Transit-Oriented Development and Health:

A Health Impact Assessment to Inform the Healthy Neighborhoods Equity Fund

MAPC, CLF, and DPH

September 27, 2013

Authors

Metropolitan Area Planning Council (MAPC): Kate Ito, Noemie Sportiche, Barry Keppard, Peter James

Contributors

Massachusetts Department of Public Health (MDPH): Ben Wood (BCHAP), Margaret Round (BEH), Christine Gorwood (BEH) and Bonnie Andrews (BCHAP).

Conservation Law Foundation (CLF): Maggie Super Church, Aviva Rothman-Shore, Gilad Rosenzweig

MAPC: Clayton Martin, Meghna Dutta, Jennifer Raitt, Bill Wang

Acknowledgements

We would like to thank Madison Park Development Corporation, Mission Hill Neighborhood Housing Services, Nuestra Comunidad Development Corporation, the City of Boston Health in All Policies Taskforce, Mariela Alfonzo (Founder, State of Place), Lea Susan Ojamaa (MDPH-BCHAP), Andrea Pinzon-Marquardt (MDPH-BCHAP), Martha Steele (MDPH-BEH), Jan Sullivan (MDPH-BEH), Mariana Arcaya (MAPC), Holly St. Clair (MAPC), Tim Reardon (MAPC), Eric Halvorsen (MAPC), Jessica Robertson (MAPC), Steve Winter (MAPC) Jon Levy (Boston University), Kim Gilhuly (Human Impact Partners). Graphic Design by Jason Fairchild of The Truesdale Group.

MAPC Executive Director

Marc Draisen

Guide to this Document

This is a Health Impact Assessment that investigates the relationship between Transit Oriented Development and health for the purpose of informing the development of the Healthy Neighborhoods Equity Fund. This document is divided into three Parts. Part I provides context for this Health Impact Assessment; reviews what a Health Impact Assessment is; discusses our stakeholder engagement process; gives an overview of the Healthy Neighborhoods Equity Fund; and provides baseline neighborhood and health characteristics. Part II examines in detail the pathways to health that might be impacted by transit-oriented development supported by the Healthy Neighborhoods Equity Fund, explaining our methodology and describing the expected changes in health outcomes. Part III summarizes the conclusions from Part II and provides recommendations for the Healthy Neighborhoods Equity Fund based on these conclusions.

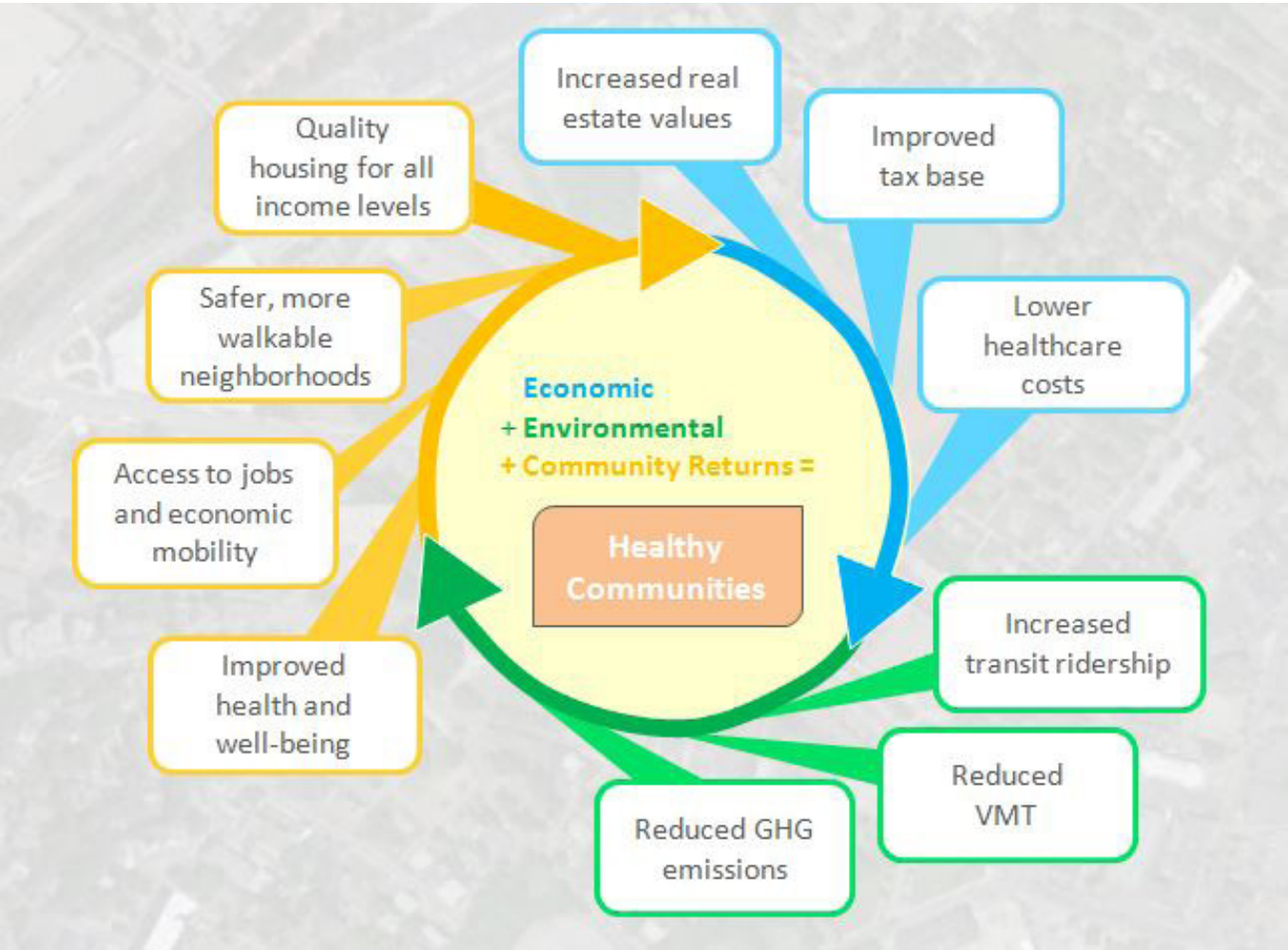


Figure 1: Healthy Neighborhoods Equity Fund Diagram

Part I

Healthy Neighborhoods Equity Fund

The Healthy Neighborhoods Equity Fund (HNEF) is a proposed $30 million private equity fund put forth by the Conservation Law Foundation (CLF) and Massachusetts Housing Investment Corporation (MHIC). The purpose of the fund is to invest patient capital in transformative mixed-income, mixed-use real estate projects in emerging markets in Massachusetts. The fund is designed to accelerate financing by bringing future value forward and providing 5-25% of overall project financing. The HNEF will utilize a blended capital stack of public, institutional, impact investors, and traditional private equity. The HNEF seeks to accomplish the following goals:

- Attract new sources of private equity to support moderately priced and market-rate housing, local job creation, commercial development, and healthy, walkable, mixed-use neighborhoods in a variety of TOD settings;
- Align equity investments with other sources of funds, including state housing, economic development, and infrastructure dollars, in order to catalyze and accelerate the development of high-impact TOD projects along key transit corridors.

The HNEF is based on a socially responsible investment model that takes into consideration the community, environmental, and health benefits of a potential project as well as the financial risks and returns (Figure 1). Since social, environmental, and health investments offer returns for the long-term, the fund is being designed to provide up-front financing to capture these future benefits of TOD projects that promote positive community health outcomes and provide economic opportunity for community residents. Therefore, this equity fund seeks to provide new capital from private equity, philanthropic, and high net-worth social impact investors that can enable larger-scale TOD projects to move forward that would not otherwise be feasible in a transitional real estate market.

Healthy Neighborhoods Equity Fund Health Impact Assessment

The Metropolitan Area Planning Council (MAPC), in partnership with the Massachusetts Department of Public Health (MDPH) and CLF, conducted a rapid Health Impact Assessment (HIA) to explore the relationship between TOD and health for the purpose of informing the development of the HNEF.

The goal of this HIA is to help define the health-related metrics of the HNEF by using three TOD projects, and their cumulative impacts, in the Roxbury/Mission Hill area, Bartlett Place, Madison Tropical Parcel 10, and Parcel 25, as case studies. Additionally, the process of the HIA will inform interested developers and potential supporters about the anticipated social and economic changes that could result from HNEF supported projects.

These three TOD projects were selected by CLF because they are generally consistent with the types of developments the HNEF is looking to fund. However, there are no financial relationships between the developers and CLF, MAPC, or MDPH.

Transit Oriented Development

Transit-Oriented Development (TOD) is a type of development that includes a mixture of housing, office, retail, and other amenities integrated into a walkable neighborhood and located within a half-mile of quality public transportation (Reconnecting America 2013).TOD has been gaining attention in recent years because there is an emerging trend that people want to live, work, shop, and play in more walkable neighborhoods that also have access to quality public transportation services. This is predicated upon market shifts in urban versus suburban living as well as younger people making conscious choices not to drive and to rely on other means of transportation. Creating these neighborhoods through TOD has potential public health benefits including:

- Reduced household driving and lowered regional congestion and air pollution, including greenhouse gas emissions (e.g., carbon dioxide, etc.)
- Walkable communities that accommodate healthy and active lifestyles
- Improved access to jobs and economic opportunity for low-income people and working families (Reconnecting America 2013)

Decision-Makers and Decision-Making Process

CLF and MHIC are in the process of developing a framework for the fund, project selection criteria, and community health objectives and indicators of interest. The launch date of the fund is anticipated to be at the end of 2013 or beginning of 2014.

Health Impact Assessment

HIAs aim to describe the potential health effects of plans, policies, or programs (National Research Council 2011). This is a rapid HIA, not a comprehensive HIA, due to its short timeframe and limited resources, which narrowed the scope's breadth of issues and level of analysis. To assess how the three TOD projects— Bartlett Place, Madison Tropical Parcel 10, and Parcel 25—might impact health and how these impacts should inform the HNEF health metrics, MAPC:

- Met with residents, developers, public health officials, non-profit groups, and other stakeholders to discuss ways the developments could impact health;
- Reviewed public health, built environment, transportation, and housing literature to understand how changes due to the developments relate to known determinants of health;
- Used recent street segment audits to measure the condition of the areas that will be impacted directly by development, as well as the surrounding neighborhoods, and;
- Worked with DPH, the Boston Public Health Commission, and the City of Boston Health in All Policies Task Force to gather health data on neighborhoods that will be impacted by development.

HIA Process

The standard steps of an HIA include screening, scoping, assessment, recommendations, reporting, and monitoring.

Screening

Screening determines the value and need of HIA by determining if the HIA will inform the decision-making process and whether or not there is a potential for significant health impacts of the proposed policy/plan/project. The screening process for this HIA took place in December 2012 and involved a selection process at Massachusetts Department of Public Health (DPH). The HNEF HIA was one of three policy/projects chosen to be completed in the summer of 2013. The project was chosen because of its potential to broadly inform funding streams for future development projects that consider health-related impacts.

Scoping

The objective of scoping is to create a plan and timeline for conducting an HIA that identifies priority issues, research questions, methods, and participant roles. This HIA scoping process was initiated in February 2013 with a scoping session in Roxbury. This session educated community stakeholders about the process and steps of HIA, discussed a variety of roles for stakeholders to play in the process, and described how HIA can be effectively used with the three proposed projects and the HNEF. This was a critical point for this HIA because the stakeholders' priority issues determined what this HIA studied and assessed. While income inequality and the local economy surfaced as a priority for the scoping session attendees, there was one important topic, race and its relation to health, that we did not address fully due to the scope, timeline, and resources for this HIA. One example framework that outlines race's relation to health is the Boston Public Health Commission's Healthy Equity Framework (http://www.bphc.org/about/research/Forms%20%20Documents/HOB12-13Docs/A_HOB12-13_Intro_Section.pdf). This framework could be useful in the continued development of the HNEF.

Assessment and Recommendations

Assessment provides a profile of existing conditions and evaluates the potential health impacts of the three proposed TOD projects. To conduct the assessment with the time and resources available for this HIA, we focused on accessible secondary resources with the guidance of our stakeholders. Assessments (Part II) are followed by evidence-based recommendations (Part III) to mitigate negative and maximize positive health impacts of the project.

Reporting

Reporting communicates the findings and recommendations gleaned during the HIA process to stakeholders and decision makers. The report considers the nature and magnitude of the health impacts and their distribution in the population. It summarizes the key health impact issues, and is followed by recommendations to improve heath determinants and outcomes.

Monitoring

Once HIA findings are disseminated in a report, the monitoring phase begins. The objective of monitoring is to review the effectiveness of the HIA process and evaluate the actual health outcomes as a result of the project.

Stakeholder Engagement

There are many ways in which TOD can affect health; therefore stakeholder engagement is essential to the HIA process because the stakeholders define what the HIA will assess. In February 2013, we held a scoping session in Roxbury with almost 50 stakeholders, including the TOD developers, residents, community development non-profits, and representatives from the City of Boston. Outreach to these stakeholders was conducted to ensure adequate representation from community residents and organizations. The scoping session provided an overview of the HIA, the HNEF and the developments that were serving as examples for the assessment. Stakeholders were engaged throughout the session to assist in making linkages between health outcomes and the developments and in prioritizing the health outcomes to be considered.

Based on the ideas and concerns contributed by stakeholders at the scoping session, we compiled a list of health determinants that we then shared back with stakeholders for comment through an online survey.

For additional stakeholder feedback, we presented to the City of Boston Health in All Policies (HiAP) Taskforce during the scoping phase to receive guidance on our approach. Feedback from the taskforce assisted us by guiding our scope and forming the foundation of our approach to the assessment. Together, the scoping session attendees and the Task Force became our Advisory Committee for this HIA. A table of our stakeholders can be found in Appendix A.

During the assessment stage, our Advisory Committee provided feedback on our initial approach, preliminary findings, methods, and data sources electronically. When preliminary findings were established, we presented again at the HiAP Taskforce to solicit feedback on our methodology and initial findings. Input received during this phase confirmed our approach to many of the pathways and helped us consider alternative methods and data for some of our pathways such as Affordable Housing and Walkability.

We also held a meeting with the developers as the HIA was concluding so that we could share our findings and discuss the role of the developments in the study area. Finally, we had technical experts in housing, transportation, and public health review our approach and methodology.

Roxbury/Mission Hill Neighborhood Profiles

Figure 2 below shows where the Roxbury and Mission Hill neighborhoods are located in Boston, approximately three miles from Downtown.

Roxbury

Nearly four square miles in size, Roxbury is a dense, majority-minority neighborhood where more than half of residents are Black or African American (Department of Neighborhood Development 2013). It is one of Boston's oldest neighborhoods and is home to a number of parks, schools, churches, and historic landmarks and architecture. The major public transit hub in Roxbury is Dudley Square bus station which serves 33,000-plus people each weekday ("Mission 180 Community Contract" 2013). Additional-

ly, the Roxbury Crossing and Ruggles stations on the Massachusetts Bay Transportation Authority's (MBTA) Orange Line subway service are located in Roxbury.

Mission Hill

Mission Hill is a one square mile, primarily residential neighborhood in which residents co-exist with the region's largest hospital complex, the Longwood Medical and Academic Area (LMA). The LMA, which is a medical, research and academic campus that comprises about a quarter of the neighborhood, employs 37,000 people and has more than 52,000 people working or studying in the area on a weekday (Mission Hill Neighborhood Housing Services 2013). Mission Hill has a significant college and university age population – 40% of its population, over twice the percentage of both Boston and Roxbury's college age population (Table 1).

Table 1: Population by Age in Roxbury, Mission Hill, and Boston

	ROXBURY		MISSION HILL		BOSTON	
Age Range	Count	Percent	Count	Percent	Count	Percent
0-17	12,090	25%	1,977	12%	103,710	17%
18-24	8,667	18%	6,733	40%	120,011	19%
25-34	6,775	14%	2,632	16%	128,084	21%
35-64	17,050	35%	3,760	22%	203,552	33%
65+	4,529	9%	1,772	11%	62,237	10%

Source: Census 2010

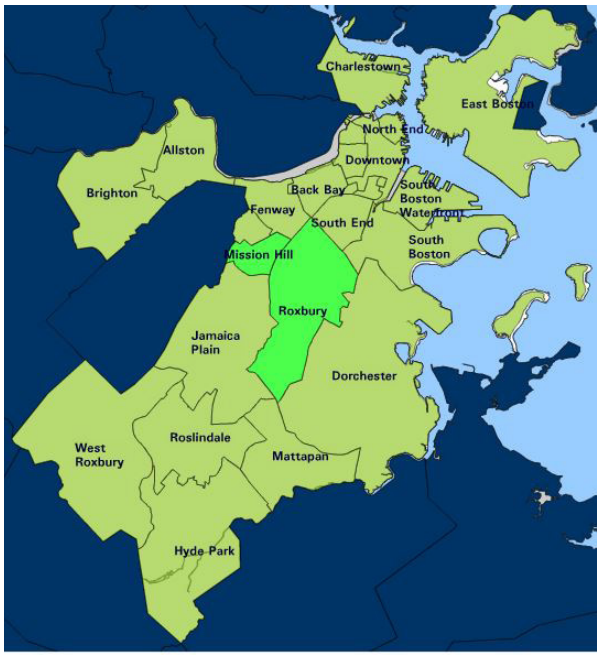


Figure 2: Roxbury and Mission Hill Neighborhoods

Mission Hill's population of 16,305 is racially and economically diverse (Boston Redevelopment Authority 2013). In addition to being served by various bus routes, the E Branch of the MBTA Green Line runs through Mission Hill.

Roxbury and Mission Hill Neighborhood Characteristics

Table 2 shows neighborhood characteristics[1] of Roxbury, Mission Hill, and Boston. Roxbury and Mission Hill have high percentages of renter-occupied units and lower median household incomes as compared to Boston.

1 While there are various definitions of neighborhoods and their boundaries in Boston, we chose to use the Boston Redevelopment Authority's definition.

Table 2: Neighborhood Characteristics

	ROXBURY	MISSION HILL	BOSTON
2010 Population	48,454	16,305	617,594
Occupied Housing Units	17,291	6,230	247,621
Average Household Size of All Occupied Units	2.5	2.3	2.3
Owner-Occupied Housing Units	3,850 (22.3%)	623 (10%)	85,756 (34.6%)
Average Household Size of Owner-Occupied Units	2.7	2	2.4
Renter-Occupied Housing Units	13,441 (77.7%)	5,607 (90%)	161,865 (65.4%)
Average Household Size of Renter-Occupied Units	2.5	2.4	2.2
Vacant Housing Units	1,511 (7.6%)	296 (4.5%)	19,782 (7.3%)
Median Household Income	$27,480	$33,291	$50,866
Households with No Vehicle Available	7,457 (44.4%)	3,332 (52.3%)	88,293 (35.9%)
Unemployment Rate	10%	5%	10%
Labor Force Participation Rate	59%	63%	69%

Source: ACS 06-2011 and Census 2010; BRA Research Division Analysis

To further understand the population of Roxbury and Mission Hill, we gathered population and average income by race/ethnicity data (Table 3). Over half of Roxbury's population is Black or African American and nearly one third are Hispanic or Latino.

Table 3: Population and Average Income by Race/Ethnicity

	ROXBURY		MISSION HILL		BOSTON	
	Population	Average Income	Population	Average Income	Population	Average Income
White	6.5%	$62,172	54.4%	$58,778	47%	$99,707
Black or African American	55.6%	$44,191	18%	$34,977	22.4%	$50,829
Hispanic or Latino	29.8%	$32,405	19.7%	$26,850	17.5%	$46,101
American Indian and Alaska Native	0.4%	N/A	0.6%	N/A	0.2%	$39,044
Asian	1.2%	$44,234	14.9%	$48,274	8.9%	$62,955
Native Hawaiian and Other Pacific Islander	0.0%	N/A	0.0%	N/A	0.0%	$76,191
Some Other Race	3.1%	$36,357	8.1%	$28,792	1.6%	$43,475
Two or More Races	3.2%	$32,973	4%	$33,950	2.4%	$66,574

Source: Census 2010; BRA Research Division Analysis

Due to the age demographics of the area, we also considered age and average income along with educational attainment (Tables 4 and 5). Roxbury has lower average incomes by age and lower educational attainment while Mission Hill's educational attainment is similar to the trend in Boston as a whole.

Table 4: Average Household Income by Householder Age

	ROXBURY	MISSION HILL	BOSTON
Less than 25	$29,325	$43,016	$37,094
25 - 44	$37,604	$60,849	$89,192
45 - 64	$37,443	$48,313	$88,392
Over 65	$27,251	$18,999	$53,702

Source: ACS 2007-2011

Table 5: Neighborhood Educational Attainment

	ROXBURY	MISSION HILL	BOSTON
Less than High School	26%	20%	16%
High School	30%	22%	23%
Some College	19%	15%	14%
Associates Degree	6%	6%	5%
Bachelors or higher	19%	39%	43%

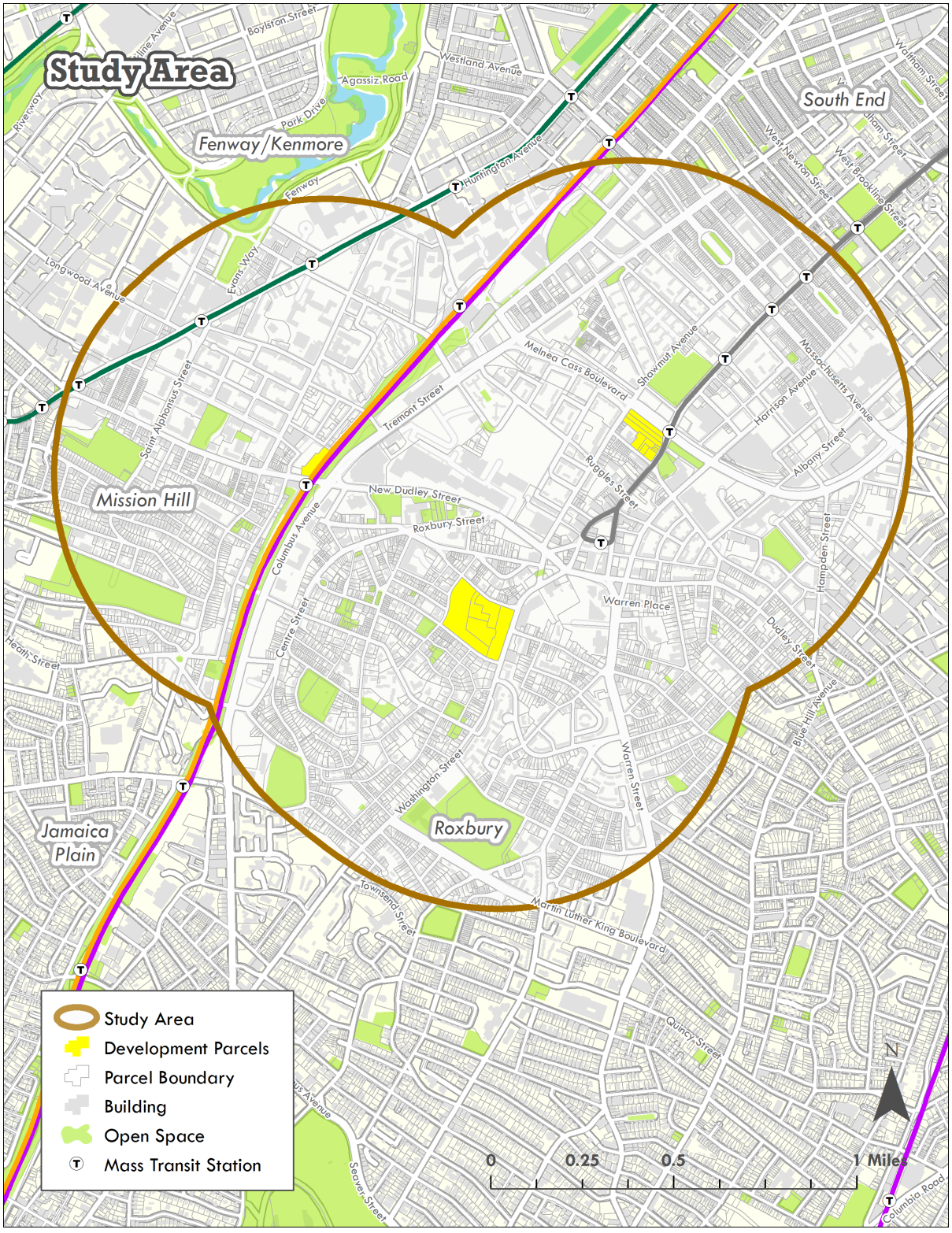
Source: ACS 2006-2010

Transit-Oriented Development Projects

As mentioned previously, the primary goal of this HIA is to pilot a process that could inform the health-related metrics of the HNEF. This pilot focuses on Bartlett Place, Madison Tropical Parcel 10, and Parcel 25 because they exemplify the type of development the HNEF seeks to support. We base our analyses on a study area which is a half-mile radius around the three TOD projects because many urban planners believe this is the relevant distance individuals are willing to walk from their homes (Agrawal, Schlossberg, and Irvin 2008; Rundle et al. 2009; Cervero 2006) (Figure 3). With this study area, we tried to analyze an area that serves as a good approximation of "neighborhood." The three developments are proximate to the Orange Line's Roxbury Crossing subway stop, Ruggles commuter rail/subway station, or the Dudley Square bus station. Each project involves a certified Community Development Corporation (CDC).

Project Notification Forms (PNFs) describe basic information about proposed large projects in the City of Boston, and detail the projects' consistency with zoning, proposed site and building features, existing and proposed transportation conditions, environmental impacts and proposed mitigation, and urban design elements. We used PNFs to glean development information for Bartlett Place and Madison Tropical Parcel 10 projects. A PNF was not available for Parcel 25 so development information was collected from the project's executive summary sheet from Mission Hill Neighborhood Housing Services and other project materials available for review.

Figure 3: Study Area



Bartlett Place

Nuestra Comunidad Development Corporation and its partner, Windale Developers, are the developers for this proposed mixed-use development that includes residential, retail, and commercial elements. The proposed development is located on an approximately 8.6 acre Brownfield site at 2556 Washington Street in Roxbury, which is a former MBTA bus yard (Figure 4).

Bartlett Place aims to be Leadership in Energy and Environmental Design for Neighborhood Development-certifiable (LEED-ND) and is intended to create a sustainable mixed-income community that bridges several of Roxbury's neighborhoods, which are located in the vicinity of the Dudley Square Station. The project will be divided into four phases that will take place over a period of up to ten years. Over this build out period, 54,000 square feet of commercial/retail space will bring new shopping opportunities and jobs to the area, 323 residential units will provide a variety of new homes from apartment buildings to townhomes, 328 new parking spaces, and a 15,500 square foot public event plaza can serve as a community gathering space.

Of the 323 residential units, about half will be a combination of affordable housing, senior housing, and live-work units while the other half will be market rate (Nuestra Comunidad Development Corporation 2013). Table 6 shows the breakdown of the development concept, including the proposed residential units.

Figure 4: Bartlett Place Site Design

Table 6: Bartlett Place Development Concept

DEVELOPMENT CONCEPT	
Commercial Space	22,153 square feet
Retail Space	31,322 square feet
Residential Units	323 units
Affordable	60 units
Market Rate	107 units
Elderly Housing	35 units
Live-Work Units	36 units
Townhomes	85 units
Public Space	15,500 square foot public plaza

Source: Bartlett Place PNF

The construction and the creation of new commercial space are projected to bring a total of about 600 jobs to the area, 200 of which are expected to be permanent. The total investment for this development will be approximately $140 million.

Madison Tropical Parcel 10

The Madison Park Development Corporation and Tropical Food International have proposed to redevelop Parcel 10, located three blocks from Dudley Square Station at the intersection of Melnea Cass Boulevard and Washington Street (Figure 5).

Figure 5: Tropical Food Rendering

The developers proposed to merge the two-acre Parcel 10 with the 2102 Washington Street property, which is the current site of Tropical Foods grocery. Recognizing the opportunity to expand Tropical Foods grocery and to reinvent the area into a mixed-use development, the Madison Tropical Parcel 10 proposal contains three buildings (Buildings A, B, and C) with a network of pedestrian walkways that connect with the Complete Streets project along Melnea Cass Boulevard. The ground floor of Building A will be the site for the newly expanded 44,000 square foot Tropical Foods, and its second floor will be used for warehousing and office space. Building B will be a new mixed-use retail and office building which will have 12,000 square feet of ground floor retail space and a total of 47,000 square feet of office space on floors 2 through 5. Finally, Building C will be a mixed-use residential and retail building. The ground floor of building C will house 7,800 square feet of retail space and 30 residential units on floors 2 through 4. Twelve units (40%) will be affordable at 60% of the Area Median Income (AMI) and the remaining 18 will be market rate (Table 7). This project is also expected to create 588 new jobs and other economic development opportunities.

Table 7: Madison Tropical Parcel 10 Development Concept

DEVELOPMENT CONCEPT	
Tropical Foods	44,000 square feet
Retail Space	19,800 square feet
Office Space	47,000 square feet
Residential Units	30 units
≤60% AMI	12 units
Market-rate	18 units

Source: Madison Tropical Parcel 10 PNF

This project is expected to take place in three phases—one for each building—where Building A will be constructed first, followed by Building B, and finally Building C. The buildout period is expected to last a little under three years with a projected end date of June 2016. The total investment for Madison Tropical Parcel 10 will be $44 million.

Parcel 25

Mission Hill Neighborhood Housing Services is the developer for Parcel 25, which is located at the intersection of Columbus Avenue, Tremont Street, and Gurney Street, across from the Roxbury Crossing Orange Line MBTA station (Figure 6).

Figure 6: Parcel 25 Rendering

Parcel 25 will transform what is currently a vacant lot into 200,000 square feet of office, retail space, and multipurpose community space, 104 residential units, and 242 parking spaces. The retail space will include 8-12 new smaller neighborhood-serving retail stores and restaurants that will be subsidized by the development to ensure economic viability. The vision for Parcel 25 emphasizes sustainability with a design that is slated to include green roofs and energy efficiency, and walkability with streetscape improvements, including the addition of trees, improved sidewalks, and pedestrian pathways connecting the development to the surrounding area (Mission Hill Neighborhood Housing Services 2013).

The development will include a signature community building with a non-profit office and multipurpose function rooms that can serve as community space. All of the residential units will be affordable and will be made up of 32 townhomes, 36 condominiums, and 36 senior rental units for low-income seniors (Table 8). The total investment for this development will be $95 million.

Table 8: Parcel 25 Development Concept

DEVELOPMENT CONCEPT	
Retail Space	16,500 square feet
Office Space	175,000 square feet
Residential Units (all affordable)	104 units
Townhomes	32 units
Condominiums	36 units
Senior Rental	36 units
Multipurpose Community Space	7,500 square feet

Source: Parcel 25 Executive Summary

Study Area Health Profile

Thus far in Part I, we introduced the HNEF and HIA, and provided background information about the Roxbury and Mission Hill neighborhoods and the three proposed TOD projects. In this section, we compiled a baseline health profile focused on health indicators for the study area that are relevant to the assessment phase of this report. This was done in order to understand how these projects may impact health. This was done for the study area because we focused on the study area throughout the assessment in Part II of the report.

The study area is considered an Environmental Justice site. All three Environmental Justice criteria are found in the study area (English language isolation, minority population, and low income) however, only a portion meets all three. Environmental justice is based on the principle that all people have a right to be protected from environmental pollution and to live in and enjoy a clean and healthful environment. These communities are defined as U.S. Census block groups that meet one or more of the following criteria: 1) the median annual household income is at or below 65% of the statewide median income for Massachusetts, 2) 25% of the residents are minority or 25% of residents are foreign born, or 3) 25% of residents are lacking English language proficiency.

Table 9 below shows the breakdown of health risk factors for the study area (represented by one zip code) and Boston from the state Behavioral Risk Factor Surveillance System (BRFSS). The state BRFSS is an annual telephone survey that collects data on health conditions, risk factors, and behaviors. We were also able to obtain small area estimates from the BRFSS for one zip code (02119) in the study area. Small area estimates can be derived from the state BRFSS in locations where responses were high enough to aggregate three to five years of data to make the estimate stable. These data show that the prevalence of all of the risk factors are significantly higher in the study area/02119 than Boston as a whole. Over half of the adults in the study area lack regular physical activity, a well-known risk factor for many chronic diseases, 40% are obese, and nearly a third smoke. In Boston, 22% of adults are obese, only 19% smoke, and 46% lack regular physical activity.

Table 9: State BRFSS Data for the Study Area and Boston

	STATE BRFSS SMALL AREA ESTIMATES FOR 02119 (2005, 2007, 2008, 2009, 2010) (95% CONFIDENCE INTERVAL)		BRFSS FOR BOSTON 2011 (95% CONFIDENCE INTERVAL)	
Adult Smoking	28.7%	(23.1-34.9)	18.9%	(17.4-20.5)
Adults Lacking Regular Physical Activity	57.9%	(51.3-64.3)	45.6%	(43.4-47.8)
Adult Obesity	39.9%	(33.9-46.2)	21.9%	(20.0-23.9)
Adult Diabetes	16.7%	(13.3-20.6)	N/A	
Adults Eating 5 Fruits/ Vegetables per Day	19.7%	(15.5-24.6)	25.6%	(23.4-27.9)
Adult Hypertension	35.2%	(30.5-40.3)	N/A	

Source: BRFSS; MDPH Analysis

The Boston Behavioral Risk Factor Surveillance System (Boston BRFSS) is modeled after the BRFSS, but is a slightly different survey. Table 10 shows that the Boston BRFSS data for Roxbury (the smallest area for which these data are available) and Boston. Although, the Boston BRFSS shows that Roxbury has higher rates of adult smoking, adults lacking regular physical activity, and adult obesity, these differ-

ences are not statistically significant. In addition, the results from the state BRFSS data indicate larger differences between the zip code 02119 and Boston compared to the results of the 2011 Boston BRFSS data. The Boston BRFSS also has data on adult asthma and persistent sadness. Adult asthma prevalence in Roxbury is slightly higher than the city as a whole (though not statistically significant), but persistent sadness is about the same.

Table 10: Boston BRFSS for Roxbury and Boston

	BOSTON BRFSS FOR ROXBURY 2010 (95% CONFIDENCE INTERVAL)		BOSTON BRFSS FOR BOSTON 2010 (95% CONFIDENCE INTERVAL)	
Adult Asthma	15%	(6.6-23.8)	11%	(9.5-12.4)
Persistent Sadness	10%	(4.5-16.3)	9%	(8.1-10.7)
Adult Smoking	18%	(11.2-24.3)	16%	(14.0-17.3)
Adults Lacking Regular Physical Activity	49%	(40.8-61.5)	43%	(41.7-46.3)
Adult Obesity	27%	(17.4-35.9)	21%	(18.9-22.7)
Adult Diabetes	11%	(6.4-15.2)	6%	(5.4-7.0)

Source: Boston BRFSS 2010; BPHC Analysis

Table 11 below shows the breakdown of hospitalizations by race/ethnicity for the study area and compares it to the larger region. The study area's leading causes of hospitalization from 2010-2012 were cardiovascular disease (1,417.3 per 100,000 vs. 1503.0 per 100,000 for Boston), mental health (929.1 per 100,000 vs. 879.8 per 100,000 for Boston), and asthma (378.3 per 100,000 vs. 278.4 per 100,000 for Boston). For cardiovascular and asthma hospitalizations, Black/African American Non-Hispanics had the highest hospitalization rates (2,359.3 per 100,000 and 629.5 per 100,000 respectively) while Whites had the highest hospitalization rate for mental health (1,417.8 per 100,000). For the outcomes shown in Table 11, nearly all the differences were not statistically significant. The exceptions are cardiovascular disease among Whites (higher in Boston than study area) and mental health hospitalizations among Whites (higher in study area than Boston).

Table 11: Hospitalization Data for the Study Area and Boston

	STUDY AREA (ZIPCODES 02118, 02119, 02120) (95% CONFIDENCE INTERVAL)			BOSTON (95% CONFIDENCE INTERVAL)	
	Count	Rate Per 100,000 (95% Confidence Interval)		Count	Rate Per 100,000 (95% Confidence Interval)
Cardiovascular Disease Hospitalizations					
Total	2720	1417.3 (1257.5, 1577.1)		25179	1503.0 (1447.3, 1558.6)
Black/African American non Hispanic	1503	2359.3 (2001.5, 2717.1)		8318	1976.2 (1848.8, 2103.6)
White	475	839.7 (613.2, 1066.3)		12103	1257.0 (1189.8, 1324.2)
Hispanic	549	1251.0 (937.1, 1565.0)		2855	1118.4 (995.4, 1241.5)
Mental Health Hospitalizations					
Total	1783	929.1 (799.7, 1058.5)		14739	879.8 (837.2, 922.4)
Black/African American non Hispanic	521	817.8 (607.2, 1028.5)		3491	829.4 (746.8, 911.9)
White	802	1417.8 (1123.5, 1712.2)		8179	849.5 (794.2, 904.7)
Hispanic	265	603.9 (385.7, 822.0)		1589	622.5 (530.7, 714.3)
Asthma Hospitalizations					
Total	726	378.3 (295.7, 460.9)		4664	278.4 (254.4, 302.4)
Black/African American non Hispanic	401	629.5 (444.6, 814.3)		2156	512.2 (447.4, 577.1)
White	94	166.2 (65.4, 267.0)		962	99.9 (81.0, 118.9)
Hispanic	198	451.2 (262.6, 639.7)		1208	473.2 (393.2, 553.3)
Diabetes Hospitalizations					
Total	422	219.9 (157.0, 282.8)		2564	153.0 (135.3, 170.8)
Black/African American non Hispanic	232	364.2 (223.6, 504.8)		1246	296.0 (246.7, 345.3)
White	56	99.0 (21.2, 176.8)		747	77.6 (60.9, 94.3)
Hispanic	117	266.6 (121.7, 411.5)		427	167.3 (119.7, 214.9)
Stroke Hospitalizations					
Total	404	210.5 (148.9, 272.1)		3880	231.6 (209.7, 253.5)
Black/African American non Hispanic	235	368.9 (227.4, 510.4)		1312	311.7 (261.1, 362.3)
White	55	97.2 (20.1, 174.3)		1723	179.0 (153.6, 204.3)
Hispanic	70	159.5 (47.4, 271.6)		467	182.9 (133.2, 232.7)
Coronary Heart Disease Hospitalizations					
Total	386	201.1 (140.9, 261.3)		3934	234.8 (212.8, 256.8)
Black/African American non Hispanic	186	292.0 (166.1, 417.9)		1010	240.0 (195.6, 284.3)
White	79	139.7 (47.3, 232.1)		2131	221.3 (193.1, 249.5)
Hispanic	90	205.1 (78.0, 332.2)		467	182.9 (133.2, 232.7)
Chronic Obstructive Pulmonary Disease Hospitalizations					
Total	371	193.3 (134.3, 252.3)		3019	180.2 (160.9, 199.5)
Black/African American non Hispanic	189	296.7 (169.8, 423.6)		707	168.0 (130.8, 205.1)
White	125	221.0 (104.8, 337.2)		2011	208.9 (181.5, 236.2)
Hispanic	N/A			158	61.9 (32.9, 90.9)

Source: MDPH Hospitalization Data; MDPH Analysis

Table 12 shows that emergency department visits in the study area for mental health and asthma were substantially higher than Boston: 8,417.5 per 100,000 vs. 3,255.6 per 100,000 and 1,554.9 per 100,000 vs. 902.0 per 100,000 respectively. Consistent with the hospitalization data, whites had the highest rate of mental health emergency department visits (12,014.5 per 100,000) and Black/African American Non-Hispanics had the highest asthma emergency department visits (2,582.2 per 100,000).

Table 12: Emergency Department Data for the Study Area and Boston

	STUDY AREA (ZIPCODES 02118, 02119, 02120)			BOSTON	
	Count	Rate Per 100,000 (95% Confidence Interval)		Count	Rate Per 100,000 (95% Confidence Interval)
Mental Health Emergency Department Visits					
Total	16154	8417.5 (8028.1, 8806.9)		54541	3255.6 (3173.6, 3337.6)
Black/African American non Hispanic	5709	8961.6 (8264.2, 9659.0)		17067	4054.7 (3872.2, 4237.2)
White	6796	12014.5 (11157.6, 12871.5)		25987	2699.0 (2600.6, 2797.5)
Hispanic	3058	6968.4 (6227.4, 7709.3)		8415	3296.5 (3085.2, 3507.9)
Asthma Emergency Department Visits					
Total	2984	1554.9 (1387.5, 1722.3)		15112	902.0 (858.9, 945.2)
Black/African American non Hispanic	1645	2582.2 (2207.9, 2956.6)		7928	1883.5 (1759.1, 2007.9)
White	288	509.1 (332.7, 685.6)		2556	265.5 (234.6, 296.3)
Hispanic	930	2119.2 (1710.6, 2527.8)		3713	1454.6 (1314.2, 1594.9)
Asian	N/A			267	201.0 (128.7, 273.3)

Source: MDPH Emergency Department Visit Data; MDPH Analysis

Additionally, pediatric asthma was available for the schools within the study area and the study area has higher pediatric asthma prevalence (14.7%) than Boston as a whole (13.9%) (Table 13). Although data were only available at the municipal level, Boston has a statistically significantly higher prevalence of children with type 2 diabetes (50 per 100,000 vs. 16 per 100,000 statewide). It should be noted that many students live outside the study area due to large assignment zones, so estimates may not reflect a pure measure of residents of the study area.

Table 13: Pediatric Asthma Prevalence in Study Area Schools

STUDY AREA SCHOOLS	PEDIATRIC ASTHMA PREVALENCE (95% CONFIDENCE INTERVAL)
Nathan Hale	18.5% (12.5 – 24.5)
Orchard Gardens	6.6% (4.7 – 8.6)
Maurice J Tobin	15.2% (11.6 – 18.8)
Higginson	21.5% (14.6 – 28.4)
James P Timilty Middle	21.8% (18.6 – 25.0)
Dearborn	2.8% (1.1 – 4.5)
O'Bryant School of Math/Science	7.4% (4.5 – 10.3)
Mission Hill School	23.6% (17.2 – 30.1)
Study Area Average	14.7%

Source: Environmental Public Health Tracking Network 2007-2008

Finally, we looked at blood lead prevalence in children in the study area (Table 14).

Table 14: Prevalence of Children 9 to 47 Months with Blood Lead Level ≥ CDC Reference Level of 5 µg/dL and Average Percentage of Children Screened in 7 Roxbury Census Tracts Including and Surrounding the Development Sites (2001-2009)

CENSUS TRACT	AVERAGE PERCENTAGE OF CHILDREN SCREENED[2]	BLOOD LEAD PREVALENCE PER 1,000 POPULATION (95% CONFIDENCE INTERVAL)[3]	STATISTICAL SIGNIFICANCE OF DIFFERENCE FROM STATEWIDE PREVALENCE
010300	25%	144.7 (105.2 – 184.3)	Statistically significantly lower
080400	≥99.9%	159.7 (117.4 – 202.0)	Not statistically significantly different
080500	≥99.9%	118.1 (99.4 – 136.8)	Statistically significantly lower
080600	64%	123.8 (87.9 – 159.7)	Statistically significantly lower
080800	≥99.9%	118.2 (75.5 – 160.8)	Statistically significantly lower
081400	83%	275.9 (233.9 – 317.9)	Statistically significantly higher
081700	81%	252.6 (219.5 – 285.8)	Statistically significantly higher
Statewide	78%	192.5 (191.6 – 193.3)	Reference group

Lead exposure is of greatest concern for young children because children exposed to lead are at risk of neurological damage. The primary source of childhood lead exposure is lead paint in housing; however, other sources include lead-contaminated soil ingested by young children playing outdoors (due to their hand-to-mouth behavior). The federal Centers for Disease Control and Prevention (CDC) has identified a reference level of 5 micrograms per deciliter (µg/dL) at which it recommends public health actions be initiated to protect children's health. For 2 of the 7 census tracts (081400 and 081700) within Roxbury, the proportion of children 9 to 47 months of age with blood lead levels above the CDC reference level is statistically significantly higher than the proportion statewide. For the remaining 5 census tracts, the proportion is either not statistically significantly different or is lower than that for the state.

[2] From MA Environmental Public Health Tracking website
[3] Prepared by MDPH/BEH Childhood Lead Poisoning Prevention Program

Part II

In Part II, we discuss the specific pathways impacting health that stakeholders identified as most likely to be affected by the three TOD projects: Bartlett Place, Madison Tropical Parcel 10, and Parcel 25. For each pathway, we describe how the pathway may be related to the projects, explain our methodology for estimating the effect of the projects on the pathway, profile the existing conditions relevant to the pathway, evaluate how the projects will impact the pathway, and provide a summary on the overall impact of the projects on the pathway.

For the purposes of this HIA's assessment, we used data available for the study area (Figure 3 above) and Boston. Conducting this assessment revealed relevant data sources that are feasible and accurate for a small area analysis.

Pathways Linking TOD and Health

Pathways are used to consider links between the proposed change and health impacts. The pathways represent a systems approach to discovering the potential impacts that a change may cause, from immediate impacts to longer term health outcomes. The main pathways that the stakeholders identified through which the three developments might impact health include:

	1. Walkability/Active Transport		7. Social Cohesion
	2. Safety from Crime		8. Green Space
	3. Economic Opportunity		9. Access to Healthy Affordable Food
	4. Displacement/Gentrification		10. Safety from Traffic
	5. Affordable Housing		11. Air Quality
	6. Green Housing		12. Environmental Contamination

These pathways can lead to health and health-related outcomes such as obesity, stress, cardiovascular disease, respiratory disease, injuries, and premature mortality. The pathway diagram below shows an overview of the potential impacts and outcomes.

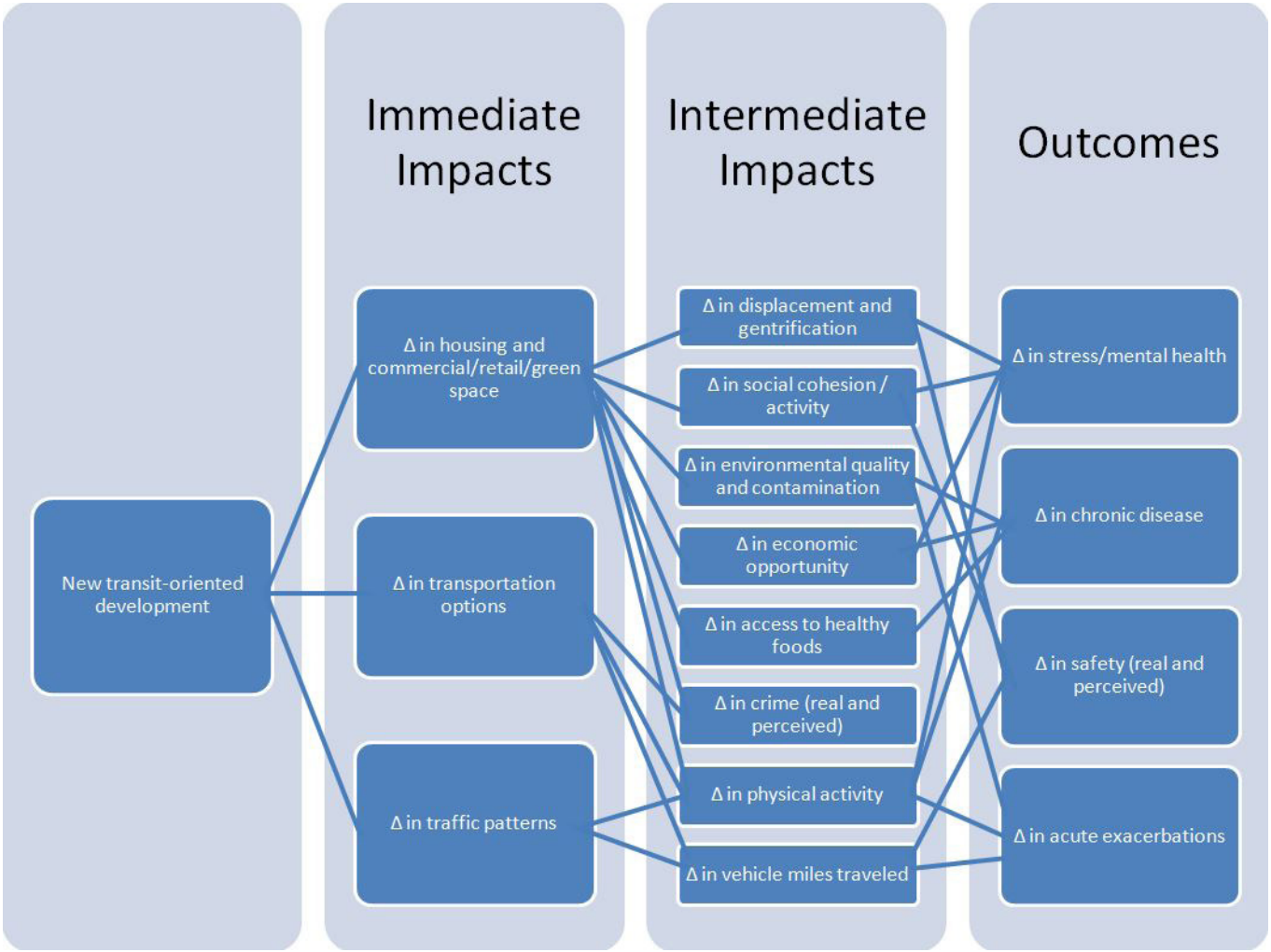


Figure 7: TOD and Health Pathway Diagram

1. Walkability/Active Transport

Background

The health benefits of physical activity have been well documented, yet less than half (48%) of all adults meet the Surgeon General's recommended 30 minutes of moderate intensity physical activity on most days of the week (Centers for Disease Control and Prevention 2010; Besser and Dannenberg 2005; Freeland et al. 2013). A recent study by Lee et al. (2012) estimates that physical inactivity causes 6% of the global burden of disease from coronary heart disease, 7% of type 2 diabetes, 10% of breast cancer, 10% of colon cancer, 9% of premature mortality. If inactivity were decreased by 10% to 25%, between 533,000 and 1.3 million deaths could be prevented every year.

In recent years, research has attempted to address this issue by working to understand the built environment and its connection to active transport, defined as walking, biking, and public transportation (which typically requires some walking or biking). For the most part, this literature is consistent in demonstrating that active transport correlates with many of TOD's characteristics including: density, mixed land-use, availability of destinations, design, and distance to transit (Ewing and Cervero 2010; Freeman et al. 2012; Giles-Corti et al. 2013; McCormack and Shiell 2011; Litman 2013). Supported by concepts from the field of transportation planning, land use patterns shape the proximity of destinations and transportation systems connect destinations, which together determine the feasibility of walking, cycling, or mass transit use. Neighborhoods that have higher population densities, access to destinations, more grid-like street patterns, and access to high quality bicycle and pedestrian infrastructure are positively associated with physical activity. Additionally, several studies show that walking to and from transit help people meet physical activity recommendations (Besser and Dannenberg 2005; Freeland et al. 2013; Lachapelle et al. 2011). Furthermore, there is emerging research that investigates TOD's efforts to reduce vehicle trips that has found that housing type and tenure, local and sub-regional density, bus service, and off- and on-street parking availability play a more important role than rail access (Chatman 2013).

In sum, there is convincing evidence that the built environment is associated with physical activity and active transport, although it is important to note that most studies are cross-sectional and observational (Ewing and Cervero 2010; Freeman et al. 2012; McCormack and Shiell 2011; Ding and Gebel 2012).

Methods

We conducted a literature review on the built environment and walkability/active transport in order to understand the relationship between what TOD would change in the built environment that would affect walkability/active transport and health. We collected mode to work, average vehicle miles traveled (VMT), and WalkScore™ data to identify baseline data, as well as transportation and parking plans from the projects' PNFs. We also calculated vehicle availability per household in one of the study area's zip codes (02119) and in Boston by multiplying the number of households by their respective vehicles available and dividing it by the total number of occupied housing units.

In addition to this, we had the opportunity to use State of Place walkability assessments, which were conducted for the three TOD projects. State of Place is a place-making and walkability diagnostic tool

intended to inform economic development, guide investment, and aid in place branding and enhancing of communities (Urban Imprint 2012). This tool, launched by Mariela Alfonzo in 2012, quantifies walkability and its economic impact based on over 165 on-the-ground built environment features that are empirically linked to walkability which are subsequently grouped into ten urban design principles (sub-indices). The ten sub-indices are:

Form/Layout	The relationship between buildings and the street
Density	Building height/compactness
Proximity	The presence of non-residential locations
Connectivity	Ease of movement between streets
Public Space/Parks	Access to quality public spaces and parks
Crime Safety	Features related to perceptions of safety/crime
Traffic Safety	Crossing ease and comfort
Aesthetics	Pleasurability and liveliness
Pedestrian Amenities	Features that allow for pedestrian comfort
Physical Activity Facilities	Physical activity and recreational facilities

The State of Place index is positively linked to significant economic premiums, including office and retail rents, retail revenues, and residential for-sale and rental values as revealed in a recent Brookings Institution study (Leinberger and Alfonzo 2012).

In December 2012, State of Place walkability assessments were conducted for all adjacent street segments to each TOD project and an additional 50% of street segments within a quarter mile radius of each project were selected at random and were surveyed for a total of 78 street segments in the study area. The surveyor walked these 78 street segments and conducted the State of Place survey which is composed of 162 points detailing many aspects of the physical characteristics of the street segment (see Appendix B for survey). The survey results were used in the State of Place algorithm, which provided the current conditions State of Place score (from 0-100) for:

1. The 78 individual street segments
2. The three sub-neighborhoods (the quarter mile radius around each development)
3. The study neighborhood (the combination of the three developments' sub-neighborhoods)

All of the State of Place scores for individual street segments, sub-neighborhoods, and the study neighborhood were normalized within the total "State of Place" proprietary range (which includes some of Washington DC and Austin, Texas). This means these scores represent the walkability index of that street segment, sub-neighborhood or neighborhood, relative to the full State of Place database.

In order to project how the neighborhood might change, a second survey was performed. This one was done virtually. The proposed developments were analyzed for their composition (land-use, functions, density, aesthetics, etc) and an updated survey was made for all segments that were adjacent to any of the three proposed developments. Then State of Place algorithm was run with these new data to create future scenarios.

Existing Conditions

Residents of the study area are more likely to use an active mode of transportation than Boston as a whole (Table 15). There is a lower percentage of people (34%) that take a car, truck, or van to work compared to Boston (46%), while more people in the study area take public transportation (35%), walk (24%), or bike (4%) than Boston (33%, 15%, and 2% respectively). The reduced reliance on driving is reflected in the average VMT per household. The average VMT per household per day in the study area is 25.5 while Boston's average is 28.1. Furthermore, the average WalkScoreTM for the study area is 83, which is categorized as very walkable (on a scale of 60-somewhat walkable to 97-walker's paradise).

Table 15: Mode to Work

	STUDY AREA		BOSTON	
	Estimate	Margin of Error	Estimate	Margin of Error
Car, truck, or van:	34%	3%	46%	1%
Public transportation (excluding taxicab)	35%	4%	33%	1%
Taxicab	0%	2%	0%	0%
Motorcycle	0%	2%	0%	0%
Bicycle	4%	3%	2%	0%
Walk	24%	4%	15%	1%
Other means	0%	3%	1%	0%
Work at home	3%	2%	3%	0%

Source: ACS 07-11, Universe: all workers over 16 who commute to work

Additionally, there are fewer vehicles available per household in the study area than Boston (Table 16). The current number of vehicles per occupied household is 0.74 in the study area and 0.90 vehicles per occupied household in Boston.

Table 16: Vehicles Available per Household

	STUDY AREA		BOSTON	
	Count	Percent	Count	Percent
Occupied Housing Units	9,735	100%	247,621	100%
No Vehicles Available	3,977	40.9%	89,499	36.1%
1 Vehicle Available	4,459	45.8%	104,522	42.2%
2 Vehicles Available	1,150	11.8%	43,005	17.4%
3 or More Vehicles Available	149	1.5%	10,595	4.3%

Source: ACS 07-11, Universe: Vehicles per Household

Finally, the State of Place current conditions score for the Bartlett Place, Madison Tropical Parcel 10, and Parcel 25 is 34 with pedestrian facilities and aesthetics receiving the highest sub-indices scores and safety from crime and traffic safety receiving the lowest sub-indices scores (Figure 8).

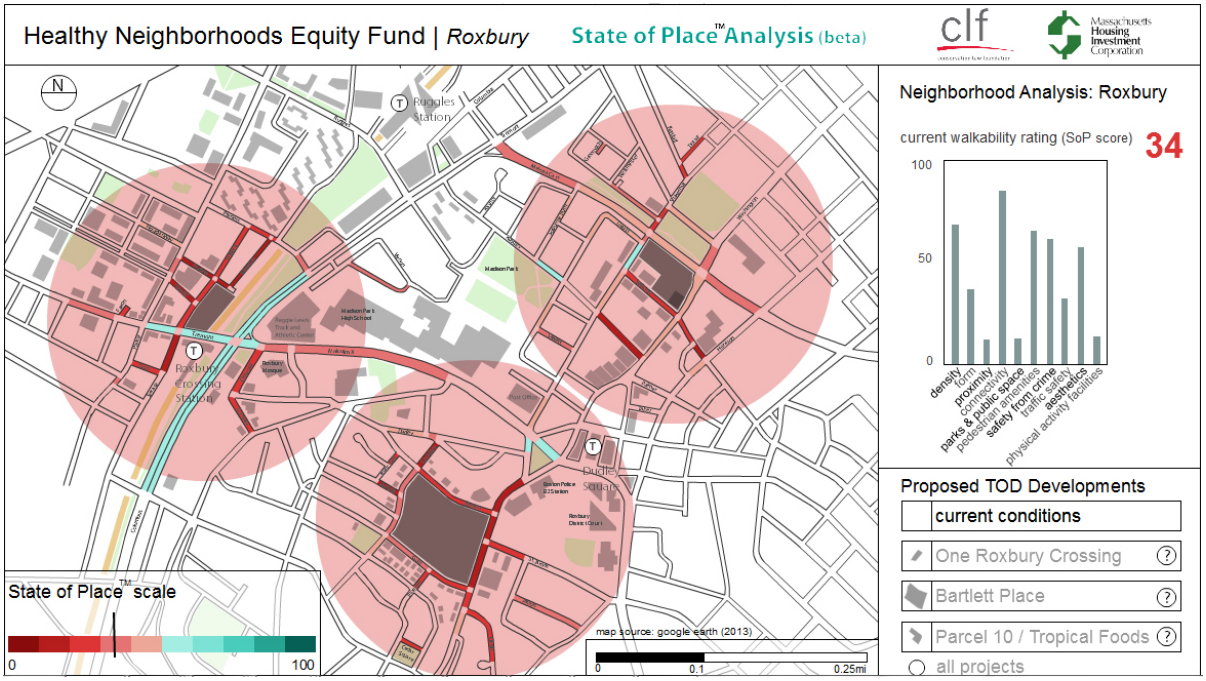


Figure 8: State of Place Current Conditions

Assessment

According to the State of Place projections, Bartlett Place, Madison Tropical Parcel 10, and Parcel 25 will improve walkability in the study area by approximately 18% (Figure 9). The new State of Place score is estimated to be 40 with the form, proximity, and pedestrian amenities sub-indices experiencing the most improvement.

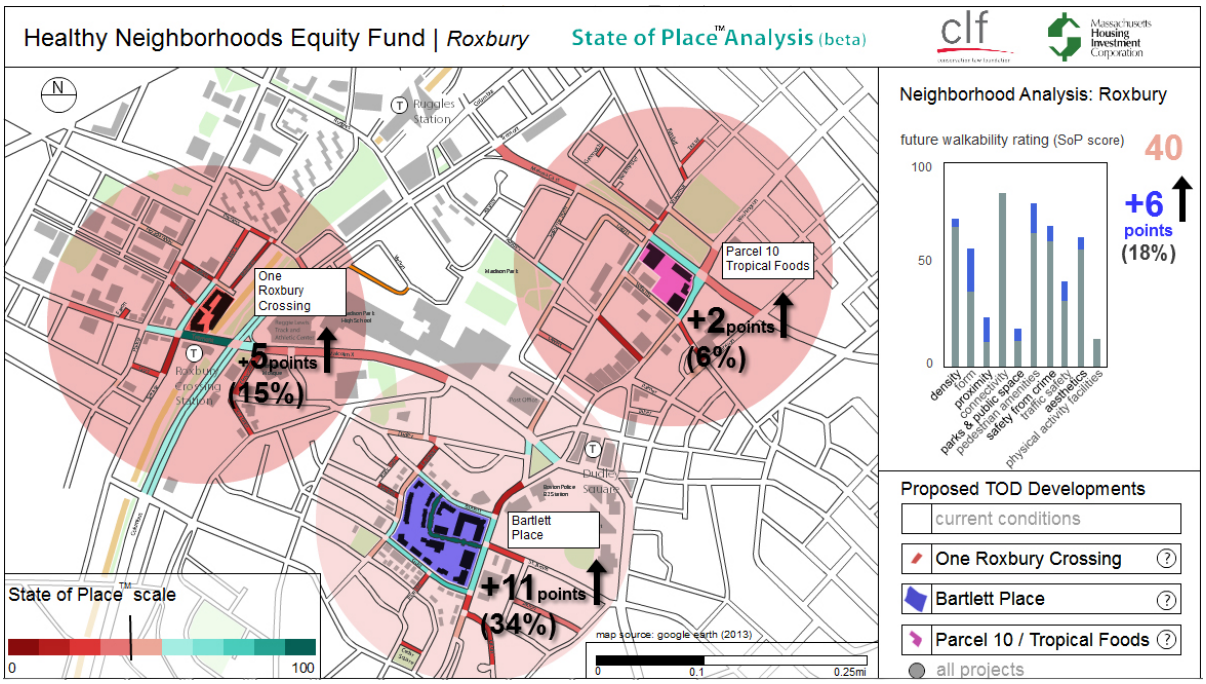


Figure 9: State of Place Projections

Although we cannot make assumptions about the physical activity levels of the new resident population because we do not know where they were living before moving to the developments, it is possible that current and future residents and employees of this area may take advantage of the walkable area and maintain or improve their physical activity levels. As the State of Place score reflects, the three TOD developments will improve walkability and will increase residential density and access to destinations which are associated with active transport. This, paired with the existing high active transport mode share in the study area, makes it likely that new and current residents will maintain or improve their physical activity through increased active transport.

Furthermore, Bartlett Place and Madison Tropical Parcel 10 will attempt to be LEED-ND certifiable. The LEED-ND certification emphasizes compact, connected neighborhoods located near existing developed areas and containing green buildings and infrastructure (USGBC 2013). A recent study suggests that vehicle miles travelled (VMT) per person trip for LEED-ND projects, ranges from 24 to 60 percent of their respective regional averages; and that the most urban and centrally located projects tended to achieve the highest alternative mode shares and lowest private vehicle trips (Ewing et al. 2013). Therefore, residents of Bartlett Place and Madison Tropical Parcel 10 may be more likely to use alternative modes of transportation and limit emissions from personal vehicles.

Finally, Tables 17 and 18 below summarize the Bartlett Place and Madison Tropical Parcel 10 transportation and parking plans (no data available for Parcel 25 at this time). These two projects are committed to implementing Transportation Demand Management (TDM) programs. The goal of TDM programs is to reduce drive-alone trips through strategies that encourage carpooling or use of alternative modes through strategies such as increasing the availability of bicycle and pedestrian accommodations, priority parking for carpools, vanpools, and car sharing programs, and reducing the availability of parking. While the TOD projects increase bicycle and pedestrian accommodations in the area, the developments assume higher rates of vehicle ownership than the current residential vehicle availability (0.74 parking spaces per households) which may potentially encourage people to drive instead of taking active transportation.

Table 17: Bartlett Place Transportation and Parking Plan

BARTLETT PLACE TRANSPORTATION AND PARKING	
Transit Access	MBTA Silver Line and local buses. Transit information and schedules will be posted in the lobbies of all buildings.
Bicycle Access	300 new bicycle parking spaces including 1 space per resident, possible Hubway station.
Pedestrian Access	Provided at all proposed vehicular access driveways and along a network of sidewalks within the project.
Parking	1 space per residential unit, 0.75 spaces per 1,000 square feet of non-residential parking.

Source: Bartlett Place PNF

Table 17: Bartlett Place Transportation and Parking Plan

BARTLETT PLACE TRANSPORTATION AND PARKING	
Transit Access	MBTA Silver Line and local buses. Transit information and schedules will be posted in the lobbies of all buildings.
Bicycle Access	300 new bicycle parking spaces including 1 space per resident, possible Hubway station.
Pedestrian Access	Provided at all proposed vehicular access driveways and along a network of sidewalks within the project.
Parking	1 space per residential unit, 0.75 spaces per 1,000 square feet of non-residential parking.

Source: Bartlett Place PNF

Table 18: Madison Tropical Parcel 10 Transportation and Parking Plan

MADISON TROPICAL PARCEL 10 TRANSPORTATION AND PARKING	
Transit Access	MBTA Silver Line, local buses.
Bicycle Access	Hubway station, indoor and outdoor bicycle racks.
Pedestrian Access	Sidewalk/streetscape improvements, internal landscaped walkways.
Parking	0.77 spaces per residential unit, 1 space per 1,000 square feet for office and local retail, 2.4 spaces per 1,000 square feet for Tropical Foods.

Source: Madison Tropical Parcel 10 PNF

Overall, the physical improvements proposed by the TOD projects will likely create a more walkable neighborhood and take steps to reduce driving trips and encourage physical activity through active transportation.

Summary

- The health benefits of physical activity have been well documented and there is convincing evidence that the built environment is associated with physical activity and active transport.
- Neighborhoods that have higher population densities, access to destinations, mixed-use development, bus service, lower on- and off-street parking availability, and access to high quality bicycle and pedestrian infrastructure are positively associated with physical activity.
- According to the State of Place projections, Bartlett Place, Madison Tropical Parcel 10, and Parcel 25 will improve walkability in the study area by approximately 18%.

2. Safety from Crime

Background

Well-lit and well-maintained walkable spaces with good visibility and access to shops, parks, and other amenities have been shown to reduce rates of crime and fear of crime (Foster, Giles-Corti, and Knuiman 2010; Hedayati Marzbali et al. 2012; Nasar and Jones 1997; Paulsen 2012; Dannenberg et al. 2003; Anderson et al. 2013). Still, one concern of TOD is the fear that crime rates will increase because of the perception that criminals travel on public transit (Paulsen 2012; Billings, Leland, and Swindell 2011). While fear of crime is more prevalent than actual victimization, fear can heighten feelings of anxiety and may constrain some people's social and physical activities as they attempt to avoid certain places or situations that they perceive to be unsafe (Foster, Giles-Corti, and Knuiman 2010; Hale 1996; Liska, Sanchirico, and Reed 1988). However, actual crime levels at transit stations and stops vary by the type of transit. Serious crime such as assault and robbery are generally low in train stations—with minor crimes such as pick-pocketing slightly elevated—while bus stops tend to have higher rates of crime, but the majority of it is concentrated at a small percentage of stops (Paulsen 2012). Moreover, numerous studies show that crime is not necessarily associated with transit stations as much as with the design and layout of adjacent neighborhoods, as well as the types of uses surrounding transit stations (Lipton et al. 2013; Minnery and Lim 2005; Paulsen 2012). In particular, areas that feature alcohol outlets (e.g. bars or liquor stores), check cashing services, vacant properties, and alleys with poor natural surveillance are associated with higher crime (Lipton et al. 2013; Minnery and Lim 2005; Paulsen 2012).

Crime Prevention Through Environmental Design

There are numerous studies that detail approaches to plan for and reduce crime opportunities, commonly referred to as Crime Prevention Through Environmental Design (CPTED). The four overlapping strategies of CPTED are (National Crime Prevention Council 2003; Mair and Mair 2003):

4. **Natural Surveillance**—criminals do not like to be observed, therefore, more "eyes on the street" keeps potential offenders under observation.

5. **Natural Access Control**—relies on physical elements such as doors, fences, and shrubs to keep unauthorized persons out of a particular place.

6. **Territorial Reinforcement**—marking clear boundaries between public and private areas helps people to take ownership of and naturally protect territories that they feel are their own.

7. **Maintenance and Management**—related to one's sense of "pride of place" because the more dilapidated a place is, the more likely it is to attract unwanted activities (National Crime Prevention Council 2003).

Communities that have used CPTED strategies have experienced reductions in crime (Marzbali et al. 2012; Mair and Mair 2003; Dannenberg et al. 2003). Therefore, in addition to reducing crime, CPTED can also benefit both mental and physical health. Some characteristics of the built environment that encourage physical activity and sense of security also may have links to crime and perceived safety (Foster, Giles-Corti, and Knuiman 2010; Loukaitou-Sideris and Eck 2007; Stafford, Chandola, and Marmot 2007).

Methods

To estimate current levels of crime in the study area, we used the City of Boston's data portal to collect and geocode the City's crime reports from January 2010 to June 2013 (most current reporting period). The types of crimes were categorized by main crime code. Additionally, we geocoded the locations of bars and liquor stores from InfoUSA, a commercially available database on points of interest, along with transit routes and stops in the study area. We conducted a literature review of crime and transit-oriented development and CPTED in order to understand the relationship between crime and the built environment. Based on the CPTED literature and the measures of crime and destinations known to attract crime, we estimated how the developments might alter the neighborhood and potentially change opportunities for crime in the study area.

Existing Conditions

In 2011, the Massachusetts violent crime rate was 428.4 per 100,000, which was higher than the United States as a whole (386.3 per 100,000), while the property crime rate in Massachusetts was lower than the United States (2,258.7 per 100,000 compared to 2,908.7 per 100,000) (FBI Uniform Crime Reports 2011). In Boston, the most prevalent crimes are assault and battery and larceny.

The study area consistently has almost double the rates of crime than Boston as a whole. Assault and battery is the most prevalent crime type (19.73 per 1,000 versus Boston's 9.58 per 1,000) followed by larceny (18.55 per 1,000 versus Boston's 11.15 per 1,000). Table 19 below shows violent and property crime for the study area and Boston.

Table 19: Violent and Property Crime in the Study Area and Boston

CRIME CODE	STUDY AREA		BOSTON	
	Count	Per 1,000	Count	Per 1,000
Violent Crime				
Assault and Battery	1,832	19.73	18,377	9.58
Aggravated Assault	842	9.07	8,012	4.18
Robbery	545	5.87	4,656	2.43
Murder	25	0.27	162	0.08
Property Crime				
Larceny	1,723	18.55	21,401	11.15
Vandalism	1,170	12.60	15,428	8.04
Larceny (Motor Vehicle)	1,112	11.97	13,538	7.06
Breaking and Entering (Residence)	562	6.05	7,207	3.76
Motor Vehicle Theft	422	4.54	4,798	2.50
Disturbing the Peace	221	2.38	1,869	0.97
Breaking and Entering (Non-Residence)	121	1.30	1,705	0.89

Source: City of Boston Crime Reports 2010-2013; MAPC Analysis

Assessment

Scholarly literature suggests that indicators associated with increased crime levels are related to the presence of alcohol outlets, vacant properties, alleys, and "incivilities"—such as graffiti, abandoned structures, and neglected facilities—as opposed to transit stops themselves (Foster, Giles-Corti, and Knuiman 2010; Paulsen 2012; Loukaitou-Sideris and Eck 2007; Lipton et al. 2013; Billings, Leland, and Swindell 2011). In fact, the highest levels of crime, most commonly robbery, are generally found two to three blocks from a station compared to within a block of the station. This may be attributed to the neighborhood characteristics, design, and land uses two to three blocks from a station, in particular, the presence of nearby liquor stores, bars, vacant properties, and other land uses with poor natural surveillance (Billings, Leland, and Swindell 2011; Paulsen 2012; Cubbin, LeClere, and Smith 2000).

Figure 10 below shows the study area with the three parcels in yellow with locations of liquor stores, bars, transit stops, and incidents of property and violent crime from January 2010-June 2013. Crime incidents appear to be more concentrated towards the South End side of the study area, Northeastern University, and around a few bus stops.

From the three TOD projects' proposals, two formerly vacant lots (Bartlett Place and Parcel 25) will be replaced by mixed-use development and all three projects will bring new lighting, pedestrian walkways, and new commuters, residents, and employees who will add "eyes on the street." The projects will increase visibility and maintenance of the parcels as well as provide sites for positive resident interaction by bringing more offices, restaurants, green space, and recreation to the area (Foster, Giles-Corti, and Knuiman 2010; Dannenberg et al. 2003; Garvin, Cannuscio, and Branas 2012). These improvements align with CPTED strategies that reduce opportunities for crime; therefore, the area may see a reduction in crime rates. Additionally, implementation of CPTED strategies may have ramifications beyond just crime prevention, such as improvements in physical activity, mental health, and social capital (Dannenberg et al. 2003).

Summary

- Rates of crime and fear of crime are associated with features of the physical environment, particularly the presence of alcohol outlets, vacant properties, alleys, and "incivilities"—such as graffiti, abandoned structures, and neglected facilities.
- Communities that have used CPTED strategies—natural surveillance, natural access control, territorial reinforcement, and maintenance and management—have experienced reductions in crime.
- The three TOD projects will eliminate two vacant lots, add new lighting and pedestrian walkways, and bring new commuters, residents, and employees to the area who will add "eyes on the street"/natural surveillance. These are CPTED strategies proven to reduce crime.

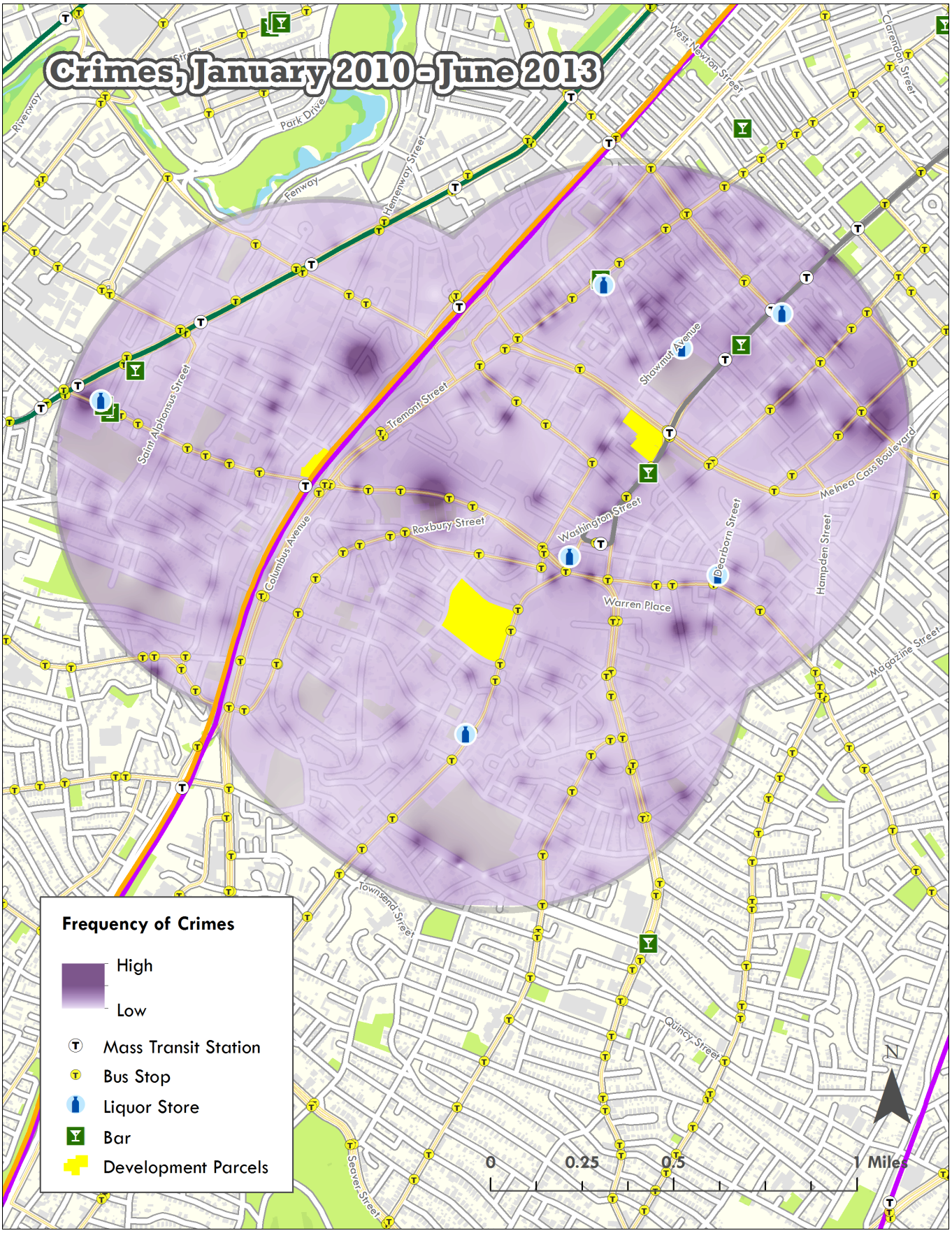


Figure 10: Total Crime in the Study Area, 2010-2013

3. Economic Opportunity

Background

Growing up in poverty, where a household does not have enough income to meet basic needs, increases a child's risk for poor health and increases risk for school failure (Brooks-Gunn and Duncan 1997). This is a factor linked to future employment and income potential. Childhood health problems often follow into adulthood and may result in reduced earnings and ability to work fewer hours (Conroy, Sandel, and Zuckerman 2010; Duncan, Ziol-Guest, and Kalil 2010).

We are interested in economic opportunity, or the ability to improve one's financial conditions, because a key social determinant of health is socioeconomic status. Socioeconomic status is the result of multiple variables such as educational level, occupation and income. Higher income is known to lead to better health outcomes, and there is evidence of increased risks for mortality, morbidity, and unhealthy behaviors for those with lower incomes (Lindahl 2002; Rehkopf et al. 2008). For example, individuals from families with average incomes of $15,000 to $20,000 are three times more likely to die prematurely than those from families with incomes greater than $70,000 (Yen and Bhatia 2002). In addition, there is a higher prevalence of obesity and type II diabetes among groups with the lowest levels of income and education and in the most deprived areas (Drewnowski 2009).

As a strategy for developing compact residential and commercial areas in places that are accessible by public transit, TOD holds great potential for supporting existing employment centers and spurring new economic development. Although recent decades have seen a decentralization of jobs from traditional central business districts, nearly a quarter of existing jobs in regions served by transit are located within a half-mile of transit stations (Center for Transit-Oriented Development 2011).

Transit station areas in the Metro Boston region could provide space for more than 130,000 new jobs by 2035 (Metropolitan Area Planning Council 2012). Similarly, TOD could accommodate an estimated 76,000 new housing units in the region, which would provide more housing for workers to connect with transit-accessible jobs in the region. At present, 37% of employment in Metro Boston is within a half-mile of a rapid transit or commuter rail station and this number could be expected to rise as new businesses come online in the area, such as at Kendall Square in Cambridge and Quincy Center.

Methods

We reviewed TOD literature on the employment opportunities that could be created by the proposed developments and the impact these opportunities could have on income or, more broadly, socioeconomic status. We reviewed American Community Survey 2007-2011 data for the City of Boston and, where available, the study area (using Census Tract level data) for educational attainment and occupational data. To identify the number of business establishments and employees, we reviewed business data from InfoUSA 2011 for the study area and from the employment and wage (ES-202) 2011 data for the city. These data provided us with the ability to estimate the expected impacts of the three proposed TODs on future economic opportunities.

Existing Conditions

Mission Hill and Roxbury are economically disadvantaged neighborhoods that have lower per capita and median household incomes relative to the city as a whole (Table 20). The median household income in Roxbury, in particular, is only slightly above half of the city's median, and approximately 47% of the households in the neighborhood earn incomes of less than $25,000.

Table 20: Neighborhood Income Data

	MISSION HILL	ROXBURY	BOSTON
Per Capita Income	$19,843	$17,827	$31,856
Median Household Income	$33,291	$27,480	$50,866

Source: ACS 2006-2010; BRA Research Division Analysis

Residents in the study area are less educated, on average, than are Boston residents overall (Table 21). The study area lags behind Boston in the percentage of people with Bachelors degree or higher as just 33% of residents over the age of 25 in the study area have a degree. Additionally, the study area has a higher share of those with a high school education or less (44%) than the city as a whole (39%).

Table 21: Educational Attainment in the Study Area and Boston

	STUDY AREA		BOSTON	
	Estimate	ME	Estimate	ME
Less than High School	20%	3%	16%	0%
High School	24%	3%	23%	0%
Some College	19%	3%	14%	0%
Associates Degree	5%	2%	5%	0%
Bachelors or higher	33%	3%	43%	1%

Source: ACS 07-11 Universe- Population over 25

Occupational data were not available at the census tract level so data for the study area could not be collected. In its place, an occupational breakdown for Roxbury, Mission Hill, and Boston were used (Table 22). Management, business, science, and arts make up the majority of occupations in Roxbury, Mission Hill, and Boston, however, service occupations and sales and office occupations are slightly higher in Roxbury and Mission Hill than in Boston as a whole.

Table 22: Neighborhood Occupational Data

OCCUPATIONAL DATA	ROXBURY	MISSION HILL	BOSTON
Management, business, science, and arts occupations	5,486 (32.4%)	3,486 (43.5%)	142,468 (44.8%)
Service occupations	4,945 (29.2%)	1,791 (22.3%)	68,760 (21.6%)
Sales and office occupations	4,425 (26.1%)	2,163 (27%)	72.815 (22.9%)
Natural resources, construction, and maintenance occupations	605 (3.6%)	71 (0.9%)	13,575 (4.3%)
Production, transportation, and material moving occupations	1,490 (8.8%)	505 (6.3%)	20,224 (6.4%)

Source: BRA Research Division Analysis, ACS 2006-2010

Data were available for the study area for the number of businesses and jobs (Table 23). The study area includes approximately 3.4% of the businesses and jobs in the city.

Table 23: Economic Data in the Study Area and Boston

	STUDY AREA	BOSTON
Businesses/ Establishments	745	21,864
Employment	19,240	561,126

Source: InfoUSA 2011 for Study Area, ES-202 2011 for municipal data

The labor force participation rate for residents in the study area is slightly lower than the city (62% vs. 69%)—however it should be noted that there may be a fairly large student population due to the number of schools in the area—and there is a lower rate of unemployment in the study area compared to the entire city (Table 24). This smaller percentage of unemployed residents is a positive sign for the study area, although the lower rate could reflect that fewer residents of the study area are actively seeking employment at present.

Table 24: Labor Force and Unemployment in the Study Area and in Boston

	STUDY AREA	BOSTON
Labor Force Participation Rate	62%	69%
Unemployment Rate	8%	10%

Source: ACS 06-11, Universe: Civilian employed population 16 years and over

Assessment

The projected number of new jobs from the development proposals was used to estimate the growth in employment in the study area. New jobs include both temporary construction jobs that are part of the development process, as well as the new permanent jobs that would be created by the expanded existing businesses, new commercial space and other support services for uses included in the new developments.

Based on the PNFs for Bartlett Place and Madison Tropical Parcel 10, the projects will result in 883 temporary construction jobs and 345 new permanent jobs. The construction jobs are part of a Boston Residents Construction Employment Program agreement with the BRA, which means that at least 50 percent of the total employee work hours will be for Boston residents, at least 25 percent of total employee work hours will be for minorities and at least ten percent of the total employee work hours will be for women. Based on a BRA press release, Parcel 25 is expected to generate 35 construction jobs (Boston Redevelopment Authority 2010). The Madison Tropical Parcel 10 development is projected to create 145 new permanent jobs and over 45% of these jobs are estimated to have salaries higher than the median household income in the neighborhoods overlapped by the study area. The Bartlett Place development is projected to create 200 permanent jobs, but wage data was not projected for these jobs. Employment data was not available for Parcel 25.

As a result of just the two developments, there will be a nearly 3% increase in the number of available jobs as well as an increase in the number of businesses operating in the study area. These changes have the potential to lead to positive changes in income and a reduction in unemployment for the study area while not requiring considerable increases in personal transportation costs for employees living in the area. A factor in determining the magnitude of the changes will be how closely the job skills of those in the study area match the requirements of the new employment opportunities, especially with a high percentage of current residents having only a high school education or less.

It should be noted as well that the three developments will result in more housing for the study area, including 320 units in Bartlett Place, 66 units in Parcel 25 and 104 units for Madison Tropical Parcel 10. Due to their proximity to the transit stations and bus lines, these new residents will also have options to connect with transit accessible jobs in downtown Boston and the surrounding areas. Moreover, if new investments in the area result in higher housing costs with the private market, these units will offer existing residents an option for remaining in the area and connecting to current or future transit-accessible jobs.

Summary

- A strong association has been shown between income levels and health outcomes, higher income predicts better health, better health behaviors, and reduced mortality risk.
- TOD holds great potential for supporting existing employment centers and spurring new economic development, and it is estimated that in the Metro Boston region transit station areas, which would be a focus for TOD, could provide space for more than 130,000 new jobs by 2035.
- The study area includes neighborhoods that have lower per capita and median household incomes relative to the city, and there are fewer residents in the study with a secondary degree or participating in the labor force than there are in the city.
- The new developments are projected to generate more the 880 temporary construction jobs with local hiring requirements, and 345 permanent new jobs will be available in the new developments.
- The housing units that will be built as part of the developments will also provide existing residents and new residents with the opportunity to connect with transit accessible jobs in downtown Boston and the surrounding region.

4. Displacement/Gentrification

Background

Investment, whether through infrastructure, new development, or improved public services, has the potential to create a rise in property values and increase the costs to live or do business in a particular area. The process that occurs when a neighborhood is transformed from one of low economic value to one of high economic value can be broadly referred to as gentrification.

Gentrification is the potential for the new development to increase the economic value and costs in the study area. Gentrification impacts health through three main pathways: 1) low-income and cost-burdened households may move out of the study area, potentially reducing social networks/cohesion and increasing commute time; 2) low-income households may remain in the study area and become more cost burdened as prices increase; 3) economically-stable households move into the area and may stimulate the local economy and have potential beneficial effects for the neighborhood.

For the purposes of this HIA, we focus on how gentrification may lead to displacement of current residents from their current housing or prevent them from moving to another home in the area. The study area is characterized by indicators associated with a location where existing residents are potentially at risk of displacement due to potential gentrification. Location indicators include:

- A high proportion of renters (84% renter occupied units in the study area compared to 66% in Boston as a whole);
- Access to job centers (Longwood Medical Center and Downtown Boston) a metropolitan area with high levels of traffic congestion (Metro Boston is ranked as the 3rd worst region for traffic congestion (Schrank, Eisele, and Lomax 2012));
- Transit access (close proximity to MBTA subway, silver line, and commuter rail stations); and
- Low housing values (e.g., 2012 median sales price of $249,000 in Roxbury vs. median housing cost of $383,000 in Boston) (Department of Neighborhood Development 2012; Kennedy and Leonard 2001; Chapple 2009).

Should the neighborhood experience gentrification, rent and home sale prices may rise and property taxes may also increase. This may result in households that can no longer afford these new costs without assistance by policies or programs and are, therefore, prevented from remaining in existing housing or unable to move to other available housing in the same neighborhood (Freeman and Braconi 2004; Newman and Wyly 2006).

Low- to moderate-income renters and fixed-income homeowners are most susceptible to displacement when gentrification results in higher housing costs. These households are more susceptible as they are most likely to already pay a disproportionate share of their income towards housing costs[4] and are not able to afford additional costs (Chapple 2009). An exception to this may be those who reside in deed-restricted affordable housing in the study area.

[4] Households paying greater than 30% of their gross household income toward housing are considered cost burdened. Households paying greater than 50% of their gross household income toward housing are considered severely cost burdened.

Low-income households already face health burdens from increased rates of chronic diseases, premature mortality and limited access to health care services and displacement can further exacerbate health related issues. Removing lower-income residents from existing social support networks can reduce the protective health effects of social cohesion (S. E. Cohen, Underwood, and Gottlieb 2000; Berkman and Syme 1979). Displacement can also increase housing insecurity which has been linked to increased risks of poor health in household members and developmental delays in children (Cook and Frank 2008; Cutts et al. 2011). When displacement occurs, residents may or may not have access to housing units in neighborhoods with access to quality schools, out-of-school activities, public sector support, health care, social service programs, and employment. Lastly, displacement may result in homelessness for the affected household. Past studies have found that 15-20% of homeless families were the result of eviction from rental housing (Shinn and Baumohl 1998).

It should be noted that in the past, racial minorities were a population group that was more susceptible, and even targeted, for displacement. However, more recently this has shifted (Kennedy and Leonard 2001). Nonetheless, to the point that a specific minority group makes up a significant portion of specific income population, it would mean that an increased cost burden could fall disproportionally on specific racial groups.

Methods

We reviewed housing data for the study area and the City of Boston. We reviewed American Community Survey 2007-11 data for the City of Boston and, where available, the study area (using Census Tract level data). To identify current rental rates for the area, data was reviewed from PadMapper, which provides service on current rents from Craigslist and other website postings for rental housing. These data provided us with the ability to estimate residential displacement impacts that could occur as a result of the three proposed TODs.

Existing Conditions

There are just over 11,000 occupied housing units in the study area and nearly 253,000 occupied units in the entire city. Eighty-four percent of the units in the study area are renter occupied as compared to 66% in Boston (Table 25).

Table 25: Housing Units by Tenure

	STUDY AREA	BOSTON
Percent Owner-Occupied	16%	34%
Percent Renter-Occupied	84%	66%

Source: Census 2010

Income distribution of home owners within the study area is similar to the distribution within Boston. As shown in Table 26, renters in the study area, however, are much more likely to be very low income than are renters in Boston (approximately 64% vs. 48%, respectively). Almost two-thirds of renter households in the study area have a gross household income at or below $35,000 annually.

Table 26: Household Income by Tenure

	STUDY AREA			BOSTON		
	Count	Estimate	ME	Count	Estimate	ME
Owner Occupied	1,929			85,266		
Less Than $35,000	276	14%	10.1%	11,705	14%	0.8%
$35,000 - $75,000	572	29%	11.7%	21,671	25%	1.0%
Greater than $75,000	1,081	56%	8.2%	51,890	61%	1.3%
Renter Occupied	8,442			152,955		
Less Than $35,000	5,428	64%	4.6%	72,915	48%	1.0%
$35,000 - $75,000	1,974	23%	3.3%	43,216	28%	0.8%
Greater than $75,000	1,040	12%	2.6%	36,824	24%	0.7%

Source: ACS 07-11

Cost-burdened households are those that spend 30% or more of their income on housing expenses. Homeowners at all income levels within the study area are more likely than renters to be housing burdened. Virtually all very low-income (< $35,000) homeowners are cost-burdened; three-quarters of moderate income ($35 - $75,000) are cost-burdened (Table 27). Combined with the Household Income by Tenure table, we see that 44% of homeowners have very low- to moderate-incomes, and 80% of these homeowners are cost-burdened.

Table 27: Percent of Cost Burdened Households by Income and Tenure

	STUDY AREA			BOSTON		
	Counts	Percent	ME	Counts	Percent	ME
Owner Occupied	929					
Less Than $35,000	270	98%	37.3%	9,790	84%	2.4%
$35,000 - $75,000	424	74%	34.3%	12,962	60%	2.4%
Greater than $75,000	235	22%	17.9%	10,403	20%	1.3%
Renter Occupied	4,757					
Less Than $35,000	3,808	70%	4.6%	55,395	76%	1.0%
$35,000 - $75,000	763	39%	3.3%	22,249	51%	0.8%
Greater than $75,000	186	18%	2.6%	2,560	7%	0.7%

Assessment

There is the potential for the proposed developments to drive economic changes in the study area, such as rent and property tax increases. Recent trends have shown that rents are rising in the vicinity of the study area, with the median rent for 2012 at $1,500 in Roxbury. This represents a 6% increase since 2005 when adjusting for inflation (Department of Neighborhood Development 2012). Citywide, the median rent for 2012 was $2,250, which represents a 13% increase since 2005 when adjusting for inflation. If the trend for increasing residential rents continues, median rent would rise to nearly $1,600 in 2012 dollars and households would incur an additional $1,200 in annual costs by 2020. The developments will also introduce new market rate units and retail and office spaces. With these changes, and given that the study area meets multiple characteristics of an area susceptible to gentrification, there is the possibility that housing and housing related costs could rise.

The populations who are likely to be at risk for displacement are low-income households and cost-burdened households. These two groups are not mutually exclusive, but by exploring each, we can assess the magnitude of displacement risk.

Focusing just on low-income households (i.e., those earning less than $35,000), it is estimated that there are 276 (7% of the total) owner-occupied households and 5,428 (32%) renter-occupied households in the study area that could be affected by rising housing costs.5 If expanded to include those earning between $35,000-$75,000, the estimate of potentially affected households in owner-occupied units rises to 848 (22%) and to 7,402 (44%) for households in renter occupied units. Alternatively, using housing cost burden as the driver, the estimated number of households that could be affected by rising costs include 270 who live in owner occupied units (24%) and 3,808 who live in rental units (28%). By either measure, both housing tenure types could be adversely impacted by higher-cost housing, but renter households are more likely to be affected.

An alternative way to look at the potential number of households at risk is to identify those who are living in housing units that have affordability deed restrictions that are set to expire over the next decade. This group could overlap with households identified, but could also be in addition since they may fall into a different housing cost burden segment due to the fixed price of their housing. Discussed in more detail in the Affordable Housing pathway, this could include over 1,831 housing units in the study area set to expire by 2020. If housing costs rise in the study area, these residents may lose their ability to find new housing in the study area.6

Although there are households that could be adversely impacted by rising costs, there are also owner-occupied households and property owners who may be able to remain should costs rise. Some groups may benefit from capital appreciation of their property, which brings the potential for a higher return when they sell as well as the ability to leverage the increased equity of their properties.

Summary

- Lower-income households and cost-burdened households (i.e., those that spend 30% or more of their income on housing expenses) are most susceptible to displacement from gentrification.
- Lower-income households already face significant health burdens; displacement may exacerbate these existing burdens by impacting social cohesion, increasing housing insecurity, distancing residents from needed social services, increasing stress, and leading to homelessness.
- Among households with a gross household income at or below $35,000 per year, this assessment estimates that 276 of those in owner-occupied units and 5,428 of those in renter-occupied units could be affected by displacement.
- Among cost-burdened households, this assessment estimates that 270 of those in owner-occupied units and 3,808 of those in renter-occupied units could be affected.
- For those that can afford increased housing costs, the capital appreciation of their property could offer a greater financial return in the future as well as the ability to leverage more capital than before the developments.

[5] These quantities and percentages are estimates with margins of error (ME). Please see table 23 and 24 for the specific MEs for each set of data.

[6] This HIA looked at the three developments, which are a among multiple other development projects under construction or planned for the in and around the study area. Displacement, as well as the provision of other housing options for current residents, could occur as a result of this larger development framework.

5. Affordable Housing

Background

A 2007 review of the health benefits of affordable housing[7] reveals myriad health benefits of affordable housing (Lubell, Crain, and Cohen 2007). Families who spend greater than 30% of their gross household income on housing costs may have insufficient funds to meet other essential needs. This can have a disproportionate impact on the health of children, as children in low-income households not receiving housing subsidies are more likely to suffer from iron deficiencies, malnutrition and underdevelopment than children in similar households receiving housing assistance (Frank et al. 2006; Alan Meyers et al. 2005; A Meyers et al. 1993). Affordable housing may improve health outcomes by redirecting household financial resources for the purchase of nutritious food and for health care expenditures. By providing families with greater residential stability, affordable housing reduces frequent moves, overcrowding, eviction and foreclosure, which may reduce stress levels, depression and feelings of hopelessness (Guzman, Bhatia, and Durazo 2005; Kappel Ramji Consulting Group 2002; Bartlett 1997). Households with limited affordable housing options may live in substandard and inadequate housing which increases the risk of lead poisoning in children, asthma attacks, and injury (Jacobs et al. 2002). Poor quality or poorly maintained housing may also contain mold, dust mites, cockroaches and rodents: allergens that contribute to asthma and other respiratory illnesses (Cohn et al. 2006; P. Breysse et al. 2004). Emerging research suggests that affordable housing may help individuals living with chronic diseases such as HIV/AIDS, diabetes and hypertension better maintain their treatment regimens and achieve higher rates of medical care (Aidala et al. 2001; Kinchen and Wright 1991; National AIDS Housing Coalition 2005; Riley et al. 2005; Ledergerber et al. 1999).

By providing households with access to neighborhoods of opportunity[8], certain affordable housing strategies can reduce stress, increase access to amenities and generate important health benefits. Families who can only find affordable housing in very high-poverty areas may be prone to greater psychological distress and exposure to violent or traumatic events. Randomized trials have demonstrated that adults who were offered the opportunity to move to a low-poverty area experienced significant improvements in mental health at levels comparable to those achieved with "some of the most effective clinical and pharmacologic mental health interventions" (Kling, Liebman, and Katz 2007)." Girls who were offered the opportunity to move to a low-poverty area also had better mental health, showed benefits in the education domain, and engaged in fewer risk behaviors compared to children remaining in high-poverty neighborhoods (Leventhal and Dupéré 2011).

Affordable housing can also help victims of domestic violence escape the physical and mental health trauma caused by abuse and avoid the health risks associated with homelessness by providing permanent or transition housing options (Moracco et al. 2004; Menard 2001; Eisenstat and Bancroft 1999).

[7] For the purposes of this HIA, affordable housing is modeled after the M.G.L. Chapter 40B designation, defined as housing that is affordable to households earning at or below 80% of the area median income, which is deed restricted for at least 15-years to ensure affordable rents or sales prices, and affirmatively furthers fair housing and marketing practices.

[8] See HUD's opportunity mapping under the Sustainable Communities program and the Kirwan Institute in *The Geography of Opportunity.*

Methods

Affordable housing is a broad term with numerous definitions. For the purposes of this HIA, affordable housing is modeled after the M.G.L. Chapter 40B designation, defined as housing that is affordable to households earning at or below 80% of the area median income, which is deed restricted for at least 15-years to ensure affordable rents or sales prices, and affirmatively furthers fair housing and marketing practices.

Given the scope and timeline of this HIA, we chose to focus primarily on the Department of Housing and Community Development's (DHCD) Subsidized Housing Inventory (SHI) as a measure of affordable housing while recognizing that there are other relevant indicators that we could not include. SHI includes deed restricted affordable units that were developed with some form of subsidy and that are only available to households who meet certain income requirements. First, we geocoded the SHI data that included street addresses to estimate the availability of affordable housing within the study area and Boston. Addresses were not available for 1,882 affordable housing units throughout Boston, meaning some of these units may fall within the study area. Data were then stratified by the year of term of deed to estimate the availability of affordable housing over time. We then compared this estimate to the geocoded SHI data available throughout the entire City of Boston. Next we used the 2005-2009 HUD Comprehensive Housing Affordability Strategy (CHAS) data to define the affordability gap—the difference between the households at a given income level and the number of units affordable at that income level—for the study area and Boston.

In addition, given that 84% of the occupied housing units are renter-occupied, we analyzed rental housing data from PadMapper to understand rental market-units by bedroom that are affordable to low, very low, and extremely low income households in the study area and in Boston.

Finally, we estimated the changes in affordable housing availability predicted in the area as a result of the three TOD projects.

Existing Conditions

The SHI data shows that there are currently 5,974 affordable housing units in the study area (Table 28). This represents 53% of the total occupied housing units (11,183) in the study area as compared to the city as a whole, where affordable housing units comprise fewer than 20% of the total occupied housing units (252,699). Additionally, of the affordable units in the study area, 49% are designated to remain affordable in perpetuity; however it is important to note that some expiring units with terms may be preserved as affordable. There is a larger percentage of housing designated as affordable in perpetuity than the city of Boston as a whole:

Table 28: Affordable Housing by Year of Expiration

YEAR OF EXPIRATION	STUDY AREA		BOSTON	
	Units	Percent of Total Units	Units	Percent of Total Units
2015	951	16%	6,469	13%
2020	880	15%	7,677	16%
2025	509	9%	4,049	8%
After 2025	672	11%	12,027	25%
Perpetuity	2,962	49%	18,620	38%
Total Units	5,974		48,842	

Source: SHI 2013; MAPC Analysis

Table 28 above serves as one measure of existing affordable housing in the area. Therefore the next question is whether the existing affordable units address unmet housing need in the neighborhood. Using CHAS data, the study area has an affordability gap of 2,775 units for households making less than 50% AMI (Table 29). Boston has an affordability gap of 56,255 units for households making less than 50% AMI, and a gap of 1,115 units for households making between 50-80% AMI.

Table 29: Affordability Gap

HOUSEHOLD INCOME	AFFORDABILITY GAP[9]	MARGIN OF ERROR
Less than 50% AMI	2,775	900.84
Between 50% - 80% AMI	-645	802.85
Between 80% - 100% AMI	-1,238	799.43
Over 100% AMI	-1,445	956.03

Source: CHAS 05-09; MAPC Analysis

Another way to measure the affordable housing stock, besides SHI, is to look at current rental listings for market units, and determine how many are affordable to those in the low, very-low, and extremely-low income HUD income limit categories, given high percentage of renters (84% of occupied units in the study area). HUD Fair Market Rent at the county level shows that the study area has higher percentages of one and two bedroom units that are affordable to low, very-low, and extremely-low income households than the city. Table 30 shows that there is a lower percentage of two, three, or four bedroom apartments that are affordable to three or four person households in the study area as compared to Boston.

[9] A positive number in this column indicates unmet housing need. A negative number indicates there is no unmet housing need.

Table 29: Rental Apartments Affordable to HUD Income Limit Categories by Bedroom

	STUDY AREA	BOSTON
Percent of One Bedroom Apartments Affordable to low, very low, and extremely low income One Person households		
Low	41%	27%
Very Low	29%	16%
Extremely Low	3%	3%
Percent of One or Two Bedroom Apartments Affordable to low, very low, and extremely low income Two Person households		
Low	30%	24%
Very Low	20%	12%
Extremely Low	4%	3%
Percent of Two or Three Bedroom Apartments Affordable to low, very low, and extremely low income Three Person households		
Low	7%	13%
Very Low	4%	3%
Extremely Low	1%	1%
Percent of Two, Three, or Four Bedroom Apartments Affordable to low, very low, and extremely low income Four Person households		
Low	9%	18%
Very Low	3%	4%
Extremely Low	0%	1%

Source: PadMapper; HUD Income Limits Documentation System

Assessment

Based on the SHI, the study area and Boston have a share of affordable housing that is much higher than the state mandated 10% threshold. In addition, almost half of the affordable housing units in the study area are designated to remain affordable in perpetuity. Still, approximately a third of the existing affordable units are set to expire by 2020. Though many could recertify, the expiration of the affordable housing designations would reduce the overall number of affordable units in the study area by 1,831 units.

The new TOD projects will contribute a minimum of 176 new affordable units to the study area. Moreover, all three TOD projects have been proactive to increase the number of affordable units in each development by proposing to exceed Boston's Inclusionary Zoning requirement. The Boston Inclusionary Zoning requirement directs housing developers to include an affordable component in their residential projects equal to 15% of the market rate units. The ratio of affordable housing units in each development ranges from approximately 20% to 100%.

Although the development will include new affordable units, these units would not replace the affordable housing units that are set to expire by 2020, and the study area could experience an overall reduction in the percentage of units on the SHI. Furthermore, there is an affordability gap of 2,775 units for households earning less than 50% AMI in the study area. The developments will help reduce

this gap as the new units come online, but they will not address the unmet housing need for lower-income households in the study area.

Additionally, though we only have data for bedroom affordability for rental housing units, there appears to be a need for affordable two, three, and four bedroom apartments for three or four person households in the study area.

Summary

- Access to affordable housing is linked to benefits for health through decreasing stress and improving mental health, increasing financial resources, adding residential stability, lowering the potential for adverse environmental exposures, aiding with chronic disease management, and avoiding domestic violence.
- There are 5,974 affordable housing units within the study area, and 49% of these units are designated to remain affordable in perpetuity; however 31% are set to expire by 2020.
- Current SHI data shows that 53% of total housing in the study area is affordable, or 5,974 affordable units, which is much higher than the state mandated 10% threshold.
- The new developments are projected to add a minimum of 176 affordable housing units to the affordable housing stock, which may have benefits for health particularly if rental prices for market rate units go up in the surrounding neighborhood as it ensures more subsidized, income-restricted affordable units will be added.

6. Green Housing

Background

Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by efficiently using natural resources, reducing waste, and protecting occupant health (EPA 2012a). There is strong evidence supporting the benefits of green buildings in terms of energy efficiency and environmental impacts, and a growing number of studies connect green building to health since people spend approximately 90% of their time indoors (Beatley 2011).

The association between health and housing dates back to the industrial revolution. In the 19th century, architecture favored narrow design, cheap materials, and little to no ventilation or natural light, which led to overcrowded and unsanitary conditions. These conditions bred infectious diseases including cholera, tuberculosis, and typhoid fever. Other examples of housing and health issues include the use of lead-based paint hazards that cause severe developmental issues especially in children; the use of asbestos—which is highly carcinogenic and an indoor air pollutant—which can range from two to five times higher than outdoor pollution and can increase the incidence of cardiovascular disease, asthma, and other respiratory diseases (Beatley 2011).

Conversely, green building can positively influence indoor air quality, reduce depletion of natural resources, stimulate demand for environmentally responsible building materials, and help reduce global warming by reducing carbon emissions (Lubell, Crain, and Cohen 2007). Additionally, it can positively impact health through improving pest control, enhancing moisture control, increasing comfort, and reducing operating costs with lower expenses for utilities and repairs (Beatley 2011).

There is evidence that green housing yields improvements in health. Green building criteria creates a residential environment that reduces exposure to airborne contaminants, pests, moisture, and harmful chemicals while prioritizing natural lighting, improved ventilation systems, and more recently, designing site locations to include bicycle and pedestrian accommodations (Beatley 2011; J. Breysse et al. 2011; Garland et al. 2013; Lubell, Crain, and Cohen 2007; Schmidt 2008; Wells and Laquatra 2009). In a before and after study, Breysse and colleagues (J. Breysse et al. 2011) investigated resident health and building performance outcomes at baseline and one year after low income housing was renovated using green principles and found that adults reported significant improvements in overall health, their children's overall health, asthma, and non-asthma respiratory problems. Green housing may also increase residents' disposable income as a result of the savings from the higher energy efficiency of their homes (Lubell, Crain, and Cohen 2007; Schmidt 2008).

Methods

There are many green housing rating systems in the United States, each with slightly different criteria. The systems include Leadership in Energy and Environmental Design (LEED), U.S Environmental Protection Agency's (EPA) Energy Star, and Enterprise Green Communities Criteria. Because of the different rating systems, it is difficult to consistently measure green housing infrastructure in a given area. Thus for the purposes of this HIA, we focus on the overarching characteristics of green housing that were

identified in our literature review of green housing and health rather than assessing the individual rating systems themselves.

However, because Bartlett Place aims to be a Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) project and because much of Boston's green housing policy revolves around LEED, we did obtain LEED project level data from the U.S. Green Building Council (USGBC).The USGBC's LEED directory is likely an underestimate of green housing projects because there are buildings that may have been able to meet the LEED standards but did not apply for certification due to cost.

Existing Conditions

In January 2007, Mayor Thomas Menino made Boston the first major city in the nation to require a green building standard through municipal zoning requirements. Article 37 of the municipal zoning code was amended to require that all large-scale projects meet the USGBC's LEED certification standards (City of Boston 2013). Furthering this, in 2011, Mayor Menino launched the Energy Positive "E+" Green Building Demonstration Program with support from NSTAR Electric and National Grid as well as the USGBC, the Boston Society of Architects, and the Boston Architectural College. E+ aims to bring energy, environmentally, and equity positive green homes to Boston's neighborhoods by challenging architects, builders, and developers to design and construct high performance green homes (City of Boston 2013). These policies have created an environment that will encourage more green building.

Currently, there are 283 LEED-certified projects in Boston, however, the USGBC's LEED directory does not currently show any LEED-certified projects in the study area.

Assessment

Because low-income populations tend to be disproportionately impacted by asthma, other respiratory illnesses, and a variety of other health problems, it is especially important to apply green building principles to affordable housing. Information on green housing was only available for Bartlett Place and Madison Tropical Parcel 10. Bartlett Place will be a LEED-ND development with all of the buildings to be LEED certified and 313 of the 323 residential units to meet LEED for Homes standards. All three of Madison Tropical Parcel 10's buildings will also be LEED certifiable and 30 residential units will be LEED for Homes certifiable. As a result, there will be at least 343 green housing units added to the area.

Green housing may improve residents' overall health, asthma, and non-asthma respiratory problems and may increase residents' disposable income as a result of reduced energy costs. This may be particularly beneficial to the study area since one of the leading causes of hospitalizations in the study area is asthma (378.3 per 100,000). Although green housing incorporates many health-enhancing features, it does not necessarily always align with the Healthy Homes principles. According to the National Center of Healthy Homes, the seven Healthy Homes principles are dry, clean, pest-free, safe, contaminant-free, ventilated, and maintained. Green housing addresses most of these principles; however, in order to maximize the desired health outcomes, the design should install and maintain adequate heating, ventilation, and air conditioning (HVAC) systems to prevent indoor air quality issues and there should be attention to safety and injury prevention in the design.

Summary

- Green building criteria creates a residential environment that reduces indoor exposure to airborne contaminants, pests, moisture, and harmful chemicals while prioritizing natural lighting, improved ventilation systems, assuming that well designed and adequate HVAC and engineering systems are installed and maintained.
- Adult residents that moved into green housing reported significant improvements in overall health, their children's overall health, asthma, and non-asthma respiratory problems. Green housing may also increase residents' disposable income as a result of the energy savings of the home.
- There will be at least 343 green housing units between Bartlett Place and Madison Tropical Parcel 10. Residents of these units will likely experience improvements in health due to reduced exposure to containments, assuming well-designed HVAC and building engineering systems are installed and maintained to minimize exposure opportunities to indoor or outdoor pollutants.

7. Social Cohesion

Background

Researchers have long known that negative "psychological" risk factors such as social isolation and stress can harm health, while social support and social cohesion can promote it. Social isolation, for example, can lead to greater levels of stress, which has well-documented health effects, as well as many other negative health impacts including increased risk of heart disease, mental health problems, and even death (Berkman and Kawachi 2000; Kawachi and Kennedy 1997).

Social cohesion, which describes the extent of connectedness and solidarity of a community, and social support are associated with positive health outcomes. Communities with greater levels of social cohesion—often characterized by high levels of trust and respect, participation in community activities and public affairs, and increased participation in community groups—have better health outcomes than those with low levels (Kawachi and Kennedy 1997; Marmot and Wilkinson 2009; Sampson 2003). This is true on an individual level as well. Those with rich social environments—who have more friends and social interactions, hold a greater level of trust in their neighbors, and are part of a more tightly knit community—have access to a greater network of social resources which in turn help them stay healthier (S. Cohen and Wills 1985). These social resources can manifest as emotional support in difficult times, material support such as a ride to work when the family car breaks down, or simply through health-promoting information shared amongst neighbors. Access to social support such as this is associated with protective health effects including improved mental health outcomes, reduced stress, better cardiovascular health, better immune system functioning and more (Berkman and Kawachi 2000; Uchino, Cacioppo, and Kiecolt-Glaser 1996).

A nascent area of research has focused on the role that arts and culture have in building more socially cohesive neighborhoods. Some studies suggest that cultural heritage forms a key part of community organizing efforts necessary for increased community and civic engagement, and often serves as the launching force for public safety initiatives and efforts geared towards economic development (The Urban Institute 2013; Weitz 1996). Further research shows that education in the arts may play an important role in almost all dimensions of youth development, including the development of strong social skills (Fiske 1999).

Finally, community public space may play an important role. In fact, neighborhoods with more public space also tend to be safer and the residents of those neighborhoods that are more walkable are more likely to report knowing their neighbors, trusting others, and being involved in social and civic events (Richard et al. 2009).

Methods

Although social cohesion can be difficult to measure, some of its elements can be quantified. After reviewing relevant research, we identified several metrics that are frequently used as a proxy for social cohesion including measures of neighborhood trust and civic engagement. As a measure of levels of trust, we used the "trust in neighbors" measure from the 2010 Boston Neighborhood Survey which was collected at the census tract level. For this measure respondents were asked how strongly they agreed with the following statement: "People in my neighborhood can be trusted".

In addition to this, we also used data on the number of volunteers based on their home zip codes and the hours they served from 2006 to 2012 provided by Boston Cares, an organization that mobilizes volunteers throughout Greater Boston. Several studies have found that volunteering rates are positively correlated with increased physical, mental, and social well-being and can therefore serve as an indicator of population health (Thoits & Hewitt 2001; Grim et al. 2007). We also chose to use volunteerism as a measure since it is used as part of the measure of the "civic, social, and community engagement" for the San Francisco Sustainable Communities Index under the public realm category (Sustainable Communities Index 2012a). Since Boston Cares data is categorized by zip code, we used the Roxbury zip code (02119) as a proxy for the study area. Rates of volunteerism were calculated by dividing the number of volunteers in Roxbury and in Boston by the total population in the neighborhood and the city, respectively, according to the 2010 US Census and then multiplying those values by 10,000 to get a rate per 10,000 people (US Census Bureau 2012). The data was coded according to volunteer home zip codes.

For civic engagement, we compared average voting rates from 2006-2012 in the study area with those in Boston, the state and the country as a whole. We chose to represent a range of years in order to include presidential election years where voter turnout is highest as well as off-election years (gubernatorial and congressional), where the voter turn-out is typically much lower (Kingdon 2011). State and National data was included to benchmark the local data and was collected from the US Census Bureau's Voting and Registration Website (US Census Bureau 2013). For local-level data, we used voting rates collected at the ward precinct level from 2006 to 2012 as provided by the Boston Indicators Project.

When assessing cultural vitality, we chose to use categories as defined by the Urban Institute that we could measure given the available data. These include: presence of the arts, participation in the arts, and support for the arts. Although we did not have the available data sources to measure all the categories, we were able to create a proxy measure corresponding to participation in the arts as outlined by the Urban Institute. The measure available to us, obtained from the publicly available data on the Boston Indicators Project website, is the percentage of K-12 students receiving in-school arts instruction in Boston Public Schools in the study area compared to Boston. These numbers are meant to be a proxy for baseline cultural vitality in the community and may not change with the increase in TOD.

Existing Conditions

Table 31 shows the average levels of trust in neighbors in the study area and in Boston as measured by the Boston Neighborhood Survey in 2010. Values range from 1 (highest trust) to 5 (lowest trust) with 3 being neutral. According to these data, the levels of inter-neighbor trust are very similar in the study area and in Boston, which are both skewed towards higher values of trust. Next, Figure 11 shows the number of volunteers per 10,000 people in Roxbury compared to Boston as a proxy for community engagement. Although the data shows that the rates of volunteerism are consistently lower in Roxbury than across the city, it also shows that these rates have been steadily rising for the last four years suggesting increasing levels of community involvement in the area.

Table 31: Average Trust in Neighbors Score

	STUDY AREA = N = 66	BOSTON N = 1718
Mean Score	2.59 (2.31-2.87)	2.34 (2.29-2.39)

Finally, Table 32 shows the national voting rates from 2008 to 2012 as well as those in Boston and the study area. As the table illustrates, both the study area and Boston consistently have higher voting rates than the national averages in the same year (with the exception of the study area in 2010). As expected, the turnout was highest in presidential election years (2008 and 2012). Particularly in 2008, these rates were substantially higher in Boston and the study area than those for Massachusetts or the country as a whole. Although the voter turnout in the study area is slightly below that in Boston, the overall rates were consistently very high particularly during presidential election years when the rates were well above the national averages. The only exception to this was in 2010 where the voter turnouts were lowest across all areas.

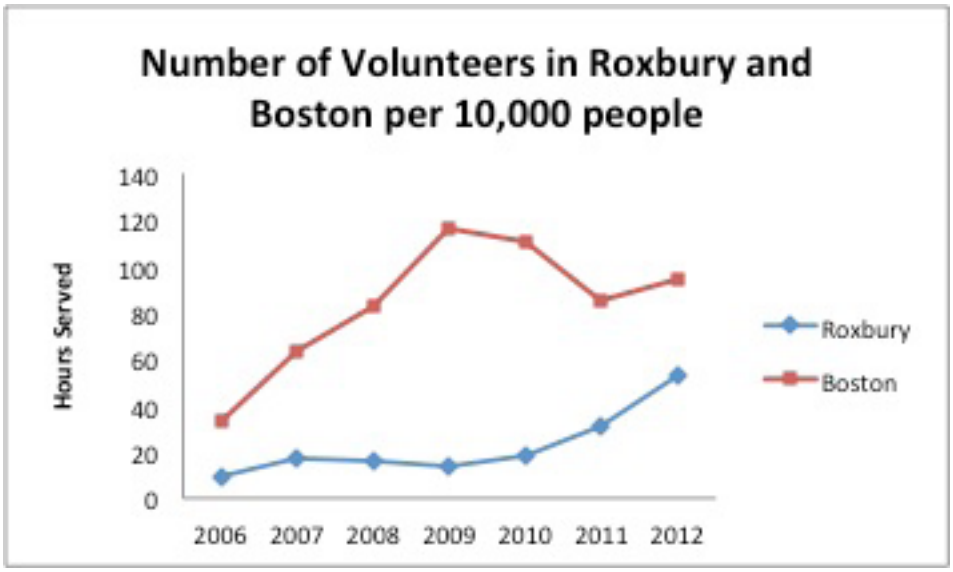


Figure 11: Number of Volunteers in Roxbury and Boston

Overall these rates show relatively high levels of civic engagement that are very similar in the study area compared to Boston and indicate a relatively high level of social cohesion.

Table 32: Percent of adults (age 18 and up) who voted from 2006 to 2012

YEAR	STUDY AREA	BOSTON	MASSACHUSETTS	UNITED STATES
2006	51.6	55.7	55.4	43.6
2008	79.3	80.7	67.1	58.2
2010	38.2	44.3	52.2	41.8
2012	63.1	66.4	65.4	56.5

Source: Boston Indicators Project

Although the proportion of students receiving weekly arts programming in public schools in the study area is slightly lower than that in Boston, this trend increased from 2008-2009 to 2010-2011 (Table 33). This suggests that there is an increased emphasis on cultural vitality and the arts in both the study area and in Boston than in previous years.

Table 33: Percent of students receiving weekly arts programming in Boston Public Schools

YEAR	STUDY AREA	BOSTON
2008-09	57.7	64.6
2009-10	47.8	68.3
2010-11	64.3	75.3

Source: Boston Indicators Project

Assessment

In order to assess how social cohesion and cultural vitality might change with the three Transit-Oriented Development (TOD) projects, we identified qualities of the neighborhood that might change based on each development and used the existing literature to assess these changes.

All three developments include plans to build residential units on properties that currently have none, which will increase the residential density of the study area neighborhood. The literature suggests that this may lead to greater levels of neighborhood trust (Marschall and Stolle 2004) and social cohesion by allowing residents more opportunities to engage and build relationships with each other when compared to less dense neighborhoods (Brisson and Usher 2005). The mixed-use nature of all three developments will likely increase the walkability of the area thereby fostering even more interaction. It is also important to consider that two of the developments, Bartlett Place and Parcel 25, will take the place of vacant lots. The literature suggests that vacant lots are often associated with crime and therefore increased levels of fear and mistrust amongst neighbors (Ross and Jang 2000). Thus their simple replacement of underutilized space should have a positive impact on the surrounding areas.

All three developments emphasize the role that they will play in the cultural vitality of the community once they are built. Bartlett Place will include a public events plaza with live music, singing, theater, and dance, a retail and interactive arts space where local artists can display their work, and a public market. While the proposal for Parcel 25 is less detailed, it does includes a plan for a community building with a non-profit arm and 8-12 small neighborhood-focused retail outlets in addition to the residential units and office buildings. Although the extent to which these developments will add to the cultural vitality of the area depends heavily on how much they connect with the existing cultural framework, they have the potential to add positive cultural value to the HIA study region. This impact will likely be greater if the developments are able to branch out into the community by, for example, reaching out to local arts programs in schools to encourage the teachers and students to be involved in the local arts scene thereby supporting the program.

Finally it is important to consider the potential effects of displacement on social cohesion for those already living in the study area. Although the measures of social cohesion for the study area may be slightly lower overall than those in Boston, there may still be smaller more tightly knit families or communities that have very high levels of social cohesion and support. If current residents are part of such groups and are displaced from the area, this may have very strong negative impacts on existing social networks, especially those that may be based on unique and historical racial or ethnic characteristics.

Summary

- Although there is not a lot of data to rely on, the levels of social cohesion and cultural vitality in the study area appear to be lower than in Boston as a whole.
- The increased residential density of all three developments will likely foster increased residential interaction and greater social cohesion in the areas surrounding the developments, particularly given that they are mixed use.
- The emphasis Parcel 25 and Bartlett place on creating dynamic cultural environments will likely have a positive impact on the surrounding communities by bringing more people together and to the area.
- If current residents get displaced from their current neighborhoods and are forced to leave existing social networks, there would likely be a strong negative impact on social cohesion for the existing community.

8. Green Space

Background

Recent studies have found that green spaces, such as parks, trails, and other open spaces, improve individual health and the community-social environment (Weich et al. 2002). Access to parks, open space, and greenery may protect against poor mental health outcomes (Parra et al. 2010; Sugiyama et al. 2008) by encouraging more socializing and thus fostering greater social support and encouraging more socializing, particularly among women (Fan, Das, and Chen 2011; Leventhal and Brooks-Gunn 2003; Truong and Ma 2006; Maas et al. 2006). Access to green space in particular may also provide opportunities for physical activity or provide members of a community with sanctuary from stress (Stigsdotter et al. 2010; van den Berg et al. 2010; Maas et al. 2009).

Further research suggests that the presence of trees themselves, in addition to other vegetation, may also promote community health. Trees and other vegetation remove air pollutants and promote cleaner and more breathable air (Jim and Chen 2008). By providing shade for streets and buildings, for example, trees shade their surrounding environments thereby perhaps reducing the presence of heat islands, UV exposure and skin cancer risk (Grant, Heisler, and Gao 2002; Stanton et al. 2004). Finally, trees more so than bushes or shrubs may also play an important role in promoting positive mental health outcomes and positive social behavior (Taylor, Kuo, and Sullivan 2001) and have even been linked to reductions in crime (Kuo and Sullivan 2001).

Methods

In order to measure green space we gathered information on the number of acres of open space in Roxbury compared to Boston (Source: MassGIS). To control for geographic area, the percentage of open space was also calculated by dividing the raw number of acres for Roxbury and Boston by the total geographic area in each, relatively. The number of acres per capita was also calculated by dividing the number of acres by the area population in order to account for population distribution in the study area compared to Boston.

To measure the presence of trees in the study area, we used a peer-reviewed tool developed by the United States Department of Agriculture (USDA) Forest Service called i-Tree (USDA Forest Service 2013). With i-Tree, we used the Canopy tool to compare the percentage of the study area that has tree canopy coverage to a percentage that does not. The tool uses aerial photography provided through Google Maps. We categorized 500 points that were randomly selected by the tool as "tree" or "non-tree" in order to generate reliable estimates.

Existing Conditions

As Table 34 illustrates, there are 3.2 acres of open space per 1,000 people in the study area and 8.4 acres of open space per 1,000 people in the entire city. The percentage of open space in the study area is half the percentage of Boston as a whole and the number of acres per capita in the study is well below the acres per capita for the entire city. Figure 12 shows a visual of the open space in the study area.

Table 34: Acres of Open Space

OPEN SPACE	STUDY AREA (POPULATION =29,891)	BOSTON (POPULATION = 617,594)
Total Acres	1,217	31,760
Acres of Open Space	95	5,206
Acres Per 1,000 people	3.2	8.4
% of Open Space	8%	16%

Source: MassGIS

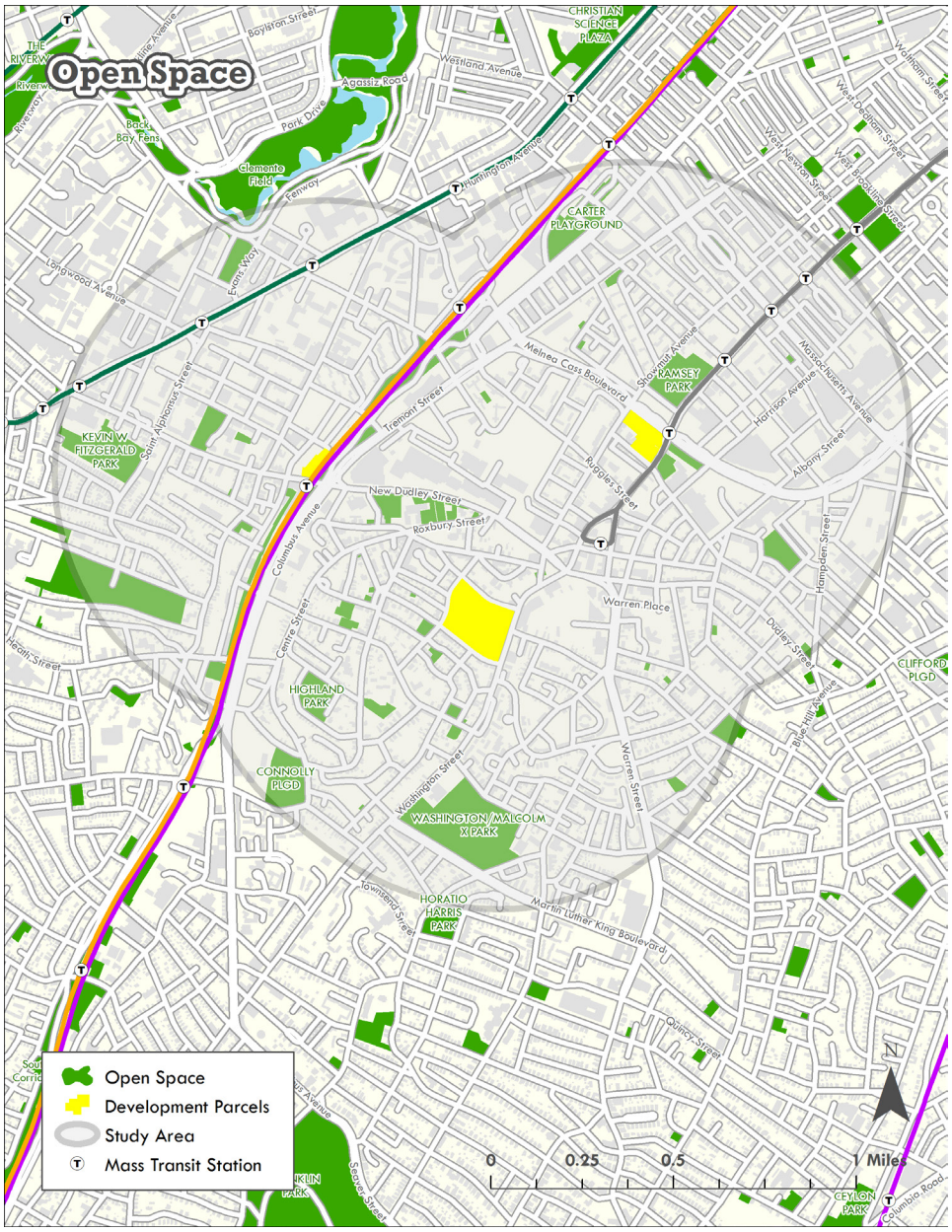


Figure 12: Map of Open Space in the Study Area

For the amount of tree canopy coverage in the study area, the i-Tree Canopy tool estimates that approximately 26.5 % of the area is covered by trees compared to 73.5 % that is not. This is very similar to the current tree canopy cover of Boston, which comprises 29 % of the total land area (Urban Ecology Institute 2008).

Assessment

In order to assess how the amount of open space and tree canopy coverage might change with the three TOD projects, we identified qualities of the neighborhood that might change based on each development and used the existing literature to assess these changes.

All three developments include plans to promote green space in their specific developments and the surrounding areas. Bartlett Place includes a plan to have 25% of their project site be green space. Together with the approximately 0.36 acre events plaza and small playgrounds for children, the plan includes a tree-lined central walkway connecting neighbors to Dudley Square and public transit, a large green-roof for community gardening, terraced areas for walking and climbing, and a protected tree zone. Parcel 10 includes plans to plant new trees lining all public sidewalks around the perimeter of the site as well as along the pedestrian walkways within the site. Parcel 25 includes plans to increase green space through the incorporation of green roofs as well as plans to plant additional trees in the site area.

Thus, we predict that the percentage of tree coverage in the study area is expected to increase due to the developments. Because of this increase in accessible green space and the number of trees in the neighborhood, these developments will likely have a positive impact on the surrounding areas.

Summary

- Green and open spaces are associated with increased social interactions and perceptions of safety, and improved mental health outcomes.
- Trees and tree canopy coverage are associated with positive social and mental health outcomes, as well as improved air quality, reduced crime, and protection from heat and UV rays from the sun.
- The study area currently has a lower percentage of acres of open space compared to Boston.
- Approximately 27% of the study area is currently covered by tree canopy.
- Because of the proposed tree plantings and green space additions, the addition of the three developments will likely improve access to green space in the study area.

9. Access to Healthy Affordable Foods

Background

A growing body of research suggests that access to healthy and nutritious foods in a neighborhood may play a critical role in residents' diets (Morland et al. 2002; Rose and Richards 2004). Most of this research has focused on supermarkets, which provide access to a greater variety of healthy foods that are generally higher quality and more affordable when compared to smaller food stores. Although some discrepancy exists in the literature, poor supermarket access has been linked to increased rates of poor health outcomes such as diabetes, cardiovascular disease, and obesity when compared to neighborhoods that have supermarkets (Cotterill and Franklin 1995; Powell, Auld, et al. 2007).

Several hypotheses exist for why residents living close to a supermarket are likely to have healthier diets than those who do not (O'Malley et al. 2013). First, healthier foods such as fruits, vegetables, and whole grains, tend to be more expensive than their less healthy counterparts, and are even more costly in smaller stores, such as corner stores, compared to supermarkets. This is problematic as neighborhoods with poor supermarket access are overwhelmingly low-income (Hendrickson, Smith, and Eikenberry 2006). The lack of supermarkets also means that people in these neighborhoods end up paying more overall for their groceries due to the increased prices in smaller food stores, which may further restrict their ability to afford healthy foods (Chung and Myers 1999). Second, residents of neighborhoods without supermarket access also typically have increased access to cheaper energy-dense processed foods often containing high contents of fat, sugar and sodium readily available at convenience stores and fast-food restaurants (Drewnowski and Specter 2004).

Neighborhoods where residents have low access to healthy food resources but ample access to unhealthy food resources have recently been highlighted in the literature, and may be linked to negative health outcomes, particularly in low-income populations (Boone-Heinonen et al. 2011; Reitzel et al. 2013). Certain food outlets such as convenience stores, for example, may increase the risk of obesity and other negative health outcomes (Powell, Slater, et al. 2007) by offering less variety, higher prices, and lower quality produce than supermarkets (Zenk et al. 2005).

Methods

First, we conducted a literature review of food access and the built environment, which highlighted the role of both healthy food access as well as unhealthy food availability. In order to measure healthy food access, we created a quantitative measure based on the available methods that was feasible to implement given our available data and resources. After considering alternatives, we chose to use a method similar to the Food Access metric developed by the San Francisco Department of Public Health for their Sustainable Communities Index. The metric, called the Food Market Score, can be found under the "Public Realm" measure of the index (Sustainable Communities Index 2012a).

The Food Market Score is a relative measure that weights the number and variety of retail food resources within a one mile radius by quality of food offerings and distance. Given the small geographic area of the region we are assessing, which only extends 0.5 miles out from each development, we chose not to incorporate distance traveled and instead create a measure of food outlet density per capita.

All food retail data was downloaded from InfoUSA and includes the following categories according to their North American Industry Classification System (NAICS) codes: General Grocery/Supermarkets (445110), Convenience Group (445120), Meat Markets (445210), Fruit and Vegetable Markets (445230 & 445230), Warehouse/Club Stores (452990), Drug Stores (446110) as well as "Specialty Food Stores" (445299). For our study, farmer's market data was obtained from the Massachusetts Department of Agricultural Resources (Massachusetts Department of Agricultural Resources 2013).

The total number of stores in each NAICS category was calculated for the study area and then validated using the methodology outlined in Food Market Score methods (Sustainable Communities Index 2012b). Since it is central to one of the developments, we also engaged stakeholders to validate the presence and type of the current Tropical Foods Grocery. This was considered particularly important given that some evidence suggests that the misclassification of business data may be greater in low income areas compared to higher income areas (Han et al. 2012). Using the methodology outlined in the Sustainable Communities Index to clean the NAICS data (Sustainable Communities Index 2012b), 11 of the 12 businesses listed as Supermarkets or General Grocery (code 445110) in the study area were recoded to "Convenience Group" (code 445120). No other changes were made. The total number of stores was then weighted according to scores developed by the San Francisco Department of Public Health that take into account quality and quantity of food offerings as well as other measures of accessibility, such as store hours (Food Market Score). These scores are scaled from 0-1, where 1 is the highest score and is equivalent to a supermarket. Since the weights range from 0-1, the sum total of the scores is equivalent to the number of grocery stores in the area.

Tropical Foods is currently categorized as a wholesaler and therefore would normally not be included in the current Food Market Score. Since our goal is to reflect the current food environment as accurately as possible, we calculated both the original score (shown in Table 35) which does not include Tropical Foods as well as a score which reflects stakeholder feedback that Tropical Foods should be categorized as a supermarket. Community Supported Agriculture (CSAs) or Virtual Supermarkets were not considered as we measured the food environment.

In order to measure the unhealthy food environment, we created an unhealthy food density score per capita. First we totaled the number of fast food stores in the study area and in Boston using InfoUSA data and then divided those totals by the population in the study area and Boston, respectively. For simplicity, only the top 10 grossing national food chains according to QSR magazine were included in this measure (QSR Magazine 2012). In order from number one to number 10, they are: McDonald's, Subway, Starbucks, Wendy's, Burger King, Taco Bell, Dunkin' Donuts, Pizza Hut, KFC, and Chick-fil-A (QSR Magazine 2012).

Existing Conditions

According to the validated NAICS coded data, there is one supermarket, but no meat markets, fruit and vegetable markets, warehouse/club stores, or specialty food stores in the study area. Table 35 below summarizes the number of outlets, their weights, and full weighted scores according to the validated NAICS codes in the study area.

Table 34: Current Study Area Food Market Score

CATEGORY	STUDY AREA BUSINESS COUNT	WEIGHTS	WEIGHTED SCORE
Supermarkets & General Grocery	1	1	1
Produce Market	0	0.9	0
Specialty Food Store	0	0.72	0
Warehouse/Club Store	0	0.72	0
Farmers Market	4	0.51	2.04
Drug Stores	2	0.41	0.82
Meat/Seafood Market	0	0.35	0
Convenience Group	23	0.25	5.75
Grand Total	30	-	9.61

Source: InfoUSA 2011

The score including the current Tropical Foods as a supermarket would bring the current Supermarket total to two (including the Mission Hill Stop & Shop and Tropical Foods), and the overall Food Market Score to 10.61.

In the study area there are 13 national fast food chain stores (ranked in the top 10 nationally) compared to 216 in Boston as a whole. Table 36 compares the relative densities per capita.

Table 36: Fast Food Retail Density per 10,000 people

FAST FOOD DENSITY	STORE DENSITY (PER 10,000 PEOPLE)
Study Area	4.3 stores per 10,000 residents
Boston	3.5 stores per 10,000 residents

Assessment

In order to assess how food access in the study area might change with the addition of the three proposed developments, we adjusted the weighted calculated above to reflect the inclusion of the newly expanded "supermarket level" Tropical Foods and the possible inclusion of the organic grocer and new farmers market that will take place in the Bartlett Place public plaza. With these additions the new supermarket count is 2, the new produce market count is 1, and the new farmer's market count is 5. This is illustrated in Table 37 below.

Table 37: Projected Study Area Food Market Score

CATEGORY	STUDY AREA BUSINESS COUNT	WEIGHTS	WEIGHTED SCORE
Supermarkets & General Grocery	2	1	2
Produce Market	1	0.9	0.9
Specialty Food Store	0	0.72	0
Warehouse/Club Store	0	0.72	0
Farmers Market	5	0.51	2.55
Drug Stores	2	0.41	0.82

CATEGORY	STUDY AREA BUSINESS COUNT	WEIGHTS	WEIGHTED SCORE
Meat/Seafood Market	0	0.35	0
Convenience Group	23	0.25	5.75
Grand Total	33	-	12.02

Source: InfoUSA 2011

Since the food market score does not include wholesalers, the original Tropical Foods is not included in this measure. If we compare this value (12.02) to the original Food Market Score of 9.61 instead of the stakeholder validated score of 10.61, we would likely be overestimating the change in the food environment. Regardless, since Tropical Foods is expanding to a full service supermarket, it may offer a wider range of food options that will likely still have a positive impact on food access, particularly because it is within approximately 1 mile of the entire study area thus increasing walkable access to healthy foods for residents.

Aside from the impact of Tropical Foods, the Bartlett Place Organic Grocer and Bartlett Place farmers market on the public plaza will likely have a positive impact for healthy food access for the study area.

The proximity of these food resources to Dudley Station and nearby transit hubs will likely increase its accessibility through public transit to nearby neighborhoods as well. The expansion of this supermarket to the area is particularly important given the residential units all three developments are proposing, as this will increase the number of people living in the area who will need access to healthy and affordable food.

Since supermarkets are widely considered the best resource for affordable healthy foods and the study area already has four farmers markets (three of which accept SNAP/EBT), the expansion of Tropical Foods will likely have a greater impact on food access for the region than the farmers markets will.

Although it is well known that supermarkets are better resources for affordable healthy foods when compared to convenience stores or smaller markets it is important to consider that they also offer access to unhealthy foods. Furthermore, the weights used in our Food Access Score were developed based on a survey administered in San Francisco (Sustainable Communities Index) and by using the same weights, our score assumes that Boston stores are similar enough to those in San Francisco and relative differences can be translated from one city to the other.

Summary

- Supermarkets are considered the best resources to obtain high quality affordable and healthy foods and communities that have more supermarkets and farmers' markets are associated with more positive health outcomes.
- The expansion of Tropical Foods will create a full service supermarket within 1 mile or less of the entire study area once it is built, and will likely have a very strong and positive impact on healthy food access for its residents.
- The public plaza in Bartlett place may be used for farmers' markets, which would also have a smaller but still positive impact on food access in the study area.
- The Bartlett Place organic grocer will also have a positive impact and the breadth of this impact will likely vary with its size and affordability.
- It isn't possible to predict what kinds of food outlets might move into the retail space in the developments, which may or may not be healthy.

10. Safety from Traffic

Background

New commercial and residential developments, especially those that involve previously vacant land or buildings, generate new trips by motorists, pedestrians, bicyclists and transit users. With the addition of new trips, there is potential for an increase in the number of traffic-related crashes that occur on the surrounding transportation system.

Motor vehicle crashes are responsible for more than 30,000 fatalities each year in the United States (National Center for Environmental Health 2012). Automobile collisions are one of the leading causes of death among people 34 years old and younger, and account for 3.2 million nonfatal injuries annually. Motor vehicle crashes impact pedestrians and bicyclists as well as motorists. In 2009, 630 cyclists and 4,092 pedestrians were killed in traffic crashes in the United States (National Highway Traffic Safety Administration 2009). The impact of crashes with pedestrians and bicyclists has more potential to lead to severe injury or fatality. As an example, a pedestrian hit at 35 mph is nearly three times more likely to die than one hit at 25 mph (Tefft 2013).

Integrated land use and transportation strategies can be used to reduce reliance on the automobile and its related effects like crashes, while creating new biking and walking facilities. One particular expression of these integrated investments is TOD. Transit use tends to be between two to five times higher among those who live and work in the TOD as compared to others traveling in the same region (Arrington and Cervero 2008). As a result, TOD often results in fewer vehicle trips that would be estimated using standard trip generation procedures (e.g., Institute of Transportation Engineer's Trip Generation manual).

Furthermore, land use and transportation investments like TOD that support public transit have the potential to reduce injury and death from transportation-related crashes through three means:

1. Changing the mode of travel from automobile to another that carries a lower risk of injury.
2. Changing the potential risk of vehicular collision for other vehicles and pedestrians.
3. Providing transportation alternatives to people with impairments that put them at high risk of injury (UCLA-CLIC 2013).

Methods

In order to estimate the effect of the proposed TODs on traffic safety, we reviewed health and transportation literature on traffic behavior, traffic safety, TODs and health. Using crash data from the Central Transportation Planning Staff (CTPS) of the Boston Region Metropolitan Planning Organization (MPO), we reviewed Massachusetts data on crashes, fatalities, and injuries and used geographic information systems (GIS) to map the crash locations. All of these data combined allowed us to estimate a range of expected impacts on crashes, fatalities, and injuries in the study area.

Existing Conditions

Based on 2009-2010 crash data, there were 423 reported crashes in the study area, which accounts for approximately 5% of all reported crashes in the City of Boston. Fatal crashes included a higher percent-

age of the crashes in the study area (0.9%) than in the city as a whole (0.3%), and the study area had a higher percentage of crashes that involved a non-fatal injury than did the entire city (36.4% vs. 33.0%) (Table 38).

Table 38: Crash Severity (% of overall crashes by severity)

	STUDY AREA	BOSTON
Fatal injury	0.9%	0.3%
Non-fatal injury	36.4%	33.0%
Not Reported	27.2%	17.6%
Property damage only	31.9%	47.4%
Unknown	3.5%	1.6%

Source: CTPS, 2009-10

In total, over the two-year period, the crash rate was 14.2 crashes per 1,000 residents within the study area and 13.5 crashes per 1,000 residents within the city overall. Figure 13 below shows the type and location of crashes in the study area.

During the 2009-2010 period, 6.7% of all reported crashes in the entire city involved a non-motorist (e.g., bicyclist, pedestrian) whereas nearly 11% of reported crashes in the study area involved a non-motorist (Table 38). Of all crashes in the study area, 6.6% involved pedestrians and 3.8% involved a bicyclist, and in the city these percentages were 4.3% and 2.2% respectively.

Table 39: Non-Motorist Crashes (% of overall crashes)

	STUDY AREA	BOSTON
Pedestrian	6.6%	4.3%
Bicyclist	3.8%	2.2%
Other Non-Motorist (wheelchair, skater, etc.)	0.5%	0.2%
Total (% of Non-Motorist Crashes)	10.9%	6.7%

Source: CTPS, 2009-10

Among the reported vehicle crashes involving non-motorists, 2 in the study area resulted in fatalities (1 pedestrian and 1 bicyclist) and 11 in the city resulted in fatalities (8 pedestrians and 3 bicyclists). Overall, during the two-year period, the non-motorist crash rate for the study area was 1.2 crashes per 1,000 residents and 0.9 crashes per 1,000 residents for the city.

Assessment

Each of the developments has commercial and residential elements and takes advantage of connections to nearby transit services: the MBTA Orange Line, MBTA Commuter Rail Line and existing MBTA bus routes. These connections to transit, in combination with the availability of pedestrian and bicycle facilities throughout the study area, also create the potential for many new walking and bicycling trips in the study area.

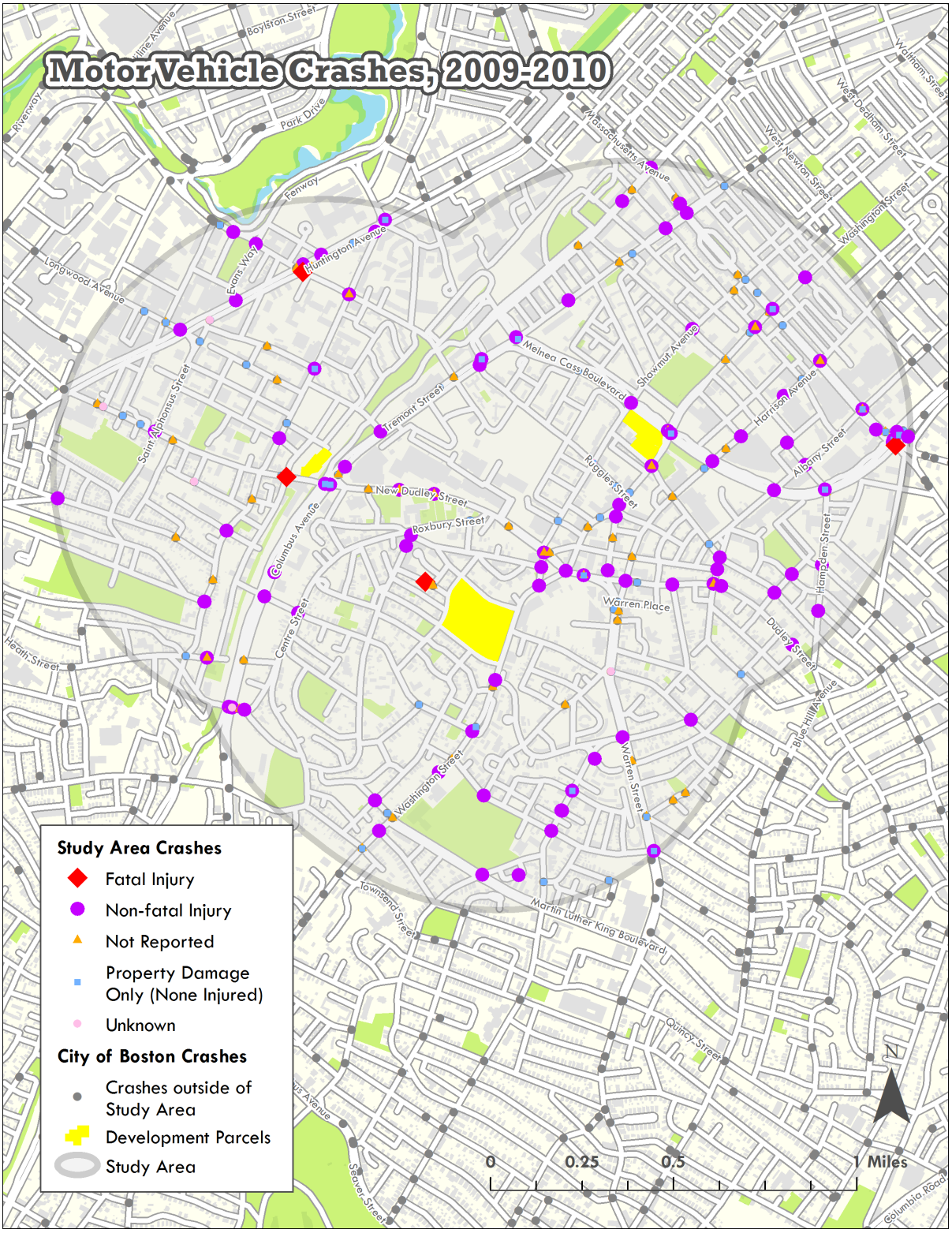


Figure 13: Motor Vehicle Crashes

PNFs for Bartlett Place and Madison Tropical Parcel 10, project approximately 3,000 new walk/bike trips and nearly 1,000 new transit trips daily. Transit trips will likely comprise of bicycle and pedestrian segments as riders go to and return from the stations or stops.

Despite the high number of new non-vehicular trips, each development is also projected to generate approximately 2,288 new vehicle trips daily. These trips would be generated by the retail and office uses (e.g., customers, employees, etc.) and new residents at each location. The changing vehicle volume and non-vehicle profile could potentially decrease traffic speeds if roads are highly congested, which could lower collision severity.

Overall, the combination of increased bicycle and pedestrian activity and vehicular activity has the potential to increase collisions in the study area. More specifically, as a location with an elevated percentage and rate of pedestrian and bicycle crashes relative to the city, the study area could be the location of additional crashes involving non-motorists. Mitigation measures, such as roadway configuration changes to accommodate bikers and pedestrians, could decrease collision risk. Examples of such measures include bike lanes, cycle tracks, bumpouts, or other traffic calming measures.

Summary

- As new development generates additional trips, there is potential to increase the number of traffic-related crashes in the surrounding neighborhood.
- There were 423 reported crashes in the study area, which had higher percentages of fatal and injury crashes as compared to the city as a whole. 6.7% of all reported crashes involved a non-motorist (e.g., bicyclist, pedestrian) in the entire city, whereas nearly 11% involved a non-motorist in the study area.
- There are projected to be 3,000 new walk/bike trips and nearly 1,000 new transit trips daily projected from two of the three developments as well as an additional 2,288 new daily vehicle trips.
- With increased vehicular and non-vehicular trips, and the higher relative percentages of crashes in the study area, there is the potential for more traffic related injuries.

11. Air Quality

Background

There is an extensive body of literature linking vehicular air pollution to mortality and hospitalizations due to asthma exacerbation, chronic lung disease, heart attacks, ischemic heart disease, and major cardiovascular disease (US EPA and Abt Associates, Inc 2010; Roman et al. 2008; Schwartz et al. 2008; Health Effects Institute 2003; Moolgavkar 2000b; Moolgavkar 2000a; Peters et al. 2001a). The Environmental Protection Agency (EPA) identifies 6 criteria air pollutants that have important human health impacts: Ozone (O_3), carbon monoxide (CO), particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and lead (Pb). The Clean Air Act requires the EPA to establish public health and welfare-based exposure standards for these six criteria air pollutants and States must develop plans to achieve these standards. Because the developments assessed will likely to lead to changes in traffic patterns, below we detail four criteria air pollutants most closely linked to vehicular traffic pollution.

Ozone

Ground level ozone, a chief ingredient in "smog," is not emitted directly into the air, but is created by chemical reactions between NOx and volatile organic compounds (VOCs) in the presence of sunlight. Emissions from motor vehicle exhaust and gasoline vapors are some of the major sources of NOx and VOC (MassDEP 2012a; EPA 2012b). Breathing ozone can irritate the respiratory system, reduce lung function, heighten sensitivity to allergens, and may contribute to premature death in people with heart and lung disease (MassDEP 2012a). In general, as concentrations of ground-level ozone increase, more people experience health symptoms, the effects become more serious, and hospital admissions for respiratory problems increase (MassDEP 2012a). When ground-level ozone reaches unhealthy levels, children and people with asthma or other respiratory diseases are the group at highest risk.

Particulate Matter

Particulate matter (PM) air pollution comes mainly from automobiles and power plants, and has been linked to higher rates of mortality and coronary disease (Dockery et al. 1993; Pope et al. 1995). Health effects include asthma exacerbation and difficult or painful breathing, especially in children and the elderly. Cardiovascular disease events account for most of the excess mortality attributed to PM exposure. Additionally, epidemiologic evidence has accumulated for a relationship between acute PM and nonfatal cardiovascular events, including: hospital admissions (Goldberg et al. 2001; Francesca Dominici et al. 2003; F. Dominici et al. 2006), myocardial infarction (Peters et al. 2001b; Zanobetti and Schwartz 2005), and cardiac arrhythmias (Dockery et al. 1993; Peters et al. 2001b; MassDEP 2012b).

Carbon Monoxide

Carbon monoxide (CO) is a poisonous gas that forms from incomplete combustion. CO is invisible and has no odor, but it can be dangerous to health and potentially fatal in high concentrations. Motor vehicle exhaust contributes roughly 60 percent of all carbon monoxide emissions nationwide, and up to 95 percent in cities. Air concentrations of CO can be particularly high in areas with heavy traffic congestion. People who suffer from cardiovascular diseases are at risk of experiencing s chest pain and other cardiovascular symptoms if exposed to carbon monoxide. People with cardiovascular and respiratory problems such as cerebrovascular disease, chronic obstructive lung disease, congestive heart failure

and anemia also are at greater risk from carbon monoxide exposure, as are young infants and developing fetuses (MassDEP 2013a).

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is one of a group of highly reactive gases containing nitrogen and oxygen in varying amounts (known collectively as oxides of nitrogen, or NOx). Many of these gases are colorless and odorless. But one, nitrogen dioxide (NO_2), often is seen along with particle pollution as a reddish-brown layer in the air over urban areas. Primary sources of NOx emissions include motor vehicles, electric utilities and other industrial, commercial and residential sources that burn fuels. Nitrogen dioxide irritates the nose and throat, especially in people with asthma, and appears to increase susceptibility to respiratory infections. When nitrogen dioxide and/or ground-level ozone reach unhealthy levels, children and people with respiratory disease are most at risk (MassDEP 2013b).

Methods

Each development projects new vehicle trips to and from the sites in their PNF. The projections with PNFs predict:

- 1,716 new daily vehicle trips generated by Bartlett Place
- 572 new daily vehicle trips generated by Madison Tropical Parcel 10 Project

These trips would be a result of the commercial uses (e.g., customers, employees, etc.) and the new residents at each location.

In accordance with the Boston Redevelopment Authority (BRA) requirements, the PNFs submitted for Bartlett Place and Madison Tropical Parcel 10 include microscale analyses of the effect of increases in traffic on air quality. The HIA evaluated carbon monoxide as a pollutant related to motor vehicle emissions and used that as a proxy to determine that any air pollution increases due to this project would not exceed national air quality standards. However, other motor vehicle emissions, such as particulate matter and nitrogen dioxide, should be evaluated in this and other TOD projects to more fully characterize background and project related air quality impacts. A microscale analysis involves modeling of CO emissions from vehicles idling at and traveling through both signaled and unsignalized intersections. The microscale analysis typically examines ground-level CO impacts due to traffic queues in the immediate vicinity of a project. CO is used in microscale studies to indicate roadway pollutant levels since it is the most abundant pollutant emitted by motor vehicles and can result in so-called "hot spot" (high concentration) locations around congested intersections. Federal air quality standards, known as the National Ambient Air Quality Standards (NAAQS), do not allow ambient CO concentrations to exceed 35 parts per million (ppm) for a one-hour averaging period and 9 ppm for an eight-hour averaging period, more than once per year at any location. The microscale analyses were conducted using air quality monitoring data, emissions estimates based on changes in traffic patterns (MOBILE6.2), and meteorology inputs (CAL3QHC) to model CO concentrations at sidewalk receptor locations. These models predict CO emissions based on expected traffic volume, speeds, and other meteorological inputs. Models predicted CO levels for both existing and future conditions to evaluate compliance of the roadways with the standards. The analyses for both Bartlett Place and Madison Tropical Parcel 10 followed the procedure outlined in U.S. EPA's intersection modeling guidance.

Baseline (2012 for Bartlett Place, 2013 for Madison Tropical Parcel 10), Interim (2017 for Bartlett Place, not conducted for Madison Tropical Parcel 10), and future year (2022 for Bartlett Place, 2018 for Madison Tropical Parcel 10) emission factor data calculated from the MOBILE6.2 model, along with traffic data, were input into the CAL3QHC program to determine CO concentrations due to traffic flowing through selected intersections. The results of the one-hour and eight-hour maximum modeled CO ground-level concentrations from CAL3QHC were added to EPA supplied background levels for comparison to the NAAQS. These values represent the highest potential concentrations at the intersection as they are predicted during the simultaneous occurrence of "defined" worst case meteorology.

No air quality analysis was available for Parcel 25; however, this site is expected to have lower traffic increases than the other sites, so air quality impacts are likely lower than for the other two developments.

Existing Conditions

To estimate background pollutant levels representative of the area, the most recent air quality monitoring data reported by the Massachusetts Department of Environmental Protection (MassDEP) in their Annual Air Quality Reports was obtained for 2007 to 2011. The closest monitor to both the Bartlett Place and Madison Tropical Parcel 10 developments is located on Harrison Avenue, which is located approximately two blocks east of Dudley Square and in the center of the study area. The corresponding maximum background concentrations in ppm were 2.9 ppm for 1-hour CO and 1.5 ppm for 8-hour CO, which are well below the NAAQS of 35 ppm for a 1-hour CO and 9 ppm for 8-hour CO.

In addition to CO, the Harrison Avenue site operated by the Mass DEP also monitors for all the other criteria air pollutants including particulate matter (PM2.5) and nitrogen dioxide. The annual air pollution concentrations for PM2.5 and NO2 in 2012 measured at the Harrison Avenue site did not exceed the NAAQS for these pollutants, however, there are health effects associated with exposure to these air pollutants at levels below the NAAQS. In addition, exposures may be higher for residents living in closer proximity to major roadways.

Assessment

Results of microscale air quality analyses for worst case scenario conditions are presented in the table below. With increased predicted traffic, increases in CO levels are predicted for the Bartlett Place and Madison Tropical Parcel 10 sites (Table 40). The projected increases in CO are relatively low, and do not approach the NAAQS.

Table 40: Microscale Air Quality Analyses for Bartlett Place and Madison Tropical Parcel 10

SCENARIO	BARTLETT PLACE		MADISON TROPICAL PARCEL 10	
	1-Hour	8-Hour	1-Hour	8-Hour
Max Background Levels	2.9	1.5	2.9	1.5
Projected Levels	4.8	3.4	4.6	3.3
National Ambient Air Quality Standard	35	9	35	9

No air quality analysis was conducted for Parcel 25; however, this site is expected to have lower traffic increases than the other sites, and would likely have smaller air quality impacts with respect to CO only.

The PNFs evaluated only carbon monoxide as a pollutant related to motor vehicle emissions. However, other motor vehicle emissions, such as particulate matter and nitrogen dioxide, should be evaluated in this and other TOD projects to more fully characterize background and project related air quality impacts. Particulate matter, in particular, may have the strongest effects compared to other pollutants. It is also important to note that there are health effects of air pollution even at levels below NAAQS, and that even small increases in air pollution may impact health negatively.

Summary

- Traffic-related air pollution has known negative impacts on respiratory and cardiovascular health.
- The developments included in this HIA are projected to increase pedestrian, bicycle, transit and auto traffic in the study area by 3,000 for walk/bike; 1,000 for transit, and 2,238 for auto trips a day.
- Microscale air quality analyses of CO projected increases in air pollution as a result of added traffic under worst case scenario conditions. These increases did not approach the federal air quality standard for CO.
- Other motor vehicle emissions, such as particulate matter and nitrogen dioxide, should be evaluated in this and other TOD projects to more fully characterize background and project related air quality impacts.

12. Environmental Contamination

Background

A brownfield is defined by the CDC as "abandoned or underused portions of land occupied by vacant businesses or closed military structures, located in formerly industrial or urban areas" (National Center for Environmental Health 2013). While there is no formal definition of the term "brownfields" in Massachusetts, brownfields are typically abandoned or for sale or lease and have been used for commercial or industrial purposes. Brownfields may have been reported to the MassDEP because contamination has been found or they may not have been assessed due to fear of unknown contamination conditions (MassDEP 2012c).

There are an estimated 450,000 brownfields in the US. Health impacts due to brownfields and contaminated sites include:

- Safety due to abandoned structures, open foundations, other infrastructure or equipment that may be compromised due to lack of maintenance, vandalism or deterioration, controlled substance contaminated sites (i.e., methamphetamine labs) and abandoned mine sites;
- Social and economic concerns due to blight, crime, reduced social capital, reductions in the local government tax base and private property values that may reduce social services; and,
- Environmental issues due to biological, physical and chemical site contamination, groundwater impacts, surface runoff or migration of contaminants as well as wastes dumped on site (EPA 2006)

Exposure to environmental contamination can have numerous health effects depending on the specifics of the prior land use and the materials remaining on the site that might be harmful to human health. Cleaning up and reinvesting in brownfields/land reuse properties has the potential to improve and protect the environment, economy, and surrounding community's health and well-being (ATSDR 2010).

State brownfields program incentives are available to buyers, and sometimes sellers, of contaminated property provided there is a commitment to cleanup during redevelopment. State incentives can help parties identify risk, limit liability, and fund the cleanup of brownfields sites enabling their reuse for industry, housing and other purposes. Parties who conduct site assessment or cleanup at any property in Massachusetts must do so under the state's cleanup law, Chapter 21E, and cleanup regulations, the Massachusetts Contingency Plan (MCP). A Licensed Site Professional (LSP) must be hired to conduct the site assessment. Brownfields sites require the same level of investigation and remediation as any other site in the MCP system. However, the MCP process allows property owners to take planned future reuses into account when performing a cleanup.

Methods

Massachusetts General Law, Chapter 21E, the state Superfund law, was originally enacted in 1983 (and amended in 1992, 1995, and 1998) and created the waste site cleanup program, which is managed by MassDEP. Contaminated properties regulated under this law are often called "21E sites." The Massa-

chusetts Department of Public Health Bureau of Environmental Health (BEH) staff researched readily available information on potential contamination on the three properties to help provide direction for further evaluation of environmental conditions at these sites.

Existing Conditions

The BEH review revealed that each of the development sites have had releases of oil or hazardous chemicals at levels sufficiently high to be regulated under the Massachusetts Contingency Plan (MCP), the state's hazardous waste program mandated under MGL Chapter 21E.

Bartlett Place

The Bartlett Place Development is proposed on the site of the former MBTA bus garage. This property has a long industrial history dating back to the late 1880s. Based on available MassDEP files and contractor reports (Arcadis 2012; Arcadis 2011), several releases of hazardous chemicals have occurred on the property over the years. These releases have included various oils (such as motor oil and transmission oil), grease, antifreeze, gasoline, diesel fuel, and kerosene. Some spills and releases have been cleaned up and both underground and aboveground storage tanks have reportedly been removed, although Arcadis (2012) noted that records for tank removals were not complete.

Currently, two chemical releases are under active investigation under the MCP: one release (RTN 3-0029936) is associated with metals, polycyclic aromatic hydrocarbons (PAHs), and petroleum compounds in soil on the property at levels above MCP reportable concentrations for soil classified as S-1 (residential use); the other release (RTN 3-0027845) is associated with the presence of 2.3 feet of petroleum product in a groundwater monitoring well on the property (Arcadis 2011). The property itself has been classified as a Tier II site under the MCP and, according to contractor reports, is under active investigation. According to Arcadis (2011 and 2012), remedial actions to address the contamination are planned as part of the development.

Groundwater is within approximately 4.3 to 10.7 feet of the ground surface (Arcadis 2011), leading to potential for vapor intrusion of volatile organic compounds (VOCs). There are two additional MCP sites near the Bartlett site where, in the past, groundwater contamination and/or vapor intrusion have been significant issues: the former Modern Electroplating Company (at 2430 Washington Street, approximately 372 feet northeast of the site) and the former Children's Services property (at 2406 Washington Street, approximately 590 feet northeast of the site). Based on available MassDEP online files, the former Modern Electroplating Facility (a Tier II site) contaminated shallow groundwater with VOCs and metals that migrated to the north and northwest, impacting the former Children's Services building.

Madison Tropical Parcel 10

According to Goldman Environmental Consultants, Inc. (GEC), the Madison Tropical Parcel 10 Project is proposed on land formerly used for commercial purposes as well as light industrial uses that included carriage, shoe, and coat manufacturing; auto repair and parking garages; and a cleaner and dyer. Currently, two chemical releases on this property are under active investigation under the MCP: RTNs 3-31259 and 3-31352. According to GEC's Phase I report (2013), the presence of petroleum contamination in soil and groundwater on the central and/or south-central portions of the site, caused by a leaking gasoline underground storage tank (which has been removed), and the presence of soil con-

taining high levels of lead in the western portion of the site require active remediation or use restrictions under the MCP. Contractor reports indicate that building materials may be present that contain asbestos (piping wrap insulation and elbow joints), lead (peeling paint), and PCBs (electrical switches and light ballasts) (GEC 2013).

Parcel 25

Although limited information is readily available, it appears from MassDEP's website that an RTN (3-0031170) was assigned to this property in 2012. More research is needed to investigate this release.

Assessment

Environmental contamination may influence the potential for exposure to site-related contamination. The change from industrial to future residential use of these properties necessitates thorough consideration of the potential health risks associated with residual contamination. Negative impacts on health may be possible with future developments if conditions are not remediated. Remediation measures being considered or undertaken as part of redevelopment should reduce or eliminate potential exposure opportunities.

Potential exposure opportunities associated with contaminated soil and groundwater should be mitigated for residents currently living and/or working near the site as well as for site workers involved in remediation and construction. Appropriate precautions should be taken during demolition/renovation activities to prevent any potential exposures to area residents and site workers. Future residents and retail employees should be protected against potential exposure opportunities associated with residual soil contamination, via direct contact with surface soil or through gardening. If a playground is constructed, soil must either meet regulatory standards or be removed and/or covered with clean soil that will prevent exposure opportunities to children using the playground. The potential for vapor intrusion of VOCs in groundwater into site buildings should be fully evaluated to protect future building inhabitants. Developers should ensure the property has been remediated to meet regulatory standards and is suitable for intended uses. Examples of possible remedial actions include installation of a sub-slab depressurization system to prevent volatile organic compounds in groundwater from entering indoor air, soil removal to meet regulatory standards, and the use of containers for gardening. A review of 21E sites in the study area revealed a number of potential sites of historical environmental contamination. These sites have the potential for negatively impacting health, although further research is required to determine the extent of this potential.

Summary

- Environmental contamination has the potential to negatively impact health and safety through opportunities for exposures in indoor air (via vapor intrusion from contaminated groundwater), direct contact to soil (e.g., on playgrounds if soil is not remediated to regulatory standards and through gardening if containers are not used with clean soil), opportunities for exposures during demolition and construction activities (e.g., detailed plans must be in place to mitigate fugitive dust emissions), and other potential impacts.
- Environmental contamination at the three sites should be remediated and mitigated in accordance with environmental agency regulations in order to minimize any future health impacts from site conditions.
- Remediation measures being considered or undertaken as part of redevelopment may reduce or eliminate potential exposure opportunities.

Part III

Summary of Findings

In order to understand neighborhood-wide effects that would most effectively inform the HNEF, we focused on the cumulative impacts of the TOD developments. Therefore, Part III of this HIA seeks to serve as a resource for the HNEF in summarizing major findings, isolating health-related metrics relevant for HNEF, and providing specific recommendations to improve each health determinant through TOD development.

Overall, the HIA predicts that these three TOD projects would have a positive public health impact assuming existing environmental contamination at all three sites is remediated and mitigated to meet applicable environmental regulatory agency standards and guidance, and also assuming that air quality impacts from motor vehicle emissions other than carbon monoxide do not pose adverse health impacts (Table 41). Once constructed, all three developments would likely create a more walkable environment and increase access to destinations; increase the area's access to healthy affordable foods through the expansion of Tropical Foods grocery; reduce crime by eliminating two currently vacant lots by replacing them with well-lit mixed-used developments that will bring new commuters, residents, and employees to the area; add trees, green and public space for social interactions; and expand economic opportunity in the area by creating 880 temporary construction jobs with local hiring requirements and 345 permanent new jobs in a transit-accessible location proximate to downtown Boston. Furthermore, residents of these future developments will benefit from at least 176 new affordable housing units and at least 343 new green housing units, which will provide incoming families with the chance for greater residential stability, but should be designed with adequate HVAC and engineering systems installed and maintained properly to prevent indoor air quality issues.

This combination of benefits outweighs the increases in traffic and the associated increases in air pollution and potential traffic safety concerns that accompany development, assuming that pollutants not evaluated in this HIA (e.g., particulate matter and nitrogen dioxide) would not significantly increase as a result of this or other TOD projects. Though the area has slightly lower levels of social cohesion than Boston as a whole, we predict that the three developments will foster greater social cohesion; however if current residents get priced out of their neighborhoods and are forced to leave existing close social networks, this would likely have a strong negative impact on the affected members of the existing community. Environmental contamination is a concern for these developments if appropriate steps are not taken to address them. Therefore, remediation and mitigation of opportunities for environmental exposures should be conducted to prevent future environmental exposures to residents, workers, and visitors, although proper remediation may actually decrease opportunities for exposure. We cannot predict how the three developments would impact home values, however it is important to note that owner-occupied and renter-occupied low income or cost-burdened households may be at risk for displacement.

These assessment findings can serve as a model for future HNEF development proposals. Table 41 below summarizes findings of the HIA specific to the TOD projects assessed. We list each health determinant and the direction of the expected health impact, with a plus sign representing a positive health

impact and a negative sign indicating a negative impact on health. The likelihood column represents the probability of this health effect occurring due to the change in the determinant. The magnitude column represents the combination of the severity of potential health impacts (the degree of health impact that would be experienced by an individual) and the distribution of those impacts across a population (the breadth of people who could experience the health impact). Finally, we include a column summarizing the strength of evidence for the literature linking each determinant to a health impact (where the number of plus signs corresponds to the strength of the literature base with one representing a weak base and four a strong base). The impacts were considered in the context of a time horizon of 10 years in the future, which would account for a majority of, if not full, buildout of the TOD projects.

Table 41: Summary of Findings

HEALTH DETERMINANT	DIRECTION OF IMPACT	LIKELIHOOD OF IMPACT	MAGNITUDE OF IMPACT	SEVERITY OF IMPACT	DISTRIBUTION	STRENGTH OF EVIDENCE
Walkability / Active Transport	+	Likely	Medium	Medium	Wide	++++
Safety from Crime	+	Likely	Medium	High	Wide	++++
Economic Opportunity	+	Likely	Medium	High	Narrow (Those Gaining Employment)	++++
Food Access	+	Likely	High	Medium	Wide	+++
Traffic Safety	-	Likely	Medium	High	Wide	++++
Affordable Housing	+	Likely	Medium	High	Narrow (Residents of Affordable Housing)	++++
Green Housing	+	Likely	Low	Medium	Narrow (Residents of Green Housing)	+++
Green Space	+	Likely	Low	Low	Narrow (Those accessing new green spaces)	++
Social Cohesion	+	Likely	Low	Low	Wide	++++
Air Quality[10]	-	Likely	Low	Low	Wide	++++
Gentrification / Displacement	-	Possible	Medium	High	Narrow (Cost Burdened)	+++
Environmental Contamination[11]	+/-	Possible	Medium	High	Narrow (Those living and working on site of remediation)	++++

[10] This assumes air quality impacts from motor vehicle emissions of other pollutants besides carbon monoxide would have similarly low impacts.
[11] This assumes that sites are remediated and mitigated in accordance with environmental agency regulations.

Recommendations

In this section, we recommend datasets for screening potential neighborhoods, identify metrics for health determinants that would benefit these communities, and provide specific strategies that developers can apply to improve health determinants through the HNEF.

The HNEF will consider projects for investment through a two-part neighborhood screening and project impact review process. Based on the results of this HIA, we gathered a number of indicators that are relevant to profiling baseline neighborhood health information to identify communities that might benefit from HNEF funding. We also identify pathways through which development may impact health, and we include relevant datasets and measures that can be used to estimate these impacts. Finally, we recommend strategies to mitigate negative impacts and maximize opportunities to improve health that are applicable to all development funded through the HNEF. This section serves as a toolkit for identifying these relevant datasets by including data sources to enable researchers/planners/developers to more easily locate these valuable resources, and then recommends approaches to optimize health through development.

Neighborhood Screening

A new TOD project should be informed by the neighborhood characteristics and health status in order to maximize the health benefits of the development. Understanding the basic health profile of the neighborhood allows the project team to more effectively define community needs and thereby address them. Below we list data sources that provide demographic and housing information at the census tract level (Table 42).

Table 42: Neighborhood Characteristic Data Sources

NEIGHBORHOOD CHARACTERISTIC DATA SOURCES	
Census/American Community Survey	Population, population by race/ethnicity, Median Household Income, Unemployment Rate
Department of Neighborhood Development, Boston Redevelopment Authority	Occupied Housing Units, Average Household Size of All Occupied Units, Affordable Units, Owner-Occupied Housing Units, Average Household Size of Owner-Occupied Units, Renter-Occupied Housing Units, Average Household Size of Renter-Occupied Units

Health data at the neighborhood level is important to understand the distribution of health outcomes in a given area and to ensure that development addresses the most pressing health concerns of a community. In addition, using the BPHC health equity framework (or similar approach) could assist in informing neighborhood characteristics, especially those that reflect racial disparities and health inequities. Datasets on health information are listed below (Table 43).

Table 43: Neighborhood Health Profile Data Sources

NEIGHBORHOOD HEALTH PROFILE DATA SOURCES	
Behavioral Risk Factor Surveillance System (BRFSS)	Adult Smoking, Adults Lacking Regular PA, Adult Obesity, Adult Diabetes, Adults Eating 5 Fruits/Vegetables per Day, Adult Hypertension, Adult Asthma (by zip code from MDPH)
Massachusetts Department of Public Health/Bureau of Environmental Health website	Pediatric Diabetes Data (by municipality and/or school)
Massachusetts Environmental Public Health Tracking System	Pediatric Asthma (by school and/or community), Childhood Blood Lead Data[12], Reproductive and Birth Outcome Data, Asthma and Heart Attack Hospitalization Data
MassCHIP	Leading causes of hospitalizations (by municipality)
OurHealthyMass.org	Chronic disease death rate, coronary heart disease hospitalization rate, heart attack hospitalization rate, stroke hospitalization rate, substance abuse hospitalization rate (by municipality)
All Payers Claims Database	This database is comprised of medical, pharmacy, and dental claims, as well as information about member eligibility, benefit design, and providers for all payers covering Massachusetts residents (not currently available)

Recommended Health Determinant Metrics

By assessing a cluster of TOD projects in this HIA, we compiled a list of metrics that could be replicated anywhere in the state. It should be noted that these metrics are intentionally broad because the HIA process has underscored that health metrics are most effective when context-specific. Therefore, setting thresholds or standards in which to view all development proposals is not optimal, and different metrics may be available for different development projects. Although this list is not intended to be comprehensive, we provide a framework of metrics in Table 44 below.

Table 44: Recommended Metrics

HEALTH DETERMINANT	HEALTH DETERMINANT METRICS	RECOMMENDED DATA SOURCES
Walkability/Active Transport	State of Place score[13] Number of bicycle and pedestrian accommodations Number of parking spaces[14]	State of Place Project Notification Forms
Safety from Crime	Geocoded crime reports Presence of CPTED strategies	Local Police Department, FBI Uniform Crime Reports Project plans
Economic Opportunity	Project plan job projections by job type Educational Attainment Per Capita Income Labor Force Participation	Project plans American Community Survey

[12] It is important to consider screening rates. Data on percentage of children screened should be reviewed and included when reporting childhood blood lead levels. The Massachusetts Environmental Public Health Tracking System is a reliable, ongoing source for investigating blood lead prevalence that is routinely updated as CDC refines their guidance on blood lead prevalence.

[13] State of Place is an assessment tool that requires on ground level audits. Although this is very time and resource intensive, the tool can provide important metrics to estimate health determinants. However, if State of Place is used for each development proposal, State of Place can be used to cross-reference many of these metrics to increase accuracy.

[14] Encourage developments with low parking ratios that are below the current neighborhood residential vehicle availability.

HEALTH DETERMINANT	HEALTH DETERMINANT METRICS	RECOMMENDED DATA SOURCES
Food Access	Food Access Score[15] Account for unhealthy food access in the region by totaling validated NAICS coded data on "fast food" and "liquor" stores	San Francisco Sustainable Communities Food Access Score InfoUSA
Safety from Traffic	Geocoded crashes by type in neighborhood Transportation access by mode	Registry of Motor Vehicle Crash data Project plans
Affordable Housing	Number of affordable housing units	Project plans SHI
Green Housing	Number of certified green housing units[16]	Project plans
Green Space	Acres per capita of open space Percentage of tree canopy coverage	MassGIS i-Tree Canopy
Social Cohesion	Voter turnout rate by ward/precinct	Municipal government
Displacement/ Gentrification	Percent of cost-burdened households in the neighborhood Percent of households making less than $35,000 in the neighborhood	American Community Survey (Cost Burdened Households by Income and Tenure) American Community Survey (Household Income by Tenure)
Air Quality	Particulate matter and NO_2 can be evaluated in terms of traffic density, air dispersion modeling, or proximity to roadways (i.e., residents living within 300 feet). Background air pollution concentrations need to be considered.	Project plans
Environmental Contamination	Potential exposures associated with the presence of onsite and near site 21E sites and National Priority List (NPL) sites as well as onsite and nearby RCRA facilities out of compliance with environmental regulatory standards	Project plans and reports (such as due diligence and contractor reports) MassDEP website (site files related to 21E sites, brownfields and RCRA facilities) USEPA website (files related to NPL sites, brownfields, and RCRA facilities)

These metrics are grounded in a strong literature base and have been chosen to focus on data sources that are public, accessible, and available at the neighborhood level anywhere in the state. In conducting this HIA, we were able to obtain more data and metrics than those provided above.

[15] Use the Food Access Score to assess healthy food access. Validate NAICS coded data by looking on Yelp and Google street view for the storefront, add in farmer's markets, sum up each type of business and multiple by the corresponding weighted score. The total score will be equivalent to the number of supermarkets in the area. If new high quality food resources such as supermarkets are being added, calculate the percentage of the area that is within 0.5 miles and then 1 mile of that new development to measure for what proportion the store is within easy and reasonable walking range, relatively speaking. Account for unhealthy food access in the region by totaling validated NAICS coded data on "fast food" and "liquor" stores using the same validation technique as for the Food Access Score.

[16] Potential rating systems for certification include LEED, Energy Star, and Enterprise Green Communities Criteria.

Recommendations for Improving Health Determinants through the Healthy Neighborhoods Equity Fund

Based on the HIA process, we have a comprehensive list of 12 health determinants that are affected by TOD. Below we list recommendations for developments to address each health determinant (Table 45). Although these determinants are separated into discrete categories for the purposes of measuring them more easily, it should be taken into account that they are interrelated. A development that successfully improves walkability, for example, could also reduce crime opportunities by encouraging more people to be on the street and improve social cohesion by increasing the number of interactions neighbors have with each other. Thus while ideally a development proposal should be well-balanced and seek to address each one of these determinants, it may do so even if it does not formally address each category. Regardless, the recommendations listed below are aimed at maximizing the health benefits and minimizing risks, and are ordered by the breadth of impact the health determinant could have on the neighborhood's health outcomes.

These recommendations should be considered in framing the HNEF.

Table 45: Recommendations for Improving Health Determinants through the HNEF

HEALTH DETERMINANT	RECOMMENDATIONS	HEALTH IMPACTS
Walkability/Active Transport	Promote density, mixed land-use, availability of destinations and amenities, short distances to transit, bicycle and pedestrian accommodations, and lower ratios of on- and off-street parking into the development design.	Physical activity, mental health, chronic disease, obesity
Safety from Crime	Incorporate Crime Prevention through Environmental Design (CPTED) strategies into the development design. Encourage developers to be aware of internal and external pathways/ connections to other destinations, particularly for routes to a transit station.	Injury, physical activity, mental health, real and perceived safety
Economic Opportunity	Require or encourage a measure similar to the Boston Redevelopment Authority's Boston Residents Construction Employment Program so that developments result in temporary, and possibly full-time, employment opportunities for residents in the impacted neighborhood. Encourage the creation of jobs through projects that offer some match to existing education levels or occupational skills of residents in the impacted neighborhood; conversely, encourage the inclusion of job training components of developments in order to assist residents to build skills and take advantage of nearby job opportunities.	Economic stability
Food Access	Encourage expanding access to healthy food resources that offer a wide range of affordable goods within walking distance, particularly in areas with low access.	Nutrition, chronic disease, obesity
Safety from Traffic	Support developments that promote a Complete Streets approach to accommodate safe bicycle, pedestrian and transit trip-making for the new residential and/or commercial development. Encourage a context-sensitive approach for proposed roadway improvements so that new or reconstructed roads are designed with narrow travel lanes and for slower vehicular speeds.	Injury, air quality, real and perceived safety
Affordable Housing	Support developments that maintain a diverse housing stock, including affordable income-restricted housing units when appropriate.	Economic stability

HEALTH DETERMINANT	RECOMMENDATIONS	HEALTH IMPACTS
Green Housing	Encourage green housing with particular attention to affordability and indoor air quality.	Exposure to environmental contaminants, chronic disease
Green Space	Promote expansion, upkeep, and access to green spaces as well as urban trees.	Physical activity, mental health, air quality
Social Cohesion	Promote developments that seek to enhance the social impact of the public spaces and social/cultural events. Consider how displacement may dissolve and therefore have a negative impact on existing social networks.	Mental health
Displacement/ Gentrification	Promote the use of anti-displacement strategies between communities and developers such as Community Benefits Agreements. Promote local regulatory changes that support anti-displacement strategies such as inclusionary zoning, condominium conversion ordinances, and one for one affordable housing replacement ordinances.	Mental health, economic stability
Air Quality	Encourage air quality analyses associated with increased motor vehicle use. Consider background concentrations. Monitor air quality during construction and after the development is complete to ensure that air quality levels do not degrade beyond projected levels. Consider mitigation measures such as reinforcing the bicycle/pedestrian infrastructure or using construction equipment with diesel retrofits.	Air quality, asthma, other respiratory diseases, and cardiovascular disease
Environmental Contamination[17]	Mitigate or remediate environmental contamination to reduce potential for exposure for residents living and/or working near the site as well as for site workers involved in remediation and construction.	Exposure to environmental contaminants, childhood blood lead levels, asthma, other relevant chronic diseases

Monitoring

The goal of monitoring is to review the effectiveness of the HIA process, evaluate final decisions and institute processes to measure health outcomes resulting from the proposed project. Although not yet explicitly measured, we found through ongoing conversations and sharing of materials that the process of conducting the HIA (discussing progress, sharing drafts and research, etc.) strengthened the research base for the HNEF and influenced the metrics for the fund. The HNEF, as a financing tool, is still evolving and we believe this HIA will continue to impact the framework of the fund and the projects it will support. We will use the HIA report to continue to interact with the decision-making organizations and track the impact of the HIA on final decisions. We further plan on conducting a process and impact evaluation to formally document the HIA process and its impact on the decision-making process.

[17] Environmental contamination should be addressed in the MEPA/NEPA process, however it is important to consider reducing the potential for exposure to environmental containments

The CLF and MHIC are currently planning their long-term outcome monitoring strategy for the HNEF. The monitoring plan will include economic, social/behavioral, environmental and health indicators for the funded projects and their neighborhoods. This HIA provides datasets that can be used to monitor HNEF-funded projects (Tables 42 and 43) and a recommended metrics table (Table 44) which provides a meaningful way to connect the datasets with health determinants.

Conclusions

This HIA was conducted to look at the health impacts of the three TOD projects of Bartlett Place, Madison Tropical Parcel 10, and Parcel 25 in order to inform health metrics for the HNEF. This HIA predicts that TOD supported by the HNEF would have an overall positive impact on the health of the surrounding community particularly since there are many health disparities and disproportionate health impacts in the neighborhood. The pathways, methods of analysis, and datasets used in this study were chosen in order to inform the metrics ultimately for use in the HNEF. Pathways, methodology, and metrics were specifically selected to be comprehensive enough to account for many different types of potential health impacts and a wide variety of neighborhood types, while remaining informative and relevant for specific development decision-making. In summary, this HIA finds:

1. There is a strong literature base that links numerous factors of TOD to health determinants.
2. Measuring TOD's effects on health outcomes can be complex due to lack of data at the neighborhood scale and about uncertainty over the population that will reside and work in the proposed developments.
3. The HIA process led to the development of a toolkit that includes a framework, recommended data sources, and recommended metrics backed by a strong literature base and reviewed by interdisciplinary experts. This toolkit should aid the HNEF in identifying appropriate development projects and evaluating their health impacts.

References

Agrawal, Asha Weinstein, Marc Schlossberg, and Katja Irvin. 2008. "How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference." *Journal of Urban Design* (13): 81–98.

Aidala, Angela, Peter Messeri, David Abramson, and Gunjeong Lee. 2001. "Housing and Health Care Among Persons Living with HIV/AIDS". Update Report #37. Joseph L. Mailman School of Public Health Columbia University.

Anderson, James M., John MacDonald, Ricky N. Bluthenthal, and J. Scott Ashwood. 2013. "Reducing Crime by Shaping the Built Environment with Zoning". Product Page. http://www.rand.org/pubs/external_publications/EP51286.html.

Arcadis. 2012. Phase I Initial Site Investigation & Tier Classificatio, Bartlett Yard, 2565 Washington Street, Roxbury, MA , RTN 3-29936. April 5, 2012.

Arcadis. 2011. Phase III Remedial Action Plan, Bartlett Yard, 2565 Washington Street, Roxbury, MA, RTN 3-27845. July 29, 2011.

Arrington, G.B., and Robert Cervero. 2008. "Effects of TOD on Housing, Parking, and Travel". TCRP Report 128. Transportation Research Board.

ATSDR. 2010. "Leading Change for Healthy Communities and Successful Land Reuse."

Bartlett, Sheridan. 1997. "The Significance of Relocation for Chronically Poor Families in the USA." *Environment and Urbanization* 9 (1) (April 1): 121–132. doi:10.1177/095624789700900101.

Beatley, Noreen. 2011. "Green Housing = Improved Health: A Winning Combination". National Center for Healthy Housing.

Berkman, L F, and S L Syme. 1979. "Social Networks, Host Resistance, and Mortality: a Nine-year Follow-up Study of Alameda County Residents." *American Journal of Epidemiology* 109 (2) (February): 186–204.

Berkman, L. F., and I. Kawachi. 2000. *Social Epidemiology*. Oxford University Press, USA.

Besser, Lilah M, and Andrew L Dannenberg. 2005. "Walking to Public Transit: Steps to Help Meet Physical Activity Recommendations." *American Journal of Preventive Medicine* 29 (4) (November): 273–280. doi:10.1016/j.amepre.2005.06.010.

Billings, Stephen B., Suzanne Leland, and David Swindell. 2011. "The Effects of the Announcement and Opening of Light Rail Transit Stations on Neighborhood Crime." *Journal of Urban Affairs* 33 (5): 549–566. doi:10.1111/j.1467-9906.2011.00564.x.

Boone-Heinonen, Janne, Penny Gordon-Larsen, Catarina I Kiefe, James M Shikany, Cora E Lewis, and Barry M Popkin. 2011. "Fast Food Restaurants and Food Stores: Longitudinal Associations with Diet in Young to Middle-aged Adults: The CARDIA Study." *Archives of Internal Medicine* 171 (13) (July 11): 1162–1170. doi:10.1001/archinternmed.2011.283.

Boston Redevelopment Authority. 2010. "Mayor Menino Announces Projects Move Forward." November. http://www.bostonredevelopmentauthority.org/press/PressDisplay.asp?pressID=574.

Boston Redevelopment Authority. 2013. "Boston's Neighborhoods: Mission Hill." http://www.bostonredevelopmentauthority.org/neighborhoods/Neighborhoods.asp?action=ViewHood&HoodID=13.

Breysse, Jill, David E Jacobs, William Weber, Sherry Dixon, Carol Kawecki, Susan Aceti, and Jorge Lopez. 2011. "Health Outcomes and Green Renovation of Affordable Housing." *Public Health Reports* (Washington, D.C.: 1974) 126 Suppl 1 (June): 64–75.

Breysse, Patrick, Nick Farr, Warren Galke, Bruce Lanphear, Rebecca Morley, and Linda Bergofsky. 2004. "The Relationship Between Housing and Health: Children at Risk." *Environmental Health Perspectives* 112 (15) (November): 1583–1588. doi:10.1289/ehp.7157.

Brisson, Daniel S., and Charles L. Usher. 2005. "Bonding Social Capital in Low-Income Neighborhoods." *Family Relations* 54 (5) (December): 644–653.

Brooks-Gunn, Jeanne, and Greg J. Duncan. 1997. "The Effects of Poverty on Children." *The Future of Children* 7 (2): 55. doi:10.2307/1602387.

Center for Transit-Oriented Development. 2011. "Transit and Regional Economic Development."

Centers for Disease Control and Prevention. 2010. "State Indicator Report on Physical Activity". Atlanta, GA: U.S. Department of Health and Human Services.

Cervero, Robert. 2006. "Alternative Approaches to Modeling the Travel-Demand Impacts of Smart Growth." *Journal of the American Planning Association* 72 (3): 285–295. doi:10.1080/01944360608976751.

Chapple, Tiffany. 2009. "Mapping Susceptaibility to Gentrification: The Early Warning Toolkit". The Center for Community Innovation at UC-Berkeley.

Chatman, Daniel G. 2013. "Does TOD Need the T?" *Journal of the American Planning Association* 79 (1): 17–31. doi:10.1080/01944363.2013.791008.

Chung, Chanjin, and Samuel L. Myers. 1999. "Do the Poor Pay More for Food? An Analysis of Grocery Store Availability and Food Price Disparities." *Journal of Consumer Affairs* 33 (2): 276–296. doi:10.1111/j.1745-6606.1999.tb00071.x.

City of Boston. 2013. "Energy Positive Boston." http://www.epositiveboston.org/.

City of Boston. 2013. "Green Buildings | City of Boston." Accessed June 19. http://www.cityofboston.gov/environmentalandenergy/buildings/.

Cohen, S., and T. A. Wills. 1985. "Stress, Social Support, and the Buffering Hypothesis." *Psychological Bulletin* 98 (2): 310–357.

Cohen, Sheldon E., Lynn G. Underwood, and Benjamin H. Gottlieb. 2000. *Social Support Measurement and Intervention: A Guide for Health and Social Scientists*. Oxford University Press.

Cohn, Richard D., Samuel J. Arbes, Renee Jaramillo, Laura H. Reid, and Darryl C. Zeldin. 2006. "National Prevalence and Exposure Risk for Cockroach Allergen in U.S. Households." *Environmental Health Perspectives* 114 (4) (April): 522–526. doi:10.1289/ehp.8561.

Conroy, Kathleen, Megan Sandel, and Barry Zuckerman. 2010. "Poverty Grown up: How Childhood Socioeconomic Status Impacts Adult Health." *Journal of Developmental and Behavioral Pediatrics: JDBP* 31 (2) (March): 154–160. doi:10.1097/DBP.0b013e3181c21a1b.

Cook, John T, and Deborah A Frank. 2008. "Food Security, Poverty, and Human Development in the United States." *Annals of the New York Academy of Sciences* 1136: 193–209. doi:10.1196/annals.1425.001.

Cotterill, Ronald, and Andrew Franklin. 1995. "The Urban Grocery Store Gap. No. 8." *University of Connecticut, Department of Agricultural and Resource Economics, Charles J. Zwick Center for Food and Resource Policy*.

Cubbin, Catherine, Felicia B. LeClere, and Gordon S. Smith. 2000. "Socioeconomic Status and Injury Mortality: Individual and Neighbourhood Determinants." *Journal of Epidemiology and Community Health* 54 (7) (July 1): 517–524. doi:10.1136/jech.54.7.517.

Cutts, Diana, Alan Meyers, Maureen Black, Patrick Casey, Mariana Chilton, John Cook, Joni Geppert, et al. 2011. "US Housing Insecurity and the Health of Very Young Children." *American Journal of Public Health* 101 (8) (August).

Dannenberg, Andrew L, Richard J Jackson, Howard Frumkin, Richard A Schieber, Michael Pratt, Chris Kochtitzky, and Hugh H Tilson. 2003. "The Impact of Community Design and Land-use Choices on Public Health: a Scientific Research Agenda." *American Journal of Public Health* 93 (9) (September): 1500–1508.

Department of Neighborhood Development. 2012. "City of Boston Real Estate Trends." http://www.cityofboston.gov/dnd/pdr/real_estate_trends.asp.

Department of Neighborhood Development, Policy, Development, and Research Division. 2013. "Roxbury Data Profile." http://www.cityofboston.gov/Images_Documents/Roxbury_Planning_District_Profile_tcm3-12996.pdf.

Ding, Ding, and Klaus Gebel. 2012. "Built Environment, Physical Activity, and Obesity: What Have We Learned from Reviewing the Literature?" *Health & Place* 18 (1) (January): 100–105. doi:10.1016/j.healthplace.2011.08.021.

Dockery, Douglas W., C. Arden Pope, Xiping Xu, John D. Spengler, James H. Ware, Martha E. Fay, Benjamin G. Ferris, and Frank E. Speizer. 1993. "An Association Between Air Pollution and Mortality in Six U.S. Cities." *N Engl J Med* 329 (24) (December 9): 1753–1759. doi:10.1056/NEJM199312093292401.

Dominici, F., R. D. Peng, M. L. Bell, L. Pham, A. McDermott, S. L. Zeger, and J. M. Samet. 2006. "Fine Particulate Air Pollution and Hospital Admission for Cardiovascular and Respiratory Diseases." *JAMA: The Journal of the American Medical Association* 295 (10): 1127–1134.

Dominici, Francesca, Aidan McDermott, Scott L Zeger, and Jonathan M Samet. 2003. "National Maps of the Effects of Particulate Matter on Mortality: Exploring Geographical Variation." *Environmental Health Perspectives* 111 (1): 39–44.

Drewnowski, Adam. 2009. "Obesity, Diets, and Social Inequalities." *Nutrition Reviews* 67 Suppl 1 (May): S36–39. doi:10.1111/j.1753-4887.2009.00157.x.

Drewnowski, Adam, and S. E. Specter. 2004. "Poverty and Obesity: The Role of Energy Density and Energy Costs." *The American Journal of Clinical Nutrition* 79 (1) (January 1): 6–16.

Duncan, Greg J., Kathleen M. Ziol-Guest, and Ariel Kalil. 2010. "Early-Childhood Poverty and Adult Attainment, Behavior, and Health." *Child Development* 81 (1): 306–325. doi:10.1111/j.1467-8624.2009.01396.x.

Eisenstat, Stephanie A., and Lundy Bancroft. 1999. "Domestic Violence." *New England Journal of Medicine* 341 (12): 886–892. doi:10.1056/NEJM199909163411206.

EPA. 2006. "Brownfields: Public Health and Health Monitoring."

EPA. 2012a. "Green Building |US EPA." http://www.epa.gov/greenbuilding/pubs/about.htm.

EPA. 2012b. "Ground Level Ozone | US Environmental Protection Agency." http://www.epa.gov/glo/.

Ewing, Reid, and Robert Cervero. 2010. "Travel and the Built Environment." *Journal of the American Planning Association* 76 (3): 265–294. doi:10.1080/01944361003766766.

Ewing, Reid, Michael J. Greenwald, Ming Zhang, Meghan Bogaerts, and William Greene. 2013. "Predicting Transportation Outcomes for LEED Projects." *Journal of Planning Education and Research* (April 22). doi:10.1177/0739456X13482978. http://jpe.sagepub.com/content/early/2013/04/19/0739456X13482978.

Fan, Yingling, Kirti V Das, and Qian Chen. 2011. "Neighborhood Green, Social Support, Physical Activity, and Stress: Assessing the Cumulative Impact." *Health & Place* 17 (6) (November): 1202–1211. doi:10.1016/j.healthplace.2011.08.008.

FBI Uniform Crime Reports. 2011. "Crime in the United States by Region, Geographic Division, and State, 2010-2011: Table 4." http://www.fbi.gov/about-us/cjis/ucr/crime-in-the-u.s/2011/crime-in-the-u.s.-2011/tables/table-4.

Fiske, Edward B. 1999. "Champions of Change: The Impact of the Arts on Learning." http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED435581.

Foster, Sarah, Billie Giles-Corti, and Matthew Knuiman. 2010. "Neighbourhood Design and Fear of Crime: A Social-ecological Examination of the Correlates of Residents' Fear in New Suburban Housing Developments." *Health & Place* 16 (6) (November): 1156–1165. doi:10.1016/j.healthplace.2010.07.007.

Frank, Deborah A, Nicole B Neault, Anne Skalicky, John T Cook, Jacqueline D Wilson, Suzette Levenson, Alan F Meyers, et al. 2006. "Heat or Eat: The Low Income Home Energy Assistance Program and Nutritional and Health Risks Among Children Less Than 3 Years of Age." *Pediatrics* 118 (5) (November): e1293–1302. doi:10.1542/peds.2005-2943.

Freeland, Amy L, Shailendra N Banerjee, Andrew L Dannenberg, and Arthur M Wendel. 2013. "Walking Associated with Public Transit: Moving Toward Increased Physical Activity in the United States." *American Journal of Public Health* 103 (3) (March): 536–542. doi:10.2105/AJPH.2012.300912.

Freeman, Lance, and Frank Braconi. 2004. "Gentrification and Displacement New York City in the 1990s." *Journal of the American Planning Association* 70 (1): 39–52. doi:10.1080/01944360408976337.

Freeman, Lance, Kathryn Neckerman, Ofira Schwartz-Soicher, James Quinn, Catherine Richards, Michael D M Bader, Gina Lovasi, et al. 2012. "Neighborhood Walkability and Active Travel (Walking and Cycling) in New York City." *Journal of Urban Health: Bulletin of the New York Academy of Medicine* (September 1). doi:10.1007/s11524-012-9758-7.

Garland, Elizabeth, Erin Thanik Steenburgh, Sadie H Sanchez, Anita Geevarughese, Les Bluestone, Laura Rothenberg, Alexander Rialdi, and Mary Foley. 2013. "Impact of LEED-certified Affordable Housing on Asthma in the South Bronx." *Progress in Community Health Partnerships: Research, Education, and Action* 7 (1): 29–37. doi:10.1353/cpr.2013.0010.

Garvin, Eugenia C., Carolyn C. Cannuscio, and Charles C. Branas. 2012. "Greening Vacant Lots to Reduce Violent Crime: a Randomised Controlled Trial." *Injury Prevention* (August 7). doi:10.1136/injuryprev-2012-040439. http://injuryprevention.bmj.com/content/early/2012/08/06/injuryprev-2012-040439.

Goldman Environmental Consultants, Inc. (GEC). 2013. Immediate Response Action (IRA) Plan, Parcel 10, Melnea Cass Boulevard, Roxbury, MA, RTN 3-31352. March 22, 2013.

Giles-Corti, Billie, Fiona Bull, Matthew Knuiman, Gavin McCormack, Kimberly Van Niel, Anna Timperio, Hayley Christian, et al. 2013. "The Influence of Urban Design on Neighbourhood Walking Following Residential Relocation: Longitudinal Results from the RESIDE Study." *Social Science & Medicine* 77 (January): 20–30. doi:10.1016/j.socscimed.2012.10.016.

Goldberg, Mark S., Richard T. Burnett, John C. Bailar III, Jeffrey Brook, Yvette Bonvalot, Robyn Tamblyn, Ravinder Singh, and Marie-France Valois. 2001. "The Association Between Daily Mortality and Ambient Air Particle Pollution in Montreal, Quebec: 1. Nonaccidental Mortality." *Environmental Research* 86 (1) (May): 12–25. doi:10.1006/enrs.2001.4242.

Grant, Richard H, Gordon M Heisler, and Wei Gao. 2002. "Estimation of Pedestrian Level UV Exposure Under Trees." *Photochemistry and Photobiology* 75 (4) (April): 369–376.

Guzman, Carolina, Rajiv Bhatia, and Chris Durazo. 2005. "Anticipated Effects of Residential Displacement on Health: Results from Qualitative Research". San Francisco Department of Public Health and South of Market Community Action Network.

Hale, C. 1996. "Fear of Crime: A Review of the Literature." *International Review of Victimology* 4 (2) (January 1): 79–150. doi:10.1177/026975809600400201.

Han, Euna, Lisa M Powell, Shannon N Zenk, Leah Rimkus, Punam Ohri-Vachaspati, and Frank J Chaloupka. 2012. "Classification Bias in Commercial Business Lists for Retail Food Stores in the U.S." *The International Journal of Behavioral Nutrition and Physical Activity* 9: 46. doi:10.1186/1479-5868-9-46.

Health Effects Institute. 2003. "Revised Analyses of Time-Series Studies of Air Pollution and Health." http://pubs.healtheffects.org/view.php?id=4.

Hedayati Marzbali, Massoomeh, Aldrin Abdullah, Nordin Abd. Razak, and Mohammad Javad Maghsoodi Tilaki. 2012. "The Influence of Crime Prevention through Environmental Design on Victimisation and Fear of Crime." *Journal of Environmental Psychology* 32 (2) (June): 79–88. doi:10.1016/j.jenvp.2011.12.005.

Hendrickson, Deja, Chery Smith, and Nicole Eikenberry. 2006. "Fruit and Vegetable Access in Four Low-income Food Deserts Communities in Minnesota." *Agriculture and Human Values* 23 (3) (October 1): 371–383. doi:10.1007/s10460-006-9002-8.

Jacobs, David E, Robert P Clickner, Joey Y Zhou, Susan M Viet, David A Marker, John W Rogers, Darryl C Zeldin, Pamela Broene, and Warren Friedman. 2002. "The Prevalence of Lead-based Paint Hazards in U.S. Housing." *Environmental Health Perspectives* 110 (10) (October): A599–606.

Jim, C Y, and Wendy Y Chen. 2008. "Assessing the Ecosystem Service of Air Pollutant Removal by Urban Trees in Guangzhou (China)." *Journal of Environmental Management* 88 (4) (September): 665–676. doi:10.1016/j.jenvman.2007.03.035.

Kappel Ramji Consulting Group. 2002. "Common Occurrence: The Impact of Homelessness on Women's Health: Phase II: Community-based Action Research." http://www.cwhn.ca/en/node/22591.

Kawachi, I., and B. P. Kennedy. 1997. "Socioeconomic Determinants of Health: Health and Social Cohesion: Why Care About Income Inequality?" *Bmj* 314 (7086): 1037.

Kennedy, Maureen, and Paul Leonard. 2001. "Dealing with Neighborhood Change: A Primer on Gentrification and Policy Choices." *The Brookings Institution*. http://www.brookings.edu/research/reports/2001/04/metropolitanpolicy.

Kinchen, K, and J D Wright. 1991. "Hypertension Management in Health Care for the Homeless Clinics: Results from a Survey." *American Journal of Public Health* 81 (9) (September): 1163–1165.

Kingdon, John W. 2011. *Agendas, Alternatives, and Public Policies*. Longman Publishing Group.

Kling, Jeffrey R, Jeffrey B Liebman, and Lawrence F Katz. 2007. "Experimental Analysis of Neighborhood Effects." *Econometrica* 75 (1): 83–119. doi:10.1111/j.1468-0262.2007.00733.x.

Kuo, Frances E., and William C. Sullivan. 2001. "Environment and Crime in the Inner City Does Vegetation Reduce Crime?" *Environment and Behavior* 33 (3) (May 1): 343–367. doi:10.1177/0013916501333002.

Lachapelle, Ugo, Larry Frank, Brian E Saelens, James F Sallis, and Terry L Conway. 2011. "Commuting by Public Transit and Physical Activity: Where You Live, Where You Work, and How You Get There." *Journal of Physical Activity & Health* 8 Suppl 1 (January): S72–82.

Ledergerber, B, M Egger, M Opravil, A Telenti, B Hirschel, M Battegay, P Vernazza, et al. 1999. "Clinical Progression and Virological Failure on Highly Active Antiretroviral Therapy in HIV-1 Patients: a Prospective Cohort Study. Swiss HIV Cohort Study." *Lancet* 353 (9156) (March 13): 863–868.

Lee, I-Min, Eric J Shiroma, Felipe Lobelo, Pekka Puska, Steven N Blair, and Peter T Katzmarzyk. 2012. "Effect of Physical Inactivity on Major Non-communicable Diseases Worldwide: An Analysis of Burden of Disease and Life Expectancy." *Lancet* 380 (9838) (July 21): 219–229. doi:10.1016/S0140-6736(12)61031-9.

Leinberger, Christoper B., and Mariela Alfonzo. 2012. "Walk This Way:The Economic Promise of Walkable Places in Metropolitan Washington, D.C." *The Brookings Institution*. http://www.brookings.edu/research/papers/2012/05/25-walkable-places-leinberger.

Leventhal, Tama, and Jeanne Brooks-Gunn. 2003. "Moving to Opportunity: An Experimental Study of Neighborhood Effects on Mental Health." *American Journal of Public Health* 93 (9) (September): 1576–1582. doi:10.2105/AJPH.93.9.1576.

Leventhal, Tama, and Véronique Dupéré. 2011. "Moving to Opportunity: Does Long-term Exposure to 'Low-poverty' Neighborhoods Make a Difference for Adolescents?" *Social Science & Medicine* (1982) 73 (5) (September): 737–743. doi:10.1016/j.socscimed.2011.06.042.

Lindahl, Mikael. 2002. "Estimating the Effect of Income on Health and Mortality Using Lottery Prizes as Exogenous of Variation in Income". IZA Discussion Paper 442. Institute for the Study of Labor (IZA). http://ideas.repec.org/p/iza/izadps/dp442.html.

Lipton, Robert, Xiaowen Yang, Anthony A Braga, Jason Goldstick, Manya Newton, and Melissa Rura. 2013. "The Geography of Violence, Alcohol Outlets, and Drug Arrests in Boston." American Journal of Public Health 103 (4) (April): 657–664. doi:10.2105/AJPH.2012.300927.

Liska, Allen E., Andrew Sanchirico, and Mark D. Reed. 1988. "Fear of Crime and Constrained Behavior Specifying and Estimating a Reciprocal Effects Model." *Social Forces* 66 (3) (March 1): 827–837. doi:10.1093/sf/66.3.827.

Litman, Todd. 2013. "Transportation and Public Health." *Annual Review of Public Health* 34 (March 18): 217–233. doi:10.1146/annurev-publhealth-031912-114502.

Loukaitou-Sideris, Anastasia, and John E Eck. 2007. "Crime Prevention and Active Living." *American Journal of Health Promotion: AJHP* 21 (4 Suppl) (April): 380–389, iii.

Lubell, Jeffrey, Rosalyn Crain, and Rebecca Cohen. 2007. "Framing the Issues—the Positive Impacts of Affordable Housing on Health". Center for Housing Policy.

Maas, Jolanda, Sonja M E van Dillen, Robert A Verheij, and Peter P Groenewegen. 2009. "Social Contacts as a Possible Mechanism Behind the Relation Between Green Space and Health." *Health & Place* 15 (2) (June): 586–595. doi:10.1016/j.healthplace.2008.09.006.

Maas, Jolanda, Robert A. Verheij, Peter P. Groenewegen, Sjerp de Vries, and Peter Spreeuwenberg. 2006. "Green Space, Urbanity, and Health: How Strong Is the Relation?" *Journal of Epidemiology and Community Health* 60 (7) (July 1): 587–592. doi:10.1136/jech.2005.043125.

Mair, Julie Samia, and Michael Mair. 2003. "Violence Prevention and Control through Environmental Modifications." *Annual Review of Public Health* 24: 209–225. doi:10.1146/annurev.publhealth.24.100901.140826.

Marmot, Michael, and Richard Wilkinson. 2009. *Social Determinants of Health*. Oxford University Press.

Marschall, Melissa J., and Dietlind Stolle. 2004. "Race and the City: Neighborhood Context and the Development of Generalized Trust." *Political Behavior* 26 (2) (June 1): 125–153. doi:10.1023/B:POBE.0000035960.73204.64.

Massachusetts Department of Agricultural Resources. 2013. "MassGrown Map." http://massnrc.org/farmlocator/map.aspx?Type=Farmers%20Markets.

MassDEP. 2012a. "Ground-Level Ozone." *MassDEP*. http://www.mass.gov/dep/air/aq/aq_ozone.htm#trends.

MassDEP. 2012b. "MassDEP:: Air & Climate :: Air Quality & Monitoring :: MassAir Version 1.3." http://public.dep.state.ma.us/MassAir/Pages/ChartByPollutant.aspx?&ht=2&hi=201.

MassDEP. 2012c. "Brownfields." November 21. http://www.mass.gov/eea/agencies/massdep/cleanup/programs/brownfields-introduction.html.

MassDEP. 2013a. "Carbon Monoxide." February 21. http://www.mass.gov/eea/agencies/massdep/air/quality/carbon-monoxide.html.

MassDEP. 2013b. "Nitrogen Dioxide." February 21. http://www.mass.gov/eea/agencies/massdep/air/quality/nitrogen-dioxide.html.

McCormack, Gavin R., and Alan Shiell. 2011. "In Search of Causality: a Systematic Review of the Relationship Between the Built Environment and Physical Activity Among Adults." *International Journal of Behavioral Nutrition and Physical Activity* 8 (1) (November 13): 125. doi:10.1186/1479-5868-8-125.

Menard, Anne. 2001. "Domestic Violence and Housing Key Policy and Program Challenges." *Violence Against Women* 7 (6) (June 1): 707–720. doi:10.1177/10778010122182686.

Metropolitan Area Planning Council. 2012. "Growing Station Areas: The Variety and Potential of Transit Oriented Development in Metro Boston."

Meyers, A, D Rubin, M Napoleone, and K Nichols. 1993. "Public Housing Subsidies May Improve Poor Children's Nutrition." *American Journal of Public Health* 83 (1) (January): 115.

Meyers, Alan, Diana Cutts, Deborah A Frank, Suzette Levenson, Anne Skalicky, Timothy Heeren, John Cook, et al. 2005. "Subsidized Housing and Children's Nutritional Status: Data from a Multisite Surveillance Study." *Archives of Pediatrics & Adolescent Medicine* 159 (6) (June): 551–556. doi:10.1001/archpedi.159.6.551.

Minnery, J. R., and B. Lim. 2005. "Measuring Crime Prevention through Environmental Design." *Journal of Architectural and Planning Research* 22 (4): 330–341.

"Mission 180 Community Contract." 2013. Boston Local Initiatives Support Corporation: Resilient Communities/ Resilient Families.

Mission Hill Neighborhood Housing Services. 2013. "Parcel 25." *Mission Hill Neighborhood Housing Services*. http://missionhillnhs.org/parcel-25/.

Mission Hill Neighborhood Housing Services. 2013. "About Mission Hill." *Mission Hill Neighborhood Housing Services*. Accessed May 14. http://missionhillnhs.org/about/.

Moolgavkar, S H. 2000a. "Air Pollution and Hospital Admissions for Chronic Obstructive Pulmonary Disease in Three Metropolitan Areas in the United States." *Inhalation Toxicology* 12 Suppl 4: 75–90. doi:10.1080/089583700750019512.

Moolgavkar, S H. 2000b. "Air Pollution and Hospital Admissions for Diseases of the Circulatory System in Three U.S. Metropolitan Areas." *Journal of the Air & Waste Management Association* (1995) 50 (7) (July): 1199–1206.

Moracco, Kathryn E, Carrie L Brown, Sandra L Martin, Judy C Chang, Lisa Dulli, Mary Beth Loucks-Sorrell, Tracy Turner, Ingrid G Bou-Saada, and Leslie Starsoneck. 2004. "Mental Health Issues Among Female Clients of Domestic Violence Programs in North Carolina." *Psychiatric Services* (Washington, D.C.) 55 (9) (September): 1036–1040. doi:10.1176/appi.ps.55.9.1036.

Morland, Kimberly, Steve Wing, Ana Diez Roux, and Charles Poole. 2002. "Neighborhood Characteristics Associated with the Location of Food Stores and Food Service Places." *American Journal of Preventive Medicine* 22 (1) (January): 23–29.

Nasar, Jack L., and Kym M. Jones. 1997. "Landscapes of Fear and Stress." *Environment and Behavior* 29 (3) (May 1): 291–323. doi:10.1177/001391659702900301.

National AIDS Housing Coalition. 2005. "Housing Is the Foundation of HIV Prevention and Treatment: Results of the National Housing and HIV/AIDS Research Summit". The National AIDS Housing Coalition.

National Center for Environmental Health. 2013. "Healthy Places Terminology." http://www.cdc.gov/healthyplaces/terminology.htm.

National Center for Environmental Health, Centers for Disease Control and Prevention. 2012. "CDC - Healthy Places - Injury." http://www.cdc.gov/healthyplaces/healthtopics/injury.htm.

National Crime Prevention Council. 2003. "CPTED Guidebook."

National Highway Traffic Safety Administration, National Center for Statistics and Analysis. 2009. "Traffic Safety Facts 2009". US Department of Transportation.

National Research Council, Committee on Health Impact Assessment. 2011. *Improving Health in the United States: The Role of Health Impact Assessment*. Washington, D.C.: The National Academies Press.

Newman, Kathe, and Elvin K. Wyly. 2006. "The Right to Stay Put, Revisited: Gentrification and Resistance to Displacement in New York City." *Urban Studies* 43 (1) (January 1): 23–57. doi:10.1080/00420980500388710.

Nuestra Comunidad Development Corporation. 2013. "Bartlett Place." http://www.nuestracdc.org/properties/60.

O'Malley, Keelia, Jeanette Gustat, Janet Rice, and Carolyn C Johnson. 2013. "Feasibility of Increasing Access to Healthy Foods in Neighborhood Corner Stores." *Journal of Community Health* 38 (4) (August): 741–749. doi:10.1007/s10900-013-9673-1.

Parra, Diana C, Luis F Gomez, Olga L Sarmiento, David Buchner, Ross Brownson, Thomas Schimd, Viviola Gomez, and Felipe Lobelo. 2010. "Perceived and Objective Neighborhood Environment Attributes and Health Related Quality of Life Among the Elderly in Bogotá, Colombia." *Social Science & Medicine (1982)* 70 (7) (April): 1070–1076. doi:10.1016/j.socscimed.2009.12.024.

Paulsen, Derek J. 2012. *Crime and Planning: Building Socially Sustainable Communities*. CRC Press.

Peters, A, D W Dockery, J E Muller, and M A Mittleman. 2001a. "Increased Particulate Air Pollution and the Triggering of Myocardial Infarction." *Circulation* 103 (23) (June 12): 2810–2815.

Peters, A., D. W. Dockery, J. E. Muller, and M. A. Mittleman. 2001b. "Increased Particulate Air Pollution and the Triggering of Myocardial Infarction." *Circulation* 103 (23): 2810–2815.

Pope, C. A., M. J. Thun, M. M. Namboodiri, D. W. Dockery, J. S. Evans, F. E. Speizer, and C. W. Heath. 1995. "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults." *American Journal of Respiratory and Critical Care Medicine* 151 (3) (March 1): 669–674.

Powell, Lisa M, M Christopher Auld, Frank J Chaloupka, Patrick M O'Malley, and Lloyd D Johnston. 2007. "Associations Between Access to Food Stores and Adolescent Body Mass Index." *American Journal of Preventive Medicine* 33 (4 Suppl) (October): S301–307. doi:10.1016/j.amepre.2007.07.007.

Powell, Lisa M, Sandy Slater, Donka Mirtcheva, Yanjun Bao, and Frank J Chaloupka. 2007. "Food Store Availability and Neighborhood Characteristics in the United States." *Preventive Medicine* 44 (3) (March): 189–195. doi:10.1016/j.ypmed.2006.08.008.

QSR Magazine. 2012. "Biggest Fast Food Brands In United States." August. http://www.qsrmagazine.com/reports/qsr50-2012-top-50-chart.

Reconnecting America. 2013. "What Is TOD?" http://www.reconnectingamerica.org/what-we-do/what-is-tod/.

Rehkopf, David H, Lisa F Berkman, Brent Coull, and Nancy Krieger. 2008. "The Non-linear Risk of Mortality by Income Level in a Healthy Population: US National Health and Nutrition Examination Survey Mortality Follow-up Cohort, 1988-2001." *BMC Public Health* 8: 383. doi:10.1186/1471-2458-8-383.

Reitzel, Lorraine R, Seann D Regan, Nga Nguyen, Ellen K Cromley, Larkin L Strong, David W Wetter, and Lorna H McNeill. 2013. "Density and Proximity of Fast Food Restaurants and Body Mass Index Among African Americans." *American Journal of Public Health* (May 16). doi:10.2105/AJPH.2012.301140.

Richard, L., L. Gauvin, C. Gosselin, and S. Laforest. 2009. "Staying Connected: Neighbourhood Correlates of Social Participation Among Older Adults Living in an Urban Environment in Montreal, Quebec." *Health Promotion International* 24 (1): 46–57.

Riley, Elise D, David R Bangsberg, David Guzman, Sharon Perry, and Andrew R Moss. 2005. "Antiretroviral Therapy, Hepatitis C Virus, and AIDS Mortality Among San Francisco's Homeless and Marginally Housed." *Journal of Acquired Immune Deficiency Syndromes (1999)* 38 (2) (February 1): 191–195.

Roman, Henry A, Katherine D Walker, Tyra L Walsh, Lisa Conner, Harvey M Richmond, Bryan J Hubbell, and Patrick L Kinney. 2008. "Expert Judgment Assessment of the Mortality Impact of Changes in Ambient Fine Particulate Matter in the U.S." *Environmental Science & Technology* 42 (7) (April 1): 2268–2274.

Rose, Donald, and Rickelle Richards. 2004. "Food Store Access and Household Fruit and Vegetable Use Among Participants in the US Food Stamp Program." *Public Health Nutrition* 7 (8) (December): 1081–1088. doi:10.1079/PHN2004648.

Ross, Catherine E., and Sung Joon Jang. 2000. "Neighborhood Disorder, Fear, and Mistrust: The Buffering Role of Social Ties with Neighbors." *American Journal of Community Psychology* 28 (4) (August 1): 401–420. doi:10.1023/A:1005137713332.

Rundle, Andrew, Kathryn M. Neckerman, Lance Freeman, Gina S. Lovasi, Marnie Purciel, James Quinn, Catherine Richards, Neelanjan Sircar, and Christopher Weiss. 2009. "Neighborhood Food Environment and Walkability Predict Obesity in New York City." *Environmental Health Perspectives* 117 (3) (March): 442–447. doi:10.1289/ehp.11590.

Sampson, Robert J. 2003. *Neighborhood-level Context and Health: Lessons from Sociology*. Oxford University Press.

Schmidt, Charles W. 2008. "Bringing Green Homes Within Reach: Healthier Housing for More People." *Environmental Health Perspectives* 116 (1) (January): A24.

Schrank, David, Bill Eisele, and Tim Lomax. 2012. "2012 Urban Mobility Report". TTI.

Schwartz, Joel, Brent Coull, Francine Laden, and Louise Ryan. 2008. "The Effect of Dose and Timing of Dose on the Association Between Airborne Particles and Survival." *Environmental Health Perspectives* 116 (1) (January): 64–69. doi:10.1289/ehp.9955.

Shinn, Marybeth, and Jim Baumohl. 1998. "Rethinking the Prevention of Homelessness". The 1998 National Symposium on Homelessness Research.

Stafford, Mai, Tarani Chandola, and Michael Marmot. 2007. "Association Between Fear of Crime and Mental Health and Physical Functioning." *American Journal of Public Health* 97 (11) (November): 2076–2081. doi:10.2105/AJPH.2006.097154.

Stanton, Warren R, Monika Janda, Peter D Baade, and Peter Anderson. 2004. "Primary Prevention of Skin Cancer: a Review of Sun Protection in Australia and Internationally." *Health Promotion International* 19 (3) (September): 369–378. doi:10.1093/heapro/dah310.

Stigsdotter, Ulrika K, Ola Ekholm, Jasper Schipperijn, Mette Toftager, Finn Kamper-Jørgensen, and Thomas B Randrup. 2010. "Health Promoting Outdoor Environments--associations Between Green Space, and Health, Health-related Quality of Life and Stress Based on a Danish National Representative Survey." *Scandinavian Journal of Public Health* 38 (4) (June): 411–417. doi:10.1177/1403494810367468.

Sugiyama, T., E. Leslie, B. Giles-Corti, and N. Owen. 2008. "Associations of Neighbourhood Greenness with Physical and Mental Health: Do Walking, Social Coherence and Local Social Interaction Explain the Relationships?" *Journal of Epidemiology and Community Health* 62 (5) (May 1): e9–e9. doi:10.1136/jech.2007.064287.

Sustainable Communities Index. 2012a. "Sustainable Communities Index - Public Realm." http://www.sustainablecommunitiesindex.org/webpages/view/53.

Sustainable Communities Index. 2012b. "Food Market Score." http://www.sustainablecommunitiesindex.org/indicators/view/116.

Taylor, Andrea Faber, Frances E. Kuo, and William C. Sullivan. 2001. "Coping with Add The Surprising Connection to Green Play Settings." *Environment and Behavior* 33 (1) (January 1): 54–77. doi:10.1177/00139160121972864.

Tefft, Brian C. 2013. "Impact Speed and a Pedestrian's Risk of Severe Injury or Death." *Accident; Analysis and Prevention* 50 (January): 871–878. doi:10.1016/j.aap.2012.07.022.

The Urban Institute. 2013. "Cultural Vitality Indicators." http://www.urban.org/projects/cultural-vitality-indicators/index.cfm.

Truong, Khoa D, and Sai Ma. 2006. "A Systematic Review of Relations Between Neighborhoods and Mental Health." *The Journal of Mental Health Policy and Economics* 9 (3) (September): 137–154.

Uchino, B N, J T Cacioppo, and J K Kiecolt-Glaser. 1996. "The Relationship Between Social Support and Physiological Processes: a Review with Emphasis on Underlying Mechanisms and Implications for Health." *Psychological Bulletin* 119 (3) (May): 488–531.

UCLA-CLIC. 2013. "UCLA Health Impact Assessment Clearinghouse Learning & Information Center." http://www.hiaguide.org/.

Urban Ecology Institute. 2008. "State of the Urban Forest: A Summary of the Extent and Condition of Boston's Urban Forest."

Urban Imprint. 2012. "State of Place." http://urbanimprint.com/about/state-of-place/.

US Census Bureau. 2013. "Voting and Registration." http://www.census.gov/hhes/www/socdemo/voting/.

US Census Bureau, Center for New Media and. 2012. "2010 Census." http://2010.census.gov/2010census/.

US EPA, OAR, and Abt Associates, Inc. 2010. "Environmental Benefits Mapping and Analysis Program (BenMAP)." *User's Manual Appendices*. http://www.epa.gov/air/benmap/docs.html.

USDA Forest Service. 2013. "i-Tree - Tools for Assessing and Managing Community Forests." http://www.itreetools.org/.

USGBC. 2013. "LEED: U.S. Green Building Council." http://www.usgbc.org/.

Van den Berg, Agnes E, Jolanda Maas, Robert A Verheij, and Peter P Groenewegen. 2010. "Green Space as a Buffer Between Stressful Life Events and Health." *Social Science & Medicine* (1982) 70 (8) (April): 1203–1210. doi:10.1016/j.socscimed.2010.01.002.

Weich, Scott, Martin Blanchard, Martin Prince, Elizabeth Burton, Bob Erens, and Kerry Sproston. 2002. "Mental Health and the Built Environment: Cross-sectional Survey of Individual and Contextual Risk Factors for Depression." *The British Journal of Psychiatry: The Journal of Mental Science* 180 (May): 428–433.

Weitz, Judith Humphreys. 1996. *Coming Up Taller: Arts And Humanities Programs For Children And Youth At Risk*. DIANE Publishing.

Wells, Nancy, and Joseph Laquatra. 2009. "Why Green Housing and Green Neighborhoods Are Important to the Health and Well-Being of Older Adults." *Generations* 33 (4) (December 1): 50–57.

Yen, I, and R Bhatia. 2002. "How Increasing the Minimum Wage Might Affect the Health Status of San Francisco Residents: A Discussion of the Links Between Income and Health". Working Paper.

Zanobetti, Antonella, and Joel Schwartz. 2005. "The Effect of Particulate Air Pollution on Emergency Admissions for Myocardial Infarction: A Multicity Case-Crossover Analysis." *Environmental Health Perspectives* 113 (8) (March 16): 978–982. doi:10.1289/ehp.7550.

Zenk, Shannon N, Amy J Schulz, Barbara A Israel, Sherman A James, Shuming Bao, and Mark L Wilson. 2005. "Neighborhood Racial Composition, Neighborhood Poverty, and the Spatial Accessibility of Supermarkets in Metropolitan Detroit." *American Journal of Public Health* 95 (4) (April): 660–667. doi:10.2105/AJPH.2004.042150.

Appendix A

Stakeholders

STAKEHOLDER GROUP/KEY CONTACT	INTEREST IN THE HIA OR RELATED DECISION?	POWER TO INFLUENCE THE DECISION (HIGH, MEDIUM, LOW)	HOW AND WHEN (WHAT STAGE) TO ENGAGE?	POTENTIAL ROLE IN/ CONTRIBUTION TO HIA
HNEF Working Group	Interest in health metrics identified	Medium	Scoping and Recommendations	Audience
Boston University	Doing similar work in the area	Medium	Throughout HIA process	Information sharing
ACE	Doing similar work in the area	Medium	Scoping and Recommendations	Information sharing
LISC	Health metrics identified	Medium - High	Throughout HIA process	Advisory Committee Member
MHIC	Health metrics identified	Medium - High	Throughout HIA process	Advisory Committee Member
Nuestra CDC	Developer	High	Throughout HIA process	CDC Developer, Advisory Committee Member
Mission Hill Neighborhood Services	Developer	High	Throughout HIA process	CDC Developer, Advisory Committee Member
Madison Park	Developer	High	Throughout HIA process	CDC Developer, Advisory Committee Member
DPH/BCHAP	Interest in HIA process	Medium - High	Throughout HIA process	Advisory Committee Member, Information source
DPH/BEH	Interest in HIA process	Medium - High	Throughout HIA process	Advisory Committee Member, Information source
City of Boston Health in All Policies Taskforce	Interest in the area and the HIA process	Medium - High	Throughout HIA process	Advisory Committee Member
DND	Interest in neighborhood development	Medium	Throughout HIA process	Advisory Committee Member
BRA	Housing stakeholder	Medium	Throughout HIA process	Advisory Committee Member
Wentworth Institute of Technology	Housing stakeholder	Low	Throughout HIA process	Advisory Committee Member
NHS	Public health stakeholder	Medium	Throughout HIA process	Advisory Committee Member
MPHA	Public health stakeholder	Low	Throughout HIA process	Advisory Committee Member
RCAH	A Roxbury health alliance	Medium	Throughout HIA process	Advisory Committee Member
DCYF Tobin Community Center	Roxbury community center	Medium	Throughout HIA process	Advisory Committee Member
Councilor Ross	Represents Roxbury	Medium	Throughout HIA process	Advisory Committee Member

STAKEHOLDER GROUP/KEY CONTACT	INTEREST IN THE HIA OR RELATED DECISION?	POWER TO INFLUENCE THE DECISION (HIGH, MEDIUM, LOW)	HOW AND WHEN (WHAT STAGE) TO ENGAGE?	POTENTIAL ROLE IN/ CONTRIBUTION TO HIA
Sociedad Latina	Roxbury Latino community organization	Medium	Throughout HIA process	Advisory Committee Member
Boston College	Interest in HIA process	Low	Throughout HIA process	Advisory Committee Member
Rep Sanchez	Represents Roxbury	Medium	Throughout HIA process	Advisory Committee Member
MONS		Medium	Throughout HIA process	Advisory Committee Member
MPDC	Works in Roxbury	Medium	Throughout HIA process	Advisory Committee Member
Residents	Roxbury Residents	High	Throughout HIA process	Advisory Committee Member
Gallery Basquat	Business in Roxbury	Medium	Throughout HIA process	Advisory Committee Member

Appendix B

State of Place Survey

Date		
Time		
Observer		
Segment #		
Answer questions 1-6 based on this end of the segment		
Intersection		
Neighborhood Identification		
1. Are there **monuments or markers** including neighborhood entry signs that indicate that one is entering a special district or area?	1	yes = 1; no = 0
Street Crossing		
2a. Consider the places on the segment that are **intended** for pedestrians to cross the street. Are these places marked for pedestrian crossing? Mark N/A if there are no **intended** places to cross.	2	all = 2; some = 1; none = 0; NA = 8
2b. What type of **marking** do the crosswalks have? Mark all that apply. Mark N/A if 2a= 0 or 8		
White painted lines	3	yes = 1; no = 0; NA = 8
Colored painted lines	4	yes = 1; no = 0; NA = 8
Zebra striping	5	yes = 1; no = 0; NA = 8
Different road surface or paving (e.g. tiles, colored concrete, marble, etc)	6	yes = 1; no = 0; NA = 8
Other	7	yes = 1; no = 0; NA = 8
3. Are there **curb cuts** at all places where crossing is expected to occur? Mark N/A if there are no intended places to cross.	8	all = 2; some = 1; none = 0; NA = 8
4. What type of **traffic/pedestrian signal(s)/system(s)** is/are provided? Mark all that apply.		
Traffic signal	9	yes = 1; no = 0
Stop sign	10	yes = 1; no = 0
Yield sign	11	yes = 1; no = 0
Pedestrian activated signal	12	yes = 1; no = 0
Pedestrian crossing sign	13	yes = 1; no = 0
Pedestrian overpass/underpass/bridge	14	yes = 1; no = 0
5. For an individual who is on this segment, how **safe (traffic wise)** do you think it is to cross the street from this segment?	15	pretty/very safe = 1; not very safe/ unsafe = 0; cul de sac = 8
6. For an individual who is on this segment, how **convenient (traffic wise)** do you think it is to cross the street from this segment?	16	pretty/very convenient =1; not very/inconvenient= 0; cul de sac = 8

Answer questions 7-11 while standing at the beginning of the segment		
Neighborhood Identification		
7. Does the segment have **banners** that identify the neighborhood?	17	some/a lot = 2; few = 1; none = 0
Street Characteristics		
8a. Is this a **pedestrianized** street?	18	yes = 1; no = 0
8b. Is the street a …	19	one way = 1; two way = 2
9. Is this segment an **alley**?	20	yes = 1; no = 0
10. How many **vehicle lanes** are there for cars? (Include turning lanes).	21	six or more = 6; five = 5; four = 4; three = 3; two = 2; one = 1; NA (no lanes for car travel) = 8
Views		
11a. Is this segment characterized by having **a significant open view** of an object or scene that is not on the segment? The view must be a prominent one.	22	yes = 1; no = 0
11b. How attractive is the open view?	23	attractive = 3; neutral = 2; unattractive = 1; NA (no views) = 8
Begin walking along segment to answer questions 12-68		
12a. What types of land uses are present on this area? Mark all that apply.		
Residential		
Single family home - detached	24	yes = 1; no = 0
Single family home/duplex - attached (2 units or fewer)	25	yes = 1; no = 0
Town home/condo/apartment housing (3 units or more)	26	yes = 1; no = 0
Mobile homes (includes manufactured homes)	27	yes = 1; no = 0
Residential, other	28	yes = 1; no = 0
School		
Elementary, middle or junior high school	29	yes = 1; no = 0
High school	30	yes = 1; no = 0
University or college (includes all types of building forms)	31	yes = 1; no = 0
School, other	32	yes = 1; no = 0
Public Space		
Plaza, square, park, playground, landscaped open space, playing fields, garden	33	yes = 1; no = 0
Public space, other	34	yes = 1; no = 0
Recreational/Leisure/Fitness		
Gym/fitness center (also includes yoga/pilates studios, etc.)	35	yes = 1; no = 0
Movie theater	36	yes = 1; no = 0
Recreational, other	37	yes = 1; no = 0

Public/Civic Building		
Community center or library	38	yes = 1; no = 0
Museum, auditorium, concert hall, theater	39	yes = 1; no = 0
Post office, police station, courthouse, Department of Motor Vehicles	40	yes = 1; no = 0
Public building, other	41	yes = 1; no = 0
Institutional		
Religious institution (church, temple, mosque, etc.)	42	yes = 1; no = 0
Hospital, medical facility, health clinic	43	yes = 1; no = 0
Institutional, other	44	yes = 1; no = 0
Commercial		
Retail stores/restaurant	45	yes = 1; no = 0
Bank/financial service	46	yes = 1; no = 0
Hotel/hospitality	47	yes = 1; no = 0
Car dealership	48	yes = 1; no = 0
Gas/service station	49	yes = 1; no = 0
Commercial, other	50	yes = 1; no = 0
Office/Service		
Offices	51	yes = 1; no = 0
Service facilities (includes insurance offices, funeral homes, dry cleaning, Laundromats, etc.)	52	yes = 1; no = 0
Office/service, other	53	yes = 1; no = 0
Industrial/Manufacturing		
Light industrial (e.g., auto paint and auto body repair shops; i.e. clean industries)	54	yes = 1; no = 0
Medium or heavy industrial (e.g. chemical plants, oil wells, etc.)	55	yes = 1; no = 0
Industrial, other	56	yes = 1; no = 0
Other		
Harbor/marina	57	yes = 1; no = 0
Undeveloped land	58	yes = 1; no = 0
Agricultural land, ranch, farming	59	yes = 1; no = 0
Nature feature	60	yes = 1; no = 0
Other	61	yes = 1; no = 0
12b. Do the buildings in this segment contain **vertical-mixed use**, that is, the building has different land uses on different floors of the building?	62	yes = 1; no = 0; NA (no buildings>1 story) = 8
12c. Determine whether any of these **distinctive retail types** are present (focusing on the form of the building).		
Big box shops (includes super stores or warehouse stores)	63	yes = 1; no = 0
Shopping mall	64	yes = 1; no = 0
Strip mall/row of shops	65	yes = 1; no = 0
Drive-thru	66	yes = 1; no = 0

13a. Mark off all types of **public space**(s) on this segment and how attractive it is		
Park/playground	67	attractive = 3; neutral = 2; unattractive = 1; 0 = no space
Playing or sport field	68	attractive = 3; neutral = 2; unattractive = 1; 0 = no space
Plaza /square /courtyard	69	attractive = 3; neutral = 2; unattractive = 1; 0 = no space
Public garden	70	attractive = 3; neutral = 2; unattractive = 1; 0 = no space
Beach	71	attractive = 3; neutral = 2; unattractive = 1; 0 = no space
Other	72	attractive = 3; neutral = 2; unattractive = 1; 0 = no space
13b. Is it possible for the general public to **use the public space**(s)?	73	unclear = 2; yes = 1; no = 0; NA = 8
Other Land Uses		
14. How many of these **land uses** are present on this segment?		
Bars/night clubs	74	some/a lot = 2; few = 1; none = 0
Adult uses	75	some/a lot = 2; few = 1; none = 0
Check cashing stores/pawn shops/bail bond stores	76	some/a lot = 2; few = 1; none = 0
Liquor stores	77	some/a lot = 2; few = 1; none = 0
15. How many of the following **gathering places** are on this segment?		
Restaurants	78	some/a lot = 2; few = 1; none = 0
Coffee shops	79	some/a lot = 2; few = 1; none = 0
Libraries/bookstores	80	some/a lot = 2; few = 1; none = 0
"Corner" store	81	some/a lot = 2; few = 1; none = 0
Art or craft galleries	82	some/a lot = 2; few = 1; none = 0
Farmers market	83	yes = 1; no = 0
16. Are these **nature features** present on this segment?		
Open field/golf course	84	yes = 1; no = 0
Lake/pond	85	yes = 1; no = 0
Fountain/reflecting pool	86	yes = 1; no = 0
Stream/river/canal/creek	87	yes = 1; no = 0
Forest or woods	88	yes = 1; no = 0
Ocean	89	yes = 1; no = 0
Mountain or hills	90	yes = 1; no = 0
Desert	91	yes = 1; no = 0
Barriers		
17. Are the following **barriers** present on this segment. Check all that apply, and whether barrier can be overcome e.g. there's a pedestrian bridge.		

Highway (elevated or below ground)	92	no barrier = 0; can be overcome = 1; can be somewhat overcome = 2; can not be overcome = 3
Railroad track	93	no barrier = 0; can be overcome = 1; can be somewhat overcome = 2; can not be overcome = 3
Impassable land use (e.g., gated community, major industrial complex, etc.)	94	no barrier = 0; can be overcome = 1; can be somewhat overcome = 2; can not be overcome = 3
River	95	no barrier = 0; can be overcome = 1; can be somewhat overcome = 2; can not be overcome = 3
Drainage ditches	96	no barrier = 0; can be overcome = 1; can be somewhat overcome = 2; can not be overcome = 3
Road with 6 or more lanes	97	no barrier = 0; can be overcome = 1; can be somewhat overcome = 2; can not be overcome = 3
Other	98	no barrier = 0; can be overcome = 1; can be somewhat overcome = 2; can not be overcome = 3
Sidewalks		
18a. How many sides of the street have sidewalks?	99	count 0 or 1 or 2
18b. Is the sidewalk **complete** on one or both sides? Mark N/A if 18a =0	100	yes = 1; no = 0; NA = 8
18c. What is the **condition** or maintenance of the sidewalk? Mark N/A if 18a =0	101	moderate or good = 2; poor = 1; under repair = 0; NA = 8
18d. Is there a decorative or unique paving that **covers most or all of the sidewalk** on the segment? (e.g., bricks, tile, etc.) Mark N/A if 18a =0	102	yes = 1; no = 0; NA = 8
18e. Determine how much of the sidewalk is covered by these **features that provide protection** from sun, rain, and/or snow. Mark N/A if 18a =0		
Arcades	103	some/ much of s'walk covered = 1; no/little covered = 0; NA = 8
Awnings	104	some/ much of s'walk covered = 1; no/little covered = 0; NA = 8
Other	105	some/ much of s'walk covered = 1; no/little covered = 0; NA = 8
18f. Is there is a **buffer** (for example, parked cars, landscaped "buffer" strip, etc.) between sidewalk or street. Mark N/A if 18a =0	106	yes = 1; no = 0; NA = 8
19. Are there **sidewalks/greenbelts/trails/paths** other than sidewalks along street?	107	yes = 1; no = 0

Bicycles		
20a. Are there **bicycle lanes** on the segment?	108	yes = 1; no = 0
20b. How are the bicycle lanes **demarcated**? Mark N/A if 20a =0	109	on road, painted line/reflectors=3; on road physical separation = 2; off road = 1; NA = 8
21. Is there a **bikeshare** system on this segment?	110	yes = 1; no = 0
Mid Block Crossing		
22a. Is there a **marked mid-block** crosswalk for pedestrians?	111	yes = 1; no = 0
22b**.** What type of **marking** does the crosswalk have? Mark all that apply. Mark N/A if 21a =0		
White painted lines	112	yes = 1; no = 0; NA = 8
Colored painted lines	113	yes = 1; no = 0; NA = 8
Zebra striping	114	yes = 1; no = 0; NA = 8
Different road surface or paving (e.g. tiles, colored concrete, marble, etc)	115	yes = 1; no = 0; NA = 8
Other	116	yes = 1; no = 0; NA = 8
Steepness		
23. How **steep** or hilly is this segment? Mark all that apply.		
Flat or gentle	117	yes = 1; no = 0
Moderate	118	yes = 1; no = 0
Steep	119	yes = 1; no = 0
Sidewalk Amenities		
24. Are there **outdoor dining areas** (e.g. cafes, outdoor tables at coffee shops or plazas, etc) located on the segment?	120	some/a lot = 2; few = 1; none = 0
25. Indicate how many of each of the following **street furniture/ sidewalk amenities** is/are present on the segment.		
Benches (not a bus stop), chairs and/or ledges for sitting	121	some/a lot = 2; few = 1; none = 0
Bus stops with seating	122	some/a lot = 2; few = 1; none = 0
Heat lamps	123	some/a lot = 2; few = 1; none = 0
Bike racks	124	some/a lot = 2; few = 1; none = 0
26. Are there obvious **public restrooms** on this segment that are **clearly open to the public**?	125	yes = 1; no = 0
Street Trees		
27a. How many street trees are on this segment? (Do not include trees that are not on the public right of way; street trees are typically between the sidewalk and the street or if there is no sidewalk, trees usually line the street)	126	some trees/trees along most or entire segment = 1; none/few trees = 0
27b. Is the **sidewalk shaded** by trees? Mark N/A if 26a =0	127	yes/somewhat = 1; no = 0; NA = 8

Buildings		
28. How many stories are most buildings on the segment?	128	5 or more = 3; 3-4 stories = 2; 1-2 stories = 1; heights vary, no predominant height = mark all that apply; NA (no buildings) = 8
29. Are there **abandoned buildings or lots** on this segment?	129	some/a lot = 2; few = 1; none = 0; NA=8
30. Does at least **50% of the segment have buildings**?	130	yes = 1; no = 0
31. What is the **average setback** (distance between buildings and the street)? Mark N/A if there are no buildings	131	xlarge (>50ft); large (20-50ft) =2; medium (10-20ft) = 1; small (<10 ft) = 0; N/A = 8
Windows		
32. How many buildings on this segment have **windows with bars**? (proportion) Mark N/A if there are no buildings	132	some/a lot = 2; few = 1; none = 0; NA = 8
Other Features of Buildings		
33. How many buildings on this segment have **front porches**? (porches you can sit on) Mark N/A if there are no buildings	133	some/a lot = 2; few = 1; none = 0; NA = 8
34. How much of the segment has **blank walls or buildings with blank walls**? Mark N/A if there are no buildings	134	some/a lot = 2; few = 1; none = 0; NA = 8
Garages		
35a. How many buildings have **garage doors** facing the street? Mark N/A if there are no buildings	135	some/a lot = 2; few = 1; none = 0; NA = 8
35b. How **prominent** are most garage doors when looking at the front of the buildings? Mark N/A if 33a = 0 or 8	136	very = 2; somewhat = 1; not very/not visible = 0; NA = 8
Parking		
36a. Is there a **surface parking lot** on this segment?	137	both sides = 2; one side = 1; no = 0
36b. What is the **average size** of the parking lot(s)? Mark N/A if 55 a = 0	138	xlarge = 4; large = 3; medium = 2; small = 1; N/A = 8
36c. How much of the segment does the **parking lot cover**? Mark N/A if 55 a = 0	139	some/a lot = 2; little = 1; NA = 8
37a. Is there a **parking structure** visible on this segment (do not include parking structures that are completely underground)?	140	yes = 1; no = 0
37b. Looking at the front of the parking structure on the street level floor, what is the **predominant use** that is visible to you? Mark N/A if 34a =0	141	parking = 2; varied = 1; not parking other uses = 0; NA = 8
Driveways		
38. How many **driveways** are visible on the segment?	142	some/a lot = 2; few = 1; none = 0
Maintenance		
39. Describe the general **maintenance of the buildings** on this segment. Mark N/A if there are no buildings	143	attractive = 3; neutral = 2; unattractive = 1; NA = 8
40. How much **graffiti** is apparent on this segment?	144	some/a lot = 2; little = 1; none = 0
41. How much **litter** is apparent on this segment?	145	some/a lot = 2; little = 1; none = 0
42. Are there **dumpsters** visible on this segment?	146	some/a lot = 2; little = 1; none = 0
43. Is there visible **electrical wiring** overhead on the segment?	147	some/a lot = 2; little = 1; none = 0

Lighting		
44. Is there **outdoor lighting** on the segment? (Include lighting that is intended to light public paths and public spaces)	148	yes = 1; no = 0
Freeways		
45. Is there a **freeway overpass/underpass** connected to **this segment**?	149	under a freeway overpass =3; next to freeway = 2; IS a freeway overpass = 1; none of the above = 0
Traffic Features		
46. What is the **posted speed limit** on this segment? Only include those on the segment itself.	150	use number; not posted =8
47. Are there measures on this segment that could **slow down traffic**? Mark all that apply.		
Speed bump/speed hump/raised crosswalk; or dips (that are intended to slow down traffic)	151	yes = 1; no = 0
Rumble strips or bumps (includes dots, reflectors, raised concrete strips, etc.)	152	yes = 1; no = 0
Curb bulb out/curb extension	153	yes = 1; no = 0
Traffic circle/roundabout	154	yes = 1; no = 0
Median	155	yes = 1; no = 0
Angled/ On-street parking (that runs along most or the entire segment - does not have to be on both sides of segment)	156	yes = 1; no = 0
48a. Is there a **cul-de-sac or permanent street closing** on this segment?	157	yes = 1; no = 0
48b. Is there a **pedestrian access point** or cut through point that allows pedestrians to go from one segment to another (even though vehicular traffic may not be able to)? Mark N/A if 45a = 0	158	yes = 1; no = 0; don't know = 7; NA = 8
Architecture/Design		
49. Rate the **attractiveness** of the segment (design + maintenance)	159	attractive = 3; neutral = 2; unattractive = 1
50. Does this segment have buildings that appear to be **historic**? (old + detailed) Mark N/A if there are no buildings	160	yes = 1; no = 0; NA = 8
51. How **interesting** is the architecture/urban design of this segment?	161	interesting = 3; somewhat interesting = 2; uninteresting = 1
Other Features of the Segment		
52. How many **street vendors or stalls** are on this segment? (do not count newspaper racks; there must be a person vending)	162	some/a lot = 2; few = 1; none = 0
53. Is there **public art** that is visible on this segment?	163	yes = 1; no = 0
54. Are there **billboards** present on this segment?	164	some/a lot = 2; few = 1; none = 0
55. How safe do you feel walking on this segment?	165	pretty/very safe = 1; not very safe/unsafe = 0

56. How many people (walking, standing, or sitting) were present on this segment while you were collecting data?	166	a lot = 3; some = 2; very few = 1; none = 0
Dogs		
57. Are there **any loose/unsupervised/barking dogs** on this segment that seem menacing?	167	yes = 1; no = 0
Olfactory Character		
58. Is the dominant smell unpleasant?	168	yes = 1; no = 0
Neighborhood Identification (OTHER END OF SEGMENT)		
Intersection		
1. Are there **monuments or markers** including neighborhood entry signs that indicate that one is entering a special district or area?	169	yes = 1; no = 0
Street Crossing		
2a. Consider the places on the segment that are **intended** for pedestrians to cross the street. Are these places marked for pedestrian crossing? Mark N/A if there are no intended places for pedestrians to cross.	170	all = 2; some = 1; none = 0; NA = 8
2b. What type of **marking** do the crosswalks have? Mark all that apply. Mark N/A if 2a= 0 or 8		
White painted lines	171	yes = 1; no = 0; NA = 8
Colored painted lines	172	yes = 1; no = 0; NA = 8
Zebra striping	173	yes = 1; no = 0; NA = 8
Different road surface or paving (e.g. tiles, colored concrete, marble, etc)	174	yes = 1; no = 0; NA = 8
Other	175	yes = 1; no = 0; NA = 8
3. Are there **curb cuts** at all places where crossing is expected to occur? Mark N/A if there are no intended places for pedestrians to cross.	176	all = 2; some = 2; none = 0; NA = 8
4. What type of **traffic/pedestrian signal(s)/system(s)** is/are provided? Mark all that apply.		
Traffic signal	177	yes = 1; no = 0
Stop sign	178	yes = 1; no = 0
Yield sign	179	yes = 1; no = 0
Pedestrian activated signal	180	yes = 1; no = 0
Pedestrian crossing sign	181	yes = 1; no = 0
Pedestrian overpass/underpass/bridge	182	yes = 1; no = 0
5. For an individual who is on this segment, how **safe (traffic wise)** do you think it is to cross the street from this segment?	183	pretty/very safe = 1; not very safe/ unsafe = 0; cul de sac = 8
6. For an individual who is on this segment, how **convenient (traffic wise)** do you think it is to cross the street from this segment?	184	pretty/very convenient =1; not very/inconvenient= 0; cul de sac = 8