Correlates of bicycle accidents[a] (n=142)

	Age-adjusted			Demographic model		
	OR	95% CI		OR	95% CI	
Age				.99	.95	1.04
Gender						
Female	1.00			1.00		
Male	1.37	.60	3.17	1.18	.49	2.87
Race						
White	1.00			1.00		
Minority	1.67	.70	3.99	1.52	.61	3.80
Hispanic						
No	1.00			1.00		
Yes	2.53	.66	9.64	2.29	.56	9.33
UMB status						
Student	1.00			1.00		
Faculty/staff	1.32	.40	4.30	1.28	.38	4.38
Living in Hubway area						
No	1.00			1.00		
Yes	1.62	.72	3.66	1.48	.63	3.47
Bike type						
Private bike user	1.00			1.00		
Hubway user	1.48	.60	3.63	1.26	.49	3.24

[a] Accident questions only asked to participants reporting some form of cycling. Accidents must have occurred within the past two years to be included in analysis

CHAPTER 6

DISCUSSION

Although awareness of Hubway (Aim 1) was fairly high among students and faculty/staff at UMB, overall awareness of station location and familiarity with the term bike share were low. Use of Hubway (Aim 1) around UMB was also found to be low, with approximately 88% of use occurring elsewhere in the Boston area. It was observed that use of Hubway was associated with significantly decreased odds of being overweight or obese (Aim 2). Higher levels of helmet use (Aim 3) were found to be associated with age and being of Hispanic/Latino descent. Although univariate statistics suggested a difference between Hubway and personal bike users in terms of helmet use, no significant difference was found in multivariable regression models. Approximately 12% of the sample reported at least one accident in the past two years, however no statistically significant correlate was found associated with an increased risk in cycling accidents (Aim 4).

Overall, awareness of Hubway was around 70%, however awareness of bike share in general (or the term “bike share”), as well as station location suggests that this awareness level may be much lower. There appears to be a need for additional promotional efforts at UMB to increase awareness of Hubway and the benefits of bike share programs in general. These efforts should possibly be concentrated on students, since they displayed lower levels of awareness than faculty/staff. Also, individuals living in Hubway communities had higher levels of awareness, than those living in a city or town without Hubway docking stations. Although this was not unexpected, as individuals living in communities with Hubway stations would have additional exposures to the system. This finding indicates a need to better inform those living outside of Boston about Hubway and potential health benefits from use of the program. About 60% of survey respondents reported commuting from outside of Boston, therefore it could prove challenging to simply increase awareness and use of Hubway in this group. However, by increasing the awareness of students and those living outside of the Hubway area, more individuals could choose to use Hubway as part of a multi-modal commute involving public transportation or driving.

Use of Hubway around UMB was very low, with only five participants using Hubway around campus in the past year. This low rate of use around UMB was surprising, as the location of docking stations at the nearby public transit station and one on campus provides students, faculty, and staff who typically use public transportation an efficient and PA friendly option to waiting for and using the campus shuttle buses. Prior studies have shown that a majority of bike share use is done as part of a multi-modal commute with public transportation (Fishman 2013 et al.), so rates of use around UMB were expected to be higher.

As mentioned previously, the most common duration of a Hubway trip was observed to be between 16 and 30 minutes. This finding was expected, since users have thirty minutes of free riding included in daily, monthly, or annual passes before small fees are charged based on additional time. Therefore, many Hubway users take trips of less than 30 minutes or return the bike to a docking station along their route and rent another to avoid the additional time based fees. This demonstrates the potential for Hubway to positively influence health, as users were getting between 50-100% of the recommended 30 minutes of PA per day through a single one way trip (USDHHS 2008). If users also made their return trip via Hubway, they would be expected to match or exceed the daily PA recommendations.

Survey respondents who reported some use of Hubway were asked to identify the main reasons for using bike share. The most commonly reported reasons for using Hubway were for recreation/leisure (60.6%), running errands (33.3%), getting to work (27.2%), and to exercise (18.2%). These results are different than what has been found in the literature; namely that a majority of bike share use is for utilitarian purposes such as getting to work, school, or running errands (Fishman et al. 2013; Fuller et al. 2011; Shaheen et al. 2012). Although utilitarian trips were common reasons for using Hubway, the main purpose for using Hubway among this study’s participants was for recreation or leisure time activity. A clear explanation for this finding is not readily apparent, but could be due to a number of factors, such as where individuals live and typically use Hubway or their preferred method of making utilitarian trips.

Survey respondents who did not use Hubway were asked to identify barriers to using the system. The top reasons for not to using Hubway were fear (40.5%), lack of interest (33.1%), station availability (32.4%), and cost (25.7%). Previous research has shown that fear and safety concerns are an important factor when deciding whether to cycle in an urban environment (Fishman, Washington, & Haworth 2012a; Fishman, Washington, Haworth 2012b; Buck & Buehler 2012; Titze, Giles-Corti, & Knuiman 2010). Therefore in order to increase levels of bike share use among the UMB community, it will be important to promote bicycle safety including creating a bike-friendly built environment, increasing helmet use, and emphasizing proper driving/cycling protocols.

Station availability also appear to be an important factor related to bike share use. Research has shown that living within close proximity of a docking station, greatly increases the odd of using the program (Fuller et al. 2011; Bachand-Marleau et al. 2012). Cost was also found to be an important concern for this population. Hubway does offer subsidized memberships to individuals from low-income communities, but discounts for students could also increase use of the program at UMB and around other universities in the Boston area. There may be little that can be done to influence the participants who reported having a lack of interest, however it is important to continue to promote active commuting and bike share use as a healthy commuting alternative to driving.

This study also attempted to assess correlates of cycling in general by the UMB population. Not surprisingly, a higher frequency of PA was associated with an increased odds of cycling. It was also found, that respondents from racial minority groups were

55% less likely to report any form of cycling than white respondents. These results are consistent with the findings from a study in which researchers found significant associations between overall PA, race, and bicycling (Sallis et al. 2013). This study also found an association between cycling and being young, male, and well-educated (Sallis et al. 2013).

Wearing a bicycle helmet is a relatively inexpensive and effective way to increase bicycle safety and reduce cycling-related injuries. The only significant correlate of helmet use was age. Similar to prior research, this study found that older individuals were more likely to wear a bicycle helmet than younger riders. One of these studies found that only 12% of college students reported wearing a helmet when cycling (Ross et al. 2010). Hispanic/Latino ethnicity was also positively associated with wearing a helmet. However, due to the low number of Hispanic/Latino cyclists and wide confidence interval, this finding should be viewed with some caution. Frequency of helmet use appeared to be different between Hubway and personal bike users, however the regression analysis did not show an association between type of rider (Hubway versus personal bike) and helmet use. This finding contrasts a study conducted in Washington, DC, which found that while 70% of private bike users reported wearing helmets only 33% of Capital Bike Share used helmets (Kraemer et al. 2012). Future research is needed to determine the factors that might contribute to different rates of helmet use among bike share and personal bike users.

This present study did not find any statistically significant demographic or behavioral correlates of cycling related accidents. In part, the purpose of evaluating cycling accidents was to determine whether bike share users were more or less likely to have accidents than private bike riders. This study found no association between type of rider and accidents. This is consistent with a prior study hat have found bike share users are at no more risk than regular cyclists to be involved in an accident (Fuller et al. 2013). Also, two international studies estimated that the health benefits of bike sharing greatly outweighed the risks associated with urban cycling (de Hartog et al. 2011, Rojas-Rueda et al 2011). As Hubway and other bike share programs grow in the U.S. it may be worthwhile to continue to examine accident rates in bike share and private bike users, including the factors that might lead to higher accident rates in one group compared to the other.

One strength of this study was examining bike share awareness, use and other aspects of cycling at a diverse urban university with access to two Hubway docking stations on or near campus. Since UMB is largely a commuter school, and a majority of bike share use occurs as part of a multi-modal commute with public transportation, there seems to be potential to increase Hubway use among students, faculty and staff. However, sustained promotional efforts would be needed to address concerns that emerged in this study such as around safety, cost, and convenience.

Limitations of this study include using a convenience sample, the low frequency of Hubway use in general and around UMB, and construction on campus during the study that affected traffic patterns and potentially bike share awareness and use. Despite not having a random sample, the demographic profile of participants was comparable to the university population at-large. The low rates of Hubway use around UMB precluded us from specifically evaluating correlates of bike share use to and from campus. Another factor that may have impacted some of the findings such as the levels of Hubway awareness and use were the construction and traffic patterns changes made during the 2014 fall semester. In the past, traffic went one-way around the university passing the Campus Center, the location of the Hubway station on campus. Due to construction projects at the university traffic was converted into a two-way and diverted away from the Campus Center. Hubway recently moved the docking station on campus to the new Integrated Science Building, which could increase visibility and therefore awareness and use.

In conclusion, Hubway awareness and use remain low among members of the UMB community. This appears to be especially true among students, so future promotional efforts may be necessary to increase awareness and use in this population. Future research should also focus on helmet use and accident rates among Hubway users. This is needed in order to gain a better understanding of the factors surrounding bicycle safety while using bike share programs in an urban environment.

APPENDIX A.

SURVEY INSTRUMENT

Do not use your browser's back button.
If you need to back up, use the button at the bottom of the screen.
The reset button will erase only the responses on the current page, but not your previous answers.
The question numbers may not be sequential depending on your responses.
After entering your response, you must click on the next button to continue.

1. How do you typically commute to the UMB campus? (Check all that apply)
   - ☐ Walk
   - ☐ Bicycle
   - ☐ Take public transit
   - ☐ Ride in motor vehicle
   - ☐ Other

1. If other, please specify: ____

2. About how long does it usually take you to get to UMB?
   - ☐ Less than 15 minutes
   - ☐ 15-30 minutes
   - ☐ 31-45 minutes
   - ☐ 46-60 minutes
   - ☐ More than 60 minutes

3. This semester, how many days per week are you usually on the UMB campus?
   - ☐ 1
   - ☐ 2
   - ☐ 3
   - ☐ 4
   - ☐ 5
   - ☐ 6
   - ☐ 7

4. What time of day do you most often come to UMB?
   - ☐ Before 9:00 AM
   - ☐ 9:00 AM - 12:00 PM
   - ☐ 12:01 PM - 3:00 PM
   - ☐ After 3:00 PM

5. Do you know what bike share programs are?
- ☐ Yes
- ☐ No

6. Have you heard of Boston's Hubway bike share program?
- ☐ Yes
- ☐ No

(If “No” skip to question #22)

7. Is there a Hubway station at the JFK/UMass MBTA station?
- ☐ Yes
- ☐ No
- ☐ Don't know

8. Is there a Hubway station on the UMB campus?
- ☐ Yes
- ☐ No
- ☐ Don't know

9. Is there a Hubway station near where you live?
- ☐ Yes
- ☐ No
- ☐ Don't know

  (If “No” or “Don’t know” skip to question #11)

10. About how long would it take you to walk to that station?
- ☐ Less than 5 minutes
- ☐ 5-9 minutes
- ☐ 10-15 minutes
- ☐ 16-30 minutes
- ☐ 31 minutes or longer
- ☐ Don't know

11. Have you ever used the Hubway bike share program?
- ☐ Yes
- ☐ No

  (If “No” skip to question #21)

12. Have you ever used the Hubway bike share program to get to/from UMB?
- ☐ Yes
- ☐ No

  (If “No” skip to question #15)

13. Have you used the Hubway bike share program to get to/from UMB in the past year?

- ☐ Yes
- ☐ No

(If "No" skip to question #15)

13. If yes, about how many times have you used it in the past year?

____

14. Have you used the Hubway bike share program to get to/from UMB in the past month?

- ☐ Yes
- ☐ No

14. If yes, about how many times have you used it in the past month?

____

15. Have you ever used the Hubway bike share program anywhere else in Boston or the surrounding communities (other than UMB)?

- ☐ Yes
- ☐ No

(If "No" skip to question #18)

16. Have you used the Hubway bike share program anywhere else in Boston or the surrounding communities in the past year (other than UMB)?

- ☐ Yes
- ☐ No

(If "No" skip to question #18)

16. If yes, about how many times have you used it in the past year?

17. Have you used the Hubway bike share program anywhere else in Boston or the surrounding communities in the past month (other than UMB)?

- ☐ Yes
- ☐ No

17. If yes, about how many times have you used it in the past month?

____

18. What is the average duration of your typical Hubway ride?

- ☐ 1-15 minutes
- ☐ 16-30 minutes
- ☐ 31-45 minutes
- ☐ 46-60 minutes
- ☐ More than 60 minutes

19. How often do you wear a helmet when using Hubway?

- ☐ Always

- ☐ Often
- ☐ Sometimes
- ☐ Rarely
- ☐ Never

20. Why do you use Hubway? (Check all that apply)
- ☐ Travel to/from school
- ☐ Travel to/from work
- ☐ Travel to/from public transportation
- ☐ Travel to/from social events
- ☐ Running errands or shopping
- ☐ Exercise (improve fitness)
- ☐ Recreation/Leisure

21. What are your main reasons for not using Hubway? (Check all that apply)
- ☐ Lack of interest
- ☐ Lack of availability of bikes
- ☐ Lack of access/availability of stations
- ☐ Health reasons
- ☐ Cost
- ☐ Fear of riding a bike on the street
- ☐ Don't know how to ride a bike
- ☐ Use my own bike

(Only asked if question #6 = "Yes" and question #11 = "No")

22. Do you own your own bicycle?
- ☐ Yes
- ☐ No

If yes, about how many times have you used it in the past year?

____

(If 'No" skip to question #24)

23. How often do you wear a helmet when riding your own bicycle?
- ☐ Always
- ☐ Often
- ☐ Sometimes
- ☐ Rarely
- ☐ Never

24. In the last two years, how many times did you have an accident while riding a bike in which you fell? Please include very minor spills with or without anyone else involved.
- ☐ 0
- ☐ 1
- ☐ 2

- ☐ 3
- ☐ 4 or more

(If “0” skip to question #28)

25. In your most recent accident, please indicate what happened (please check all that apply)?

- ☐ Collided with moving motor vehicle (car, bus, truck)
- ☐ Collided with parked motor vehicle
- ☐ Collided with other cyclists
- ☐ Collided with pedestrian
- ☐ Collided with fixed object (tree, wall, post, etc.)
- ☐ Collided with dog or other animal
- ☐ Fell due to road conditions (debris, storm drains, construction, slick roads, etc.)
- ☐ Fell due to own actions
- ☐ Other

26. In your most recent bicycle accident, how serious were your injuries?

- ☐ Minor injuries- no medical attention needed
- ☐ Minor injuries- required medical attention
- ☐ Serious injuries- required visit to emergency room
- ☐ Serious injuries- required hospitalization

27. Please indicate the type of injuries you had during your most recent bicycle accident?

	Scrapes	*Bruises*	*Sprain/ Strain*	*Fracture*	*Dislocation*	*Laceration*	*Concussion*	*Internal Injuries*
Upper Extremity (shoulder, arms, wrist, hands)	☐	☐	☐	☐	☐	☐	☐	☐
Lower Extremity (hips, legs, knees, ankles, feet)	☐	☐	☐	☐	☐	☐	☐	☐
Head	☐	☐	☐	☐	☐	☐	☐	☐
Face (eyes, nose, mouth, teeth)	☐	☐	☐	☐	☐	☐	☐	☐
Trunk (ribs, internal organs)	☐	☐	☐	☐	☐	☐	☐	☐
Neck and Spine	☐	☐	☐	☐	☐	☐	☐	☐

28. In the past week, on how many days have you done a total of 30 minutes or more of physical activity, which was enough to raise your breathing rate? This may include sport, exercise and brisk walking or cycling for recreation or to get to and from places, but should not include housework or physical activity that may be part of your job.

- ☐ 0

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7

29. What is your current status at UMB? (Select one)
    - ☐ Faculty
    - ☐ Staff
    - ☐ Student

30. What is your current standing?
    - ☐ Undergraduate
    - ☐ Graduate

31. What is your current employment status?
    - ☐ Employed full-time
    - ☐ Employed part-time
    - ☐ Not employed

32. With what gender do you identify yourself?
    - ☐ Male
    - ☐ Female
    - ☐ Transgender

33. How old are you (in years)?

    ____

34. How tall are you without shoes (feet)?
    - ☐ 3
    - ☐ 4
    - ☐ 5
    - ☐ 6
    - ☐ 7

35. How tall are you without shoes (inches)?
    - ☐ 0
    - ☐ 1
    - ☐ 2
    - ☐ 3
    - ☐ 4
    - ☐ 5
    - ☐ 6

- ☐ 7
- ☐ 8
- ☐ 9
- ☐ 10
- ☐ 11

36. How much do you weigh (in pounds) without shoes? (to the nearest 1/4 pound)

    ____

37. Are you Hispanic?
    - ☐ Yes
    - ☐ No

38. What is your race? (Check all that apply)
    - ☐ American Indian or Alaskan Native
    - ☐ Asian
    - ☐ Black or African American
    - ☐ Native Hawaiian or Pacific Islander
    - ☐ White
    - ☐ Other

38. If other, please specify:

    ____

39. What is your home zip code?

    ____

40. Please feel free to provide additional comments:

    ____

____

____

____

____

____

41. Can we contact you for future research on bike share programs?
    - ☐ Yes
    - ☐ No

42. If yes, please provide the following information:

    First name:

    ____

    Last name:

    ____

    Email:

    ____

Phone:(xxx-xxx-xxxx)
____

43. Would you like to be entered into a drawing for a chance to win a $25 gift card?
   - ☐ Yes
   - ☐ No

44. If yes, please provide the following information:
   First name:
   ____
   Last name:
   ____
   Email:
   ____
   Phone:(xxx-xxx-xxxx)
   ____

Thank you! We appreciate the time you have taken to participate.

Please click the SUBMIT button below to complete the survey.

APPENDIX B.

INFORMED CONSENT

Introduction and Contact Information

You are being asked to participate in a research study assessing awareness and participation in bike share programs by the UMass Boston community. You will also be asked about your recent physical activity habits and commute to and from campus. The principal investigator is Professor Philip Troped, Department of Exercise and Health Sciences. Please read this form and if you have any questions please contact Dr. Troped at 617-287-3809 or phil.troped@umb.edu.

What Will Happen in This Study

This is a one-time study. Participants will be asked to complete an online survey. You will be asked to provide basic information like height, weight, and education level. You will also be asked about your typical level of physical activity and how you commute to and from UMB.

Risks and Discomforts

There are no known risks for participating in this study. The survey does not ask personal questions that could bring up negative or distressful feelings, but if for some reason you feel uncomfortable you may stop your participation at any time. If you have additional concerns please contact Dr. Troped.

Potential Benefits

There are no direct benefits for participating in this survey. Your alternative would be to not participate.

Confidentiality

Your participation in this research study is confidential. None of the information gathered will be presented in a way that allows for identification of any participants. Results obtained for this project will be stored in a password protected file that only the research team can access.

Voluntary Participation

The decision to participate in this study is voluntary. If you decide to take part in the study, you may still stop your participation at any time.

Your Rights:

You have the right to ask questions about this study before you agree to participate. You may contact Dr. Troped. Alternatively, if you have any questions or concerns about your rights as a research participant, please contact a representative of the Institutional Review Board (IRB) at the University of Massachusetts Boston, which oversees research involving human participants. The IRB may be reached at the following address: IRB, Quinn Administration Building-2-080, University of Massachusetts Boston, 100 Morrissey Boulevard, Boston, MA 02125-3393. You can also contact the IRB by telephone or e-mail at 617- 287-5370 or at human.subjects@umb.edu.

If you wish to participate hit the Next button.

APPENDIX C.

RECRUITMENT E-MAIL

All students, faculty, and staff are invited to take an online survey that will assess awareness and use of bike share programs. The only requirements for participation are that you are have a valid UMB email address, can read/understand English, and willing and able to give informed consent.

The survey should take approximately 5 minutes to complete, and if you wish you can be entered into a drawing for one of ten $25 gift cards.

Your participation in this study is voluntary and you may withdraw at any time.

If you wish to participate please click on the link below, read the informed consent page, and follow the instructions for completing the survey.

This study has been approved by the UMass Boston Institutional Review Board.

The principal investigator is Dr. Philip Troped. Please contact him with any questions or concerns you may have at phil.troped@umb.edu.

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