Frames and Games:
Testing a Public Health Orientation to Climate Adaptation Planning

by

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Abstract

Current urban climate adaptation planning efforts tend to focus on protecting a city's physical assets from potential climate-related disasters, with an increasing emphasis on enhancing resilience, or building places that can absorb and withstand climatic shocks. Scholars and practitioners have critiqued climate adaptation planning's current focus on protecting physical assets, pointing out that adaptation plans rarely incorporate equity or social vulnerability. Consequently, calls have emerged for climate adaptation planning to focus on human vulnerabilities instead.

To that end, my dissertation probes why and how the health impacts of climate change should be given a more prominent role in climate adaptation planning efforts. In reality, to structure the conversation around climate change to be about public health, cities will need new approaches to enhance public awareness of and facilitate engagement with climate risk management choices. Responding to calls for research on ways for cities to operationalize a focus on the health impacts of climate change, my dissertation project tested three methods of engaging citizens in public health-oriented climate adaptation planning.

I find that cities have much to gain from framing climate change as a public health issue, as it boosts public concern about the severity of the problem and builds public support for policy action. I also find that serious games enhance awareness of local climate-related health risks and collective decision-making capacities, and argue that cities should utilize face-to-face and digital game-based engagement in climate adaptation planning efforts. My dissertation concludes with recommendations for cities on how to use a variety of public engagement methods to create pathways for envisioning local preferences in climate adaptation planning.

This dissertation engages with and contributes to three areas of theory and practice. First, the dissertation examines the proposed normative and pragmatic benefits of cities adopting a public health orientation to climate adaptation planning. Second, the dissertation presents new tools for cities to enhance public awareness of and facilitate engagement with climate risk management choices. Finally, the dissertation project considers planners' roles in science-intensive planning and policymaking processes, in particular, through addressing the unique challenges to enhancing public engagement around climate change. Furthermore, it examines how planners can foster collective decision-making capacities among different publics, and ultimately, enable technically sound and politically feasible responses by individuals and communities to adapt to climate change.

Thesis Supervisor: Lawrence Susskind
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Chapter 1

Introduction

1.1 Overview

The summer and fall of 2017 saw a number of record-breaking hurricanes in the U.S. Gulf Coast, the Eastern seaboard, Puerto Rico, and the Caribbean. The recent increases in the intensity, frequency, and duration of hurricanes, along with the incidence of the most intense (Category 4 and 5) storms are, in part, due to increased atmospheric and sea surface temperatures from climate change (Melillo, 2014; Emanuel, 2017). Furthermore, even if we were to stop emitting greenhouse gases today, these climate impacts are expected to continue for the next few centuries (Solomon et al., 2009; IPCC, 2014; Melillo, 2014).

Hurricane Harvey, a category 4 storm, dumped more than 50 inches of rain over southeast Texas, resulting in more than 80 deaths and $180 billion of damage (Amadeo, 2017). The historic and catastrophic devastation caused by the storm poses a host of public health concerns. Hurricane Harvey and ensuing floods caused more than 800 wastewater treatment facilities and 13 Superfund sites with toxic chemicals to flood (Hernandez, Zezima, & Achenbach, 2017). Tests found standing water in flooded homes in Houston to have up to 135 times of what is considered safe of E. coli, a measure of fecal contamination (Kaplan & Healy, 2017). News stories broke of how a senior citizen and a firefighter contracted necrotizing fasciitis, or 'flesh-eating bacteria,' from the contaminated floodwaters (Astor, 2017). Along with increased risks of infectious diseases, wound infections, and diarrhea from toxic waters, post-Harvey residents will have to grapple with health threats from mold, mosquitoes and other disease vectors, and mental health stressors, long after the flooding drains and media attention subsides (Grigg, 2017). The health impacts of climate change are significant.

As cities in the U.S. and around the world are increasingly experiencing the impacts of climate change, many are starting to include climate considerations in their planning processes (Bierbaum et al., 2013; IPCC, 2014). Cities are not only looking to mitigate greenhouse gas emissions from buildings, industries, and transportation to prevent future climate change, but are also looking to prepare for and manage climatic changes already underway. Climate change adaptation to date has mostly focused on how cities can protect their physical assets from potential climate-related disasters, with an increasing emphasis on enhancing resilience, or creating places that can absorb and withstand climatic shocks (Hughes, 2015).

Scholars and practitioners have critiqued climate adaptation planning's current focus on protecting physical assets, pointing out that adaptation plans rarely incorporate equity or social vulnerability (Hughes, 2015). Consequently, calls have emerged for climate adaptation planning to focus on *human vulnerabilities* instead (IPCC, 2014, Ch. 15; Rumbach & Kudva, 2011).

To that end, this dissertation concerns why and how the health impacts of climate change should be given a more prominent role in climate adaptation planning efforts. In reality, to reframe the conversation around climate change to be about public health, cities will need new approaches to enhance public awareness of and facilitate engagement with climate risk management choices. Responding to calls for research on ways for cities to operationalize a focus on the health impacts of climate change, this dissertation project tested three public engagement methods regarding public health-oriented climate adaptation planning.

The remainder of this introduction covers the following: first, a summary on cities, climate change, and public health is presented. Second, there is an introduction to climate adaptation planning, along with a review of efforts to engage the public in climate adaptation planning in the United States. Then, public engagement and climate adaptation planning in the city of Cambridge, MA, where this dissertation research is based, is examined. Lastly, the introduction briefly discusses the public engagement methods tested in this dissertation to enhance understanding of climate-related risks and increase public support for climate policies among Cambridge residents.

1.2 Cities, Climate Change, and Public Health

In April 2016, the U.S. Global Change Research Program (USGCRP) released a report called *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (Climate and Health Assessment), delineating the observed and projected impacts of climate change on the health and wellbeing of individuals and communities in the United States. Furthermore, the report states that the assessment is intended to inform the planning community: "The USGCRP Climate and Health Assessment has been developed to inform public health officials, *urban and disaster response planners*, decision makers, and other stakeholders within and outside of government who are interested in better understanding the risks climate change presents to human health" (USGCRP, 2016, p. vi, emphasis added). The assessment leaves no doubt about the severity of climate change risks we face, and how these risks will pervade the daily lives of everyone. Furthermore, it describes in useful, accessible terms how climate change will directly affect the health and wellbeing of our communities today, and calls for action from planners to address the health impacts of climate change now.

While climate change affects all places, cities, and in particular, coastal cities, face many climate risks, including sea-level rise and storm surges, precipitation-driven flooding, and extreme heat due to the urban heat island effect (WHO, 2013; IPCC, 2014; Watts et al., 2015). In terms of public health, the potential impacts on residents' health and well-being are formidable, ranging from a higher prevalence of existing and introduced vector-borne, food and waterborne diseases, heat stress, and respiratory symptoms that are exacerbated by poor air quality, to the challenges posed by more frequent and intense extreme weather events that in turn can cause injuries, death, mental health issues, infrastructure breakdown, and other public health risks. Vulnerable populations, including low-income communities, communities of color, children, and the elderly, are particularly at risk from these impacts (USGCRP, 2016; IPCC, 2014).

Further information on how current and future climate impacts can impact people's health and well-being, the climate drivers, the exposure pathways, and health outcomes that result from exposure, and the disproportionate climate-related health risks of certain populations is in Chapter 2.

1.3 Climate Adaptation Planning and Public Engagement

Cities in the United States, and across the world, are beginning to take action to address climate change risks by creating adaptation plans. Previous climate-related disaster experiences, perceived climate change threats, and the existence of political leadership have been cited as drivers of local climate adaptation action (Anguelovski & Carmin, 2011; Betsill & Bulkeley, 2007; Bierbaum et al., 2013). In addition, larger population sizes, higher levels of commitment from elected officials, and higher municipal expenditures per capita have also been shown to be associated with U.S. cities pursuing adaptation planning (Shi, Chu, & Debats, 2015). As Hughes (2015) notes, public support is rarely a driver for climate adaptation planning. Instead, public opinion is often considered an impediment by cities in planning to adapt to climate change (Hughes, 2015, p. 22). In particular, cities have found that most publics in the U.S. do not find climate adaptation to be a political priority, even if they are aware of climate impacts and of its anthropogenic causes (Howe, Mildenberger, Marlon, & Leiserowitz, 2015), highlighting the importance of communicating the need for climate adaptation to elected officials and the public (Carmin et al., 2012; Howe et al., 2015; Shi, Chu, & Debats, 2015).

According to Tang et al. (2010), 85% of climate action plans in cities in the U.S. include policies for public engagement (Tang, Brody, Quinn, Chang, & Wei, 2010). Regardless of the high proportion of cities tangibly making public engagement a facet of their adaptation policies, there have been continuous calls to further enhance the participation of stakeholders, from assessing risks and vulnerabilities to designing and implementing operational approaches in adapting to climate change (Moser and Satterthwaite, 2008; Anguelovski and Carmin, 2011; Carmin et al., 2012; Dannevig et al., 2012), implying that there is room for more and better public engagement in climate adaptation planning. Indeed, a number of recent studies surveying local planners, managers, and officials involved with climate adaptation planning show that building capacity in community engagement around climate change to be a pressing need (Moser & Pike, 2015; Nordgren, Stults, & Meerow, 2016).

Further information on climate adaptation planning and public engagement in climate adaptation planning is in Chapters 3 and 4.

1.4 Public Engagement Methods

Method I. Issue Framing

The first study probes how issue framing, specifically framing climate change as a public health concern, affects perceived knowledge about climate change, concern for local climate risks, and policy preferences regarding climate adaptation planning. Framing is one of the primary means policymakers can use to influence public opinion. According to Druckman (2001), a framing effect occurs when in the course of describing an issue or event, an "emphasi[s] on a subset of potentially relevant considerations causes individuals to focus on these considerations when constructing their opinions" (Druckman, 2001, pp. 226–231).

Framing climate change as a public health concern versus an environmental one was tested through a randomized, controlled message experiment where participants were randomly assigned to read one of two differently framed vignettes each of approximately 300 words. The messages were structured identically, but emphasized either the environmental or public health impacts of climate change. A total of 169 Cambridge residents participated in the survey experiment between September 2015 and May 2016. In addition, 139 mTurk workers from the Northeast region of the United States also participated in July 2017.

Issue framing, the framing survey experiments, and the results are explained in more detail in Chapter 5.

Method II. Face-to-Face Role-Play Simulation (RPS)

The second study analyzes the efficacy of a face-to-face role-play simulation in enhancing perceived knowledge about climate change, increasing concern for local climate risks, and shifting policy preferences regarding climate adaptation planning. Role-play simulations are a form of experiential learning, where one takes on a different role from their everyday life and interacts with other participants to act out a real-life situation in a safe and supportive environment. Role-play simulations offer interactive ways of mastering technical information within fixed rules and constrained outcomes (Abt, 1987; de Suarez et al., 2012; Gee, 2003; Rumore et al., 2016; Sawyer & Smith, 2008).

The face-to-face role-play simulation used in this dissertation project is a game set in the fictional city of Mapleton with six different assigned roles: City Manager, the Director of Public Health, the Director of Public Housing, President of the local Chamber of Commerce, Executive Director of a local environmental advocacy organization, and a local university planner. With the help of a neutral facilitator, participants debate and recommend policy decisions to local officials in Mapleton to help prepare the city for the future health impacts of climate change. The data presented in the game was based on the results of the Vulnerability Assessment conducted by the city of Cambridge in 2015. Overall, 118 residents participated in the face-to-face role-play simulation, in six public workshops, between November 2015 and May 2016.

Similarly, the face-to-face role-play simulation, the process of deploying it in the city of Cambridge, and subsequent results are explained in more detail in Chapter 6.

Method III. Digital Game

The third and last study tests the influence of a digital game on perceived knowledge about climate change, concern for local climate risks, and policy preferences regarding climate adaptation planning. Digital games have been touted for their potential to recruit a larger and more diverse group of participants, when compared to face-to-face public engagement efforts. In addition, digital games allow for in-game assessment of learning. Through the use of points, levels, or questions, most games contain innate evaluation mechanisms that can be used to assess players' learning regarding climate change. Digital games can also collect player data electronically, increasing the speed and data quality of analyses significantly (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013; Gordon & Baldwin-Philippi, 2014; Shaffer, 2006; Squire, 2003, 2006; Wu & Lee, 2015).

The digital game used in this dissertation project focuses on the increased health risks posed by rising temperatures, reduced air quality, increasing extreme weather, expanding water-related illness, and decreased food safety. This game is a single player game, where each player steps into the roles of hypothetical Cambridge residents that are more at risk to the health impacts of climate change, because of factors like where they live, biological sensitivity, or other socioeconomic factors. Players also learn actionable steps a caretaker can take for each of these roles to alleviate sub-population-specific climate change health risks. 229 residents completed more than 10,400 game actions during 57 days of game play between March and May 2017.

The digital game is also explained in more detail in Chapter 7.

1.5 Research Question and Hypotheses

As mentioned, this dissertation developed and implemented three public engagement interventions in the city of Cambridge, Massachusetts: 1) exposure to a health versus an environmental frame of climate change, 2) participation in a face-to-face role-play simulation highlighting the likely health impacts of climate change, and 3) participation in a digital game highlighting the likely health impacts of climate change.

This dissertation project explored the central research question of: how do these public engagement tools influence Cambridge residents' perceptions of local climate risks and their policy priorities in climate adaptation planning? The project was initiated with the main hypothesis that an emphasis on the health impacts of climate change would increase residents' understanding of and concern for climate change, and furthermore, increase policy support for climate adaptation planning efforts. A public health frame was also hypothesized to increase the perceived geographic, social, and temporal proximity of climate change.

The outcomes of interest, or the dependent variables, capture attitude shifts by measuring changes in cognition, affect, and behavior[1]. Other dependent variables of interest measure learning in the face-to-face role-play simulation and the digital game, either through self-reports or learning assessments.

The first research question concerns the efficacy of the three public engagement methods studied in this dissertation.

Q1: How does each public engagement method affect participants' attitudes regarding local climate risks and policy support for climate adaptation planning efforts?

Hypothesis 1.1. Issue framing of climate change: Compared to the residents that are exposed to an environmental frame of climate change or are not exposed to any frame, the residents that are exposed to a health frame of climate change will, on average, have higher levels of 1) knowledge of global warming or climate change, 2) perceived seriousness of the threat climate change poses, 3) concern for climate impacts on the city of Cambridge, 4) confidence in effective local climate adaptation in Cambridge, 5) willingness to pay higher taxes for Cambridge to reduce climate risks, and 6) a higher proportion of the group respondents picking "increased risks of disease, hospitalization, and death" as the climate risk the city of Cambridge should prioritize in its climate adaptation policies.

Hypothesis 1.2. Role-play simulation: Compared to before participating in the face-to-face role-play simulation, participants will have, on average, after playing the role-play simulation: higher levels of 1) knowledge of global warming or climate change, 2) perceived seriousness

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1 In social psychology, attitude is defined as "an individual's disposition to respond favorably or unfavorably to an object, person, institution, or event, or to any other discriminable aspect of the individual's world" (Ajzen, 1989, p. 241). Rosenberg and Hovland (1960) posit in their tripartite model of attitude structure that one's attitude can be inferred by measuring three components of cognition, affect, and behavior (Rosenberg & Hovland, 1960). This tripartite model of attitude structure is the most prevalent conceptual model of attitude in social psychology research (see Ajzen, 1989; Allport, 1964; Hilgard, 1980; McGuire, 1969 for a review) (see Bagozzi, Tybout, Craig, & Sternthal, 1979; Breckler, 1984; Eagly & Chaiken, 2007 for a discussion regarding the construct validity of the tripartite classification of attitudes).

of the threat climate change poses, 3) concern for climate impacts on the city of Cambridge, 4) confidence in effective local climate adaptation in Cambridge, 5) willingness to pay higher taxes for Cambridge to reduce climate risks, 6) a higher proportion of the participants picking "increased risks of disease, hospitalization, and death" as the climate risk the city of Cambridge should prioritize in its climate adaptation policies, and 7) a higher proportion of the participants picking "emergency preparedness" as the policy approach the city of Cambridge should use primarily to manage the health impacts of climate change.

Hypothesis 1.3. Digital game: Compared to before participating in the digital game, participants will have, on average, after playing the digital game: higher levels of 1) knowledge of global warming or climate change, 2) perceived seriousness of the threat climate change poses, 3) concern for climate impacts on the city of Cambridge, 4) willingness to pay higher taxes for Cambridge to reduce climate risks, and 5) a higher proportion of the participants picking "increased risks of disease, hospitalization, and death" as the climate risk the city of Cambridge should prioritize in its climate adaptation policies.

The second research question concerns the relative efficacy of face-to-face role-play simulations versus digital games in effecting learning.

Q2: How does each game (face-to-face role-play simulation versus digital game) foster participants' learning in different dimensions of public health-oriented climate adaptation planning?

The face-to-face role-play simulation and the digital game were hypothesized to have different relative strengths in cultivating learning around local climate-related health risks and climate adaptation planning. The digital game was expected to be more effective in participants' substantive learning about the health impacts of climate change, while the face-to-face role-play simulation was predicted to be stronger in inducing participants' perspective-taking and envisioning of possible future adaptation planning options.

Hypothesis 2.1. Compared to the group of residents that play the face-to-face role-play simulation, the group of residents who play the digital game will, on average, all else equal, will have higher levels of self-reported learning about the health impacts of climate change.

Hypothesis 2.2. Compared to the group of residents that play the digital game, the group of residents who play the face-to-face role-play simulation will, on average, all else equal, will have higher levels of self-reported learning about 1) the viewpoints of different stakeholders in Cambridge in dealing with climate change, and 2) imagining how Cambridge can proceed with climate adaptation.

In essence, this dissertation analyzes the effects of three interventions: 1) issue framing of climate change, 2) a face-to-face role-play simulation, and 3) a digital role-play game on a) subject matter awareness of climate change and health, b) concern for local climate risks, and c) support for various local climate adaptation efforts.

1.6 Dissertation Structure

The dissertation is organized as follows. Part I lays out the context for this dissertation: Chapter 2 delves into the health impacts of climate change. Chapter 3 summarizes climate adaptation planning and public engagement in climate adaptation planning in the United States. Chapter 4 discusses unique challenges to understanding and engaging with climate change and examines the prescriptive research to date on enhancing public engagement with climate change. Part II covers the three public engagement methods tested in this dissertation project to enable the city of Cambridge to better respond to the public health risks posed by climate change. Chapters 5, 6, and 7 explain each public engagement method's design and implementation, and present the results. Finally, in Part III, Chapter 8 discusses the results, and their policy implications for local governments' roles in enhancing awareness of and commitment to managing climate-related health risks, and ultimately, better engaging their publics in climate adaptation planning processes.

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Chapter 2

Cities, Climate Change, and Public Health

In 2007, the World Health Organization declared that climate change will be the defining issue for public health in the 21st century (Chan, 2006). Climate change poses a series of significant and far-reaching threats to human health and well-being all over the world (USGCRP, 2016; IPCC, 2014; Kinney et al., 2015; Luber et al., 2014).

As seen in Figure 2.1 below, impacts can be direct (through climate-related changes in the frequency, intensity, and duration of extreme weather events, such as heat waves, floods, storms, or droughts) or indirect (through climate-related changes in natural and physical systems, expanding and increasing the geographical range and incidence of infectious diseases). Climate change can also affect public health through climate-related violence and displacement, environmental degradation, and other development setbacks (WHO 2013, pp. 1-3). In the last decade, deaths, injuries, and other health problems from floods, drought and other climate-related disasters cost an estimated $14 billion in the U.S. (USGRPC, 2016; IPCC, 2014; Watts et al., 2015, p. 1864).

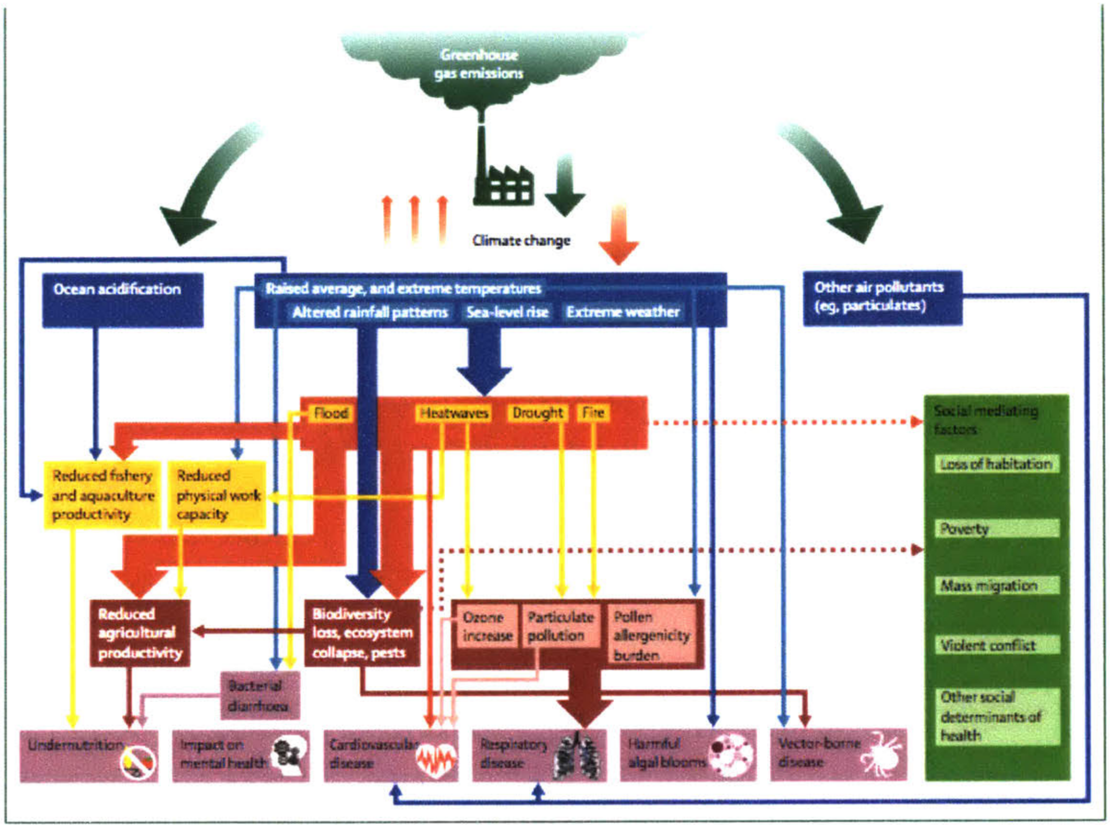

Figure 2.1: The causal links between climate change and health (from Watts et al., 2015, p. 1863)

Focusing on the links between specific climate impacts and associated health outcomes, the figure below (Figure 2.2) details how each climate impact translates into public health impacts in more detail, and indicates the populations most vulnerable to climate-sensitive health threats.

Climate Change Impacts	Health Impacts	Populations Most Affected
Extreme Heat	• Premature death • Cardiovascular stress and failure • Heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones	• Elderly • Children • Diabetics • Poor, urban residents • People with respiratory diseases • Agricultural workers • Those active outdoors
Poor Air Quality/ Air Pollution	• Increased asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular and respiratory diseases	• Children • Elderly • People with respiratory diseases • Low income • Those active outdoors
Wildfires	• Injuries and death from burns and smoke inhalation • Eye and respiratory illnesses due to air pollution • Exacerbation of asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular and respiratory diseases • Risk from erosion and land slippage after wildfires • Displacement and loss of homes	• People with respiratory diseases
Severe Weather, Extreme Rainfall, Floods, Water Issues	• Population displacement, loss of home and livelihood • Death from drowning • Injuries • Damage to potable water, wastewater, and irrigation systems, resulting in decrease in quality/quantity of water supply and disruption to agriculture • Water- and food-borne diseases from sewage overflow	• Coastal residents, and residents in flood-prone areas • Elderly • Children • Low income
Increased average temperature	• Cardiovascular disease Increased number and range of: • Vector-borne disease, such as West Nile virus, malaria, Hantavirus, or plague • Water-borne disease, such as cholera and *E. coli* • Food-borne disease, such as *salmonella* poisoning • Harmful algal blooms causing skin disease and poisoning • Allergies caused by pollen, and rashes from plants such as poison ivy or stinging nettle • Vulnerability to wildfires and air pollution	• Children • Elderly • Agricultural workers • Those active outdoors • People with respiratory disease • People with acute allergies
Agricultural Changes	• Changing patterns and yields of crops, pests, and weed species, resulting in higher prices for food and food insecurity, hunger, and malnutrition • Changes in agriculture/forestry, leading to lost or displaced jobs and unemployment	• Agricultural workers • Rural communities • Low income • Elderly • Children
Drought	• Hunger and malnutrition caused by disruption in food and water supply, increased cost and conflict over food and water • Food- and water-borne disease • Emergence of new contagious and vector-borne disease	• Low income • Elderly • Children
All Impacts	**Mental health disorders** (e.g., depression, anxiety, Post-Traumatic Stress Disorder, substance abuse, and other conditions) caused by: • Disruption, displacement, and migration • Loss of home, lives, and livelihood **Health Care Impacts:** • Increased rates of illness and disease, emergency room use, and related costs borne by employers, health plans, and residents • Damage to health facilities	• All populations • Low income • Health care staff

Figure 2.2: Human Health Effects of Climate Change (from CDPH, 2012, p. 9)

Within the large range of health outcomes shaped by the weather and climate, simply put, climate change can affect health in two ways: as the climate continues to change, the risks to our health and well-being will grow, due to either an 1) increase in the severity or frequency of health problems already affected by climate or weather factors or 2) unprecedented health problems in places where they did not previously occur (USGCRP 2016, Chapter 1).

In response, there are a variety of international and national climate change and human health assessments seeking to provide overviews of the large range of health outcomes sensitive to climate (USGCRP, 2016; IPCC, 2014; Kinney et al., 2015; Luber et al., 2014). In other words, these assessments present health risks under current climate variability conditions and more recent climate change, analyze the relationships between past climate and health outcomes, and estimate future health risks under various climate scenarios (WHO, 2013).

For some health impacts, the metrics currently available can only describe changes in risk of exposure, while for others, metrics can project actual changes in health outcomes, such as the likely number of new cases of a disease or additional deaths. In other words, the strength of the causal links between a climate change impact and related health outcomes varies (USGCRP 2016, p. xi; Appendix 4). To illustrate this point, we are able to project the predicted change in actual outcomes due to climate and weather factors for the following climate-sensitive health risks with the most confidence: air pollution and allergens and increase in morbidity; extreme heat and the increase in number of premature deaths; earlier onset of Lyme disease due to warmer temperatures in the eastern states; and an increase in waterborne illnesses (USGCRP 2016, Appendix 1).

To date, the USGCRP National Climate and Health Assessment (2016) is the most recent climate and health assessment presenting observed and projected impacts of climate change on the health and well-being of individuals and communities in the United States. The assessment consists of seven topical chapters devoted to specific health impacts and exposures: temperature related death and illness; air quality impacts; extreme events; vector-borne diseases; water-related illnesses; food safety, nutrition, and distribution; and mental health and well-being (USGCRP, 2016). The following section will summarize the health impacts deemed to be the most significant to individuals and communities in the U.S.

1. **Temperature-related death and illness**

An increase of both average and extreme temperatures can lead to an increase in heat-related deaths and illnesses, particularly in children, the elderly, and economically disadvantaged groups. Higher-than-average temperatures interfere with the body's ability to regulate its internal temperature control, resulting in heat cramps, heat exhaustion, heat stroke, and can even result in fatal hyperthermia in extreme heat. In addition, higher temperatures can also exacerbate chronic conditions such as cardiovascular disease, respiratory disease, cerebrovascular disease, and diabetes. Research has shown extended periods of exposure to higher temperatures lead to an increase in hospital admissions for cardiovascular, respiratory, and kidney disorders (USGCRP 2016, pp. 6-7, Chapter 2).

2. **Air quality impacts**

An increase in temperatures and wildfires, along with decreased precipitation, will in turn increase ozone and particulate matter, amplifying the risks of cardiovascular and respiratory conditions. Modified weather patterns lead to an increase in the quantity and prevalence of outdoor air pollutants, such as ground-level ozone (O^3) and fine particulate matter. In addition, more carbon dioxide (CO^2) fosters growth in plant varieties that produce aeroallergens. Finally, higher pollen concentrations and longer pollen seasons worsens allergies and asthma. As outdoor air quality decreases, indoor air quality also decreases, leading to negative respiratory and cardiovascular health outcomes (USGCRP 2016, pp. 8-9, Chapter 3).

3. **Impacts of extreme weather events on health**

The frequency, duration, and severity of some extreme events will increase due to climate change, increasing the risks of a range of negative health impacts before, during, and after the events. In addition to health impacts such as injury or death during storms and floods, health impacts can also occur before or after an extreme event, in the stages of disaster preparation and post-event recovery. Property damage, critical infrastructure and social services delivery disruption, and environmental degradation from the event may continue to pose health risks long after the climate hazard. Similarly, the impacts of a disaster can be affecting other areas near the actual site of the event (USGCRP 2016, pp. 10-11, Chapter 4).

4. **Vector-borne diseases**

Vectors, such as mosquitoes, ticks, and fleas, carry viruses, bacteria, and protozoa, and transmit vector-borne diseases. Climate factors, especially temperature extremes and precipitation patterns, influence the seasonality, distribution, and prevalence of vector-borne diseases. In particular, ticks are projected to show earlier each year and also expand northward, increasing risks of exposure to Lyme disease vectors. Both the distribution and number of Lyme disease cases have increased in the Northeast and the Upper Midwest. Also, through increased habitat availability and reproduction rates, the prevalence and distribution of mosquitoes that transit West Nile virus are projected to increase as well (USGCRP 2016, pp. 12-13, Chapter 5).

5. **Water-related illnesses**

Climate factors, such as temperature, precipitation and related runoff, hurricanes, and storm surge, will affect fresh and marine water resources, increasing people's exposure to water-related contaminants, or bacteria, viruses, and protozoa in the water. Toxins produced by certain harmful algae and cyanobacteria also cause waterborne illnesses. Ingestion, inhalation, or direct contact with contaminated water, along with consumption of contaminated fish and shellfish, leads to water-related illnesses (USGCRP 2016, pp. 14-15, Chapter 6).

6. **Food safety, nutrition, and distribution**

Rising temperatures and subsequent changes in weather patterns and extreme climate events lead to increased food contamination or spoilage, and disruption of food distribution. In particular, higher temperatures increase Salmonella incidence in food, while warmer seasons also increase the risks of exposure to Salmonella.

In addition, while higher CO^2 concentrations stimulate growth in some plant varieties, the increase in CO^2 also decreases the amount of protein and essential minerals in several staple crops, such as wheat, rice, and potatoes. In other words, rising atmospheric carbon dioxide levels directly decrease the nutritional density of certain foods (USGCRP 2016, pp. 16-17, Chapter 7).

7. **Mental health and well-being**

Climate-related events can exacerbate mental health stressors, with greater risks for children, the elderly, pregnant and post-partum women, people with pre-existing mental illnesses, the economically disadvantaged, the homeless, and first responders. The mental health risks of climate change include stress, anxiety, depression, and post-traumatic stress. In addition, certain mental health medications impair the body's ability to regulate internal temperatures, increasing the health risks of rising temperatures and extreme heat (USGCRP 2016, pp. 18-19, Chapter 8).

This section above examined the range of climate-related health risks that the United States is likely to face with continued climate change. However, it is important to note that many climate-sensitive health outcomes are inherently place-specific. For instance, Stone's work on urban heat documents how in urban areas, local temperatures can increase as much from local urban heat island effects as from global climate change impacts (Stone, 2012). Sailor et al. (2016) find that this phenomenon tends to be underreported, as the IPCC's and other international and national climate assessments tend to focus on global average ambient air temperatures, instead of locally experienced thermal stress, which is dependent on not just air temperatures, but also surface temperatures, air pollution, humidity, and wind speeds (Stone, 2012; Sailor et al., 2016).

Consequently, the health impacts of climate change will vary across geographic regions and populations, making it imperative for regional, state, and local governments to prepare for the specific health outcomes their communities will face (Luber et al., 2014; Marinucci, Luber, Uejio, Saha, & Hess, 2014). In preparing for and managing place-specific climate-related health risks, municipal policymakers must first assess their community's vulnerability to climate-related health risks. The next section will delve into the concept of vulnerability, and how it relates to assessing a community's vulnerability to climate-related health risks.

Vulnerability to climate-related health risks

Vulnerability to climate-related health risks is defined as the propensity for the health of individuals or communities to be adversely affected as a result of exposure to a climate hazard (IPCC, 2014). There are three main components that contribute to vulnerability: 1) exposure to climate-related health risks, 2) sensitivity to those hazards, and 3) the capacity to respond effectively or adapt to the consequences of climate change. Exposure refers to the magnitude, frequency, and duration of an environmental exposure or disease risk, and is dependent on the level of climate change that occurs. Climate hazards in cities can impact health not only through direct exposure, but also through a range of secondary hazards, many of which are driven by infrastructure disruptions (Kinney et al., 2015; Rosenthal & Brechwald, 2013; Rosenzweig & Solecki, 2010). Certain sub-populations are more sensitive to climate risks; lower levels of hazards impact them more than the general population. One example is elderly populations' heightened sensitivity to extreme heat. Exposure and sensitivity combine with adaptive capacity to determine overall vulnerability to climate-related health risks. Adaptive capacity ranges from an individual's ability to adapt to different climate conditions to a municipality's ability to plan for and manage climate-related events. As an example of adaptive capacity, it is possible that people might physiologically adapt to higher temperatures in the future. In contrast, the adaptive capacity of low-income populations to adapt to rising temperatures may be constrained by difficulties in paying for air conditioning (Brown, Proust, Spickett, & Capon, 2011; Ebi, 2013; Patz, Campbell-Lendrum, Gibbs, & Woodruff, 2008; Smit & Wandel, 2006).

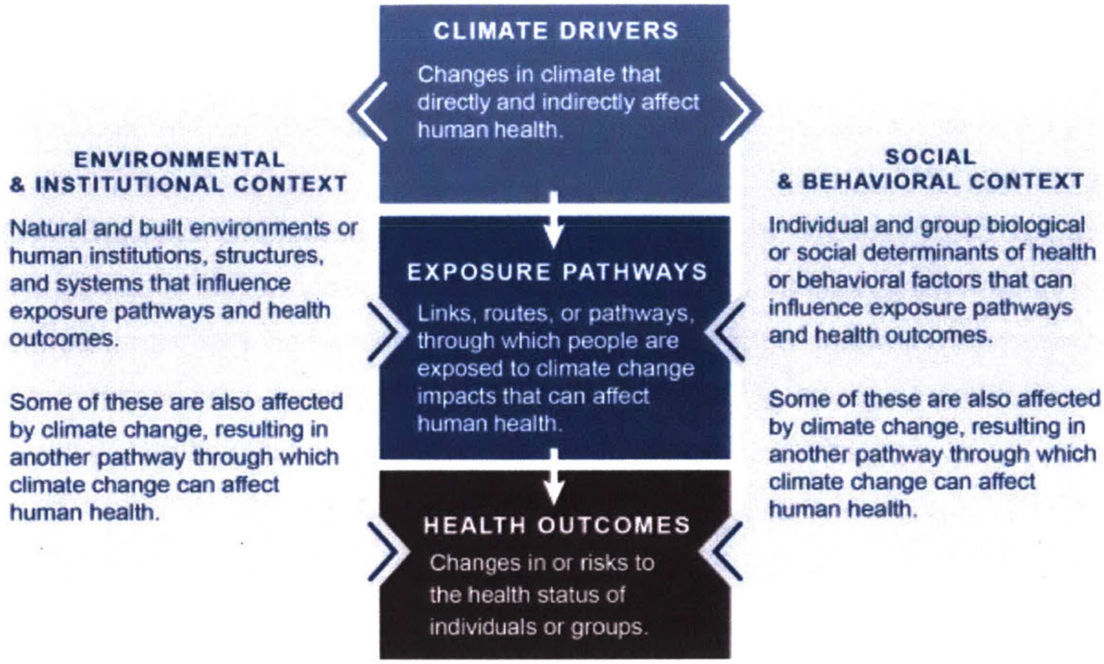

Figure 2.3: Exposure Pathway Diagram (from USGCRP, 2016, p. x)

Many factors influence the impact of climate change on people's health and well-being. A community's vulnerability may be affected by climate change or by non-climate factors, such as demography, economic development, infrastructure, behavior, technology, and ecosystems. An individual's vulnerability may be influenced by factors such as age, socioeconomic status, and pre-existing or chronic medical conditions (USGCRP 2016, p. viii).

In figure 2.3 above, the diagram shows that climate change can affect health outcomes directly or by influencing the environmental, institutional, social, and behavioral contexts that alter human health and well-being. The center boxes show how climate drivers of health affect people through exposure pathways, resulting in certain health outcomes. The left gray box represents the larger environmental and institutional context that can affect an individual's or a community's vulnerability to the health impacts of climate change (USGCRP 2016, p. x). For example, while injuries and deaths from flooding may seem like a consequence of only rain, storm surges, and sea-level rise, it is important to remember that the environmental and institutional context set by factors such as infrastructure and land use planning, the effectiveness of emergency preparedness programs, and the coverage of the current public health system are equally significant (WHO, 2013, p. 14). The gray box on the right includes social and behavioral factors that affect a community's vulnerability to the health impacts of climate change (USGCRP 2016, p. x). Demographics, pre-existing medical conditions, and genetic factors are the main baseline vulnerability conditions to consider for community health (Balbus & Malina, 2009). In the case of flooding, social determinants of health heavily influence an individual's health outcome. Poverty; geographical, cultural, or linguistic isolation; dependency on caregivers; limited mobility; homelessness; and institutionalization lower adaptive capacity, and subsequently put individuals at a higher risk for adverse health outcomes from flooding (USGCRP 2016, pp. 103-104).

As vulnerability to climate change is place-specific, it differs across regions, among urban, rural, and coastal communities, and among individuals within communities (USGCRP 2016, p. 20, Chapter 9; Balbus & Malina, 2009; O'Neill, Kinney, & Cohen, 2008; Uejio et al., 2011). The vulnerability of a location is impacted by factors such as baseline climate and geographical circumstances that cause differential exposure to climatic risks (WHO, 2013, p. 14). Locations with greater health threats from climate change include urban areas, particularly with heat island effects and air quality issues, coastal and other flood-prone areas, areas with higher levels of allergens and other air pollutants, and areas with limited access to water, energy, and transportation infrastructure (USGCRP 2016, p. 250).

Within communities, the vulnerability of individuals and groups often arises from inadequate resources in avoiding exposure to climate-related health risks or adapting to climate change (Patz, Gibbs, Foley, Rogers, & Smith, 2007; WHO, 2013, pp. 23–24). For instance, living in densely populated areas or in older housing stock makes one more vulnerable to heat waves and flooding (WHO, 2013, pp. 19–21). Older buildings without adequate natural ventilation or air conditioning are poorly adapted to warmer temperatures. Older buildings are also more likely to expose residents to indoor air contaminants and mold. These risks are exacerbated after storms and flooding events, and are particularly high in buildings with inadequately sealed windows and roofs (City of Cambridge, 2015, p. 8; USGCRP 2016, p. 250; Chapter 3).

Integrating Public Health into Climate Planning

Once cities have determined their vulnerabilities to climate-related health risks, they must plan for and manage threats to people's health and well-being. Scholars have remarked on how the absence of a direct planning linkage between climate adaptation planning goals and actual human health outcomes leads to adaptation strategies that only indirectly address the underlying end goals of reducing negative climate impacts on health and improving overall health and well-being (Sailor et al., 2016).

As the actual end goal of climate adaptation planning is, arguably, to alleviate threats to and improve the health and well-being of the city's inhabitants, instead of planting a certain number of trees or cooling the surface temperature of a city by a certain number of degrees, municipal policymakers and agencies should situate climate-health interactions front and center in their climate planning efforts. For example, in contrast to tree planting initiatives with metrics based on the number of trees planted or climate mitigation initiatives based on the number of degrees temperature increases should be confined to, the cities of Phoenix, Boston, and Philadelphia are creating community cooling centers and neighborhood watch programs to address extreme heat events around reducing excess mortality and morbidity (Bierbaum et al., 2013).

In that sense, the BRACE framework is a notable decision support tool in structuring climate adaptation planning with the goal of reducing adverse health impacts of climate change. While the Centers for Disease Control and Prevention (CDC)'s BRACE framework (Building Resilience Against Climate Effects) was designed for local public health agencies to adapt to and manage the place-specific health impacts of climate change (Marinucci et al., 2014), the BRACE framework has much to offer to all municipal planners and policymakers aiming to reduce excess mortality and morbidity in cities facing climate change. BRACE defines [public health] adaptation as "any short- or long-term strategies that can reduce adverse health impacts or enhance resilience in response to observed or expected changes in climate and associated extremes" (Marinucci et al. 2014, p. 6436).

As many climate-related health threats are place-specific, BRACE aims to clarify and prioritize urgent climate-related health risks in a certain location. The iterative framework consists of 1) a vulnerability assessment, 2) modeling of projected health impacts, 3) an evaluation of intervention options, 4) development of a locally tailored adaptation plan, and 5) monitoring and evaluation of the plan (Marinucci et al., 2014). The figure below (Figure 2.4) provides more details on each of the five steps.

Step No.	BRACE Step Title	Description of Functions
Step 1	**Anticipating Climate Impacts and Assessing Vulnerabilities**	Identify the scope of climate impacts, associated potential health outcomes, and populations and locations vulnerable to these health impacts.
Step 2	**Projecting the Disease Burden**	Estimate or quantify the additional burden of health outcomes due to climate change.
Step 3	**Assessing Public Health Interventions**	Identify the most suitable health interventions for the health impacts of greatest concern.
Step 4	**Developing and Implementing a Climate and Health Adaptation Plan**	Develop a written plan that is regularly updated. Disseminate and oversee the implementation of the plan.
Step 5	**Evaluating Impact and Improving Quality of Activities**	Evaluate the process. Determine the value of information attained and activities undertaken.

Figure 2.4. The Five Steps of BRACE: Building Resilience Against Climate Effects (from Marinucci et al., 2014, p. 6436)

Through the Climate-Ready States and Cities Initiative, the Centers for Disease Control and Prevention (CDC) is assisting public health agencies in 16 states and two cities apply the BRACE framework and prepare for the health impacts of climate change. The state grantees are Arizona, California, Florida, Illinois, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Vermont and Wisconsin, and the city grantees are New York City and San Francisco. The grantees are in various stages of applying the BRACE framework. Most are in the process of developing partnerships between state and city public health agencies, with climate scientists now conducting vulnerability assessments (Marinucci et al., 2014).

Another noteworthy framework is the California Health and Equity's checklist for integrating public health into climate planning, shown below in Figure 2.5. This framework places more of an emphasis on the multi-sectoral and multi-level governance aspects of climate adaptation planning for health (California Department of Public Health, 2012). We can see that the checklist focuses on: 1) building collaborative relationships between climate planning and public health agencies, 2) identifying community-relevant health goals and co-benefits of climate planning strategies, 3) specifying relevant climate and health indicators in the plan, and subsequently measuring outcomes regularly, and 4) educating and engaging local policymakers, the media, community partners, and residents about climate and health linkages.

Checklist for Integrating Health into Climate Action Planning

- Meet with local health department staff about climate planning process and implementation.
- Invite public health and other local health organizations to participate in climate plan development and coordinate and collaborate on implementation. Local health partners include hospitals, clinics, Health Plans, the County Medical Society, American Lung Association local chapters, and community health organizations, many of whom are becoming more involved in land use, transportation, and climate and health issues.
- Make sure local policymakers understand the health and climate change connections and how these can be part of the overall climate plan.
- Identify and include health goals and co-benefits in a Request for Proposals for consultants, to ensure that health impacts will be integrated in the planning process early on.
- Identify relevant local health data and indicators for use in the climate plan.
- Identify public health co-benefits and potential adverse health consequences early in the screening, development, or implementation phases of the climate planning process. Health partners may be able to help with this analysis. For any identified negative consequences that may be associated with the climate plan, have a clear plan for mitigating or preventing these consequences.
- Identify health co-benefits that resonate most with the community's conditions and goals to ensure the climate plan addresses the unique needs and interests of the local community.

- Include climate change and health information as part of community outreach and engagement during the development, adoption, and implementation phases.
- Identify health partners who can help with outreach, education, and communication strategies.
- As part of evaluation and reporting on climate planning progress, make sure that health outcomes are included and measured. Health partners may be able to help with this.
- When reporting progress to elected officials, media, partners, and residents, make sure to reinforce the human welfare, equity, and health benefits of measures to reduce GHG and strengthen community readiness.

Figure 2.5. Checklist for Integrating Health into Climate Planning (adapted from CDPH, 2012, p. 13)

In terms of actual implementation, there are several climate initiatives at the city level that attempt to mitigate the urban heat island effect through urban-scale cooling strategies. For instance, Chicago has implemented its Urban Forests policy to mitigate extreme heat, along with other goals, such as improving air quality (Harlan & Ruddell, 2011). In addition, the NYC Cool Roofs Program was initiated to apply white paint to roofs in areas experiencing heat extremes, with the goal of painting 1 million square feet of rooftop per year. Up to date, the program has focused on painting the roofs of public housing and government buildings (Solecki et al., 2015).

However, these initiatives tend to be piecemeal, and systematic public health-oriented climate adaptation plans are hard to find. In addition, a majority of the climate plans that incorporate any public health elements merely acknowledge that climate change will have public health impacts, and fall short of delineating location-specific climate and health linkages and articulating planning strategies to alleviate the health risks of climate change (California Department of Public Health, 2012, 18).

In summary, current health-oriented climate adaptation planning efforts exhibit three main shortcomings:

First, they fail to fully incorporate and be structured around climate-health linkages, and subsequently, are not necessarily aligned with the end goal of alleviating the health risks of climate change. As Sailor et al. (2016) point out, many of these initiatives' goals are often stated in terms of the scope of implementation (one million trees, one million square feet of white paint) instead of intended outcomes regarding air quality, actual indoor temperatures, or human health. This leads to subpar policy design and implementation in enhancing community health outcomes (Sailor et al., 2016). Therefore, public health-oriented climate adaptation efforts should instead start setting goals based on health outcomes and improvements, and subsequently measure and evaluate policy progress towards these goals. This will also make climate adaptation planning processes more robust, adhering to principles laid out in Füssel (2007), by 1) assessing adaptation needs in a more inclusive way, by linking future climate impacts with more current policy concerns, 2) prioritizing co-benefits arising from adapting to climate change and reducing excess mortality and morbidity, and 3) reducing the risk of maladaptation actions arising from the uncertainty and complexity of climate projections, by focusing on low-regret or no-regret options (Füssel, 2007).

Second, the health impacts of climate change need further elaboration to enable understanding by both key stakeholders and the public. Research has shown that about two-thirds of Americans do not really give that much thought to how climate change might affect people's health. In addition, only about a quarter of the population is able to accurately name specific types of harm from climate change to human health (Maibach et al., 2015). Lack of knowledge of climate-health linkages, and specifically, about how climate change harms health outcomes today, poses a substantial barrier to furthering public health-oriented climate adaptation planning (California Department of Public Health, 2012).

Lastly, we need a climate adaptation planning that will confront how the health impacts are uneven, not only across cities, but also within cities. Research has documented extensively how substantial health inequities that exist today (Arcaya, Arcaya & Subramanian, 2015) are only likely to be exacerbated by climate change (Patz et al., 2007; WHO, 2013; IPCC, 2014). Namely, people who live in geographically vulnerable places and lack the adaptive capacity to alleviate the health risks of climate change are disproportionately vulnerable to climate-related health risks. Without accounting for these differential impacts on different populations, climate adaptation planning may fail to adequately reduce the health risks of climate change for those that are most at risk. For instance, current urban cooling strategies have been found to result in differential effects in reducing mortality rates according to age, income, and race (Vargo et al., 2016). In other words, unless health-oriented climate initiatives and programs engage with their publics in collective learning and dialogue, with a focus on expanding beyond the typical environmental and land-use planning actors and directly involving the people most vulnerable to these impacts, status-quo efforts are unlikely to address the health inequities of climate change (Sailor et al., 2016).

In response to the outlined limitations of current efforts to integrate public health in climate adaptation planning, this dissertation project developed and tested methods to help cities prepare their publics to participate in collective decision-making processes to address the uneven distribution of health risks of climate change.

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Chapter 3

Climate Adaptation Planning and Public Engagement

Climate Adaptation Planning

Cities in the United States, and across the world, are beginning to take action to address climate change risks by creating adaptation plans. The Intergovernmental Panel on Climate Change (IPCC) defines climate adaptation as "the process of adjustment to actual or expected climate and its effects in order to either lessen or avoid harm or exploit beneficial opportunities," and climate adaptation planning as "the construction of actual strategies and plans in societies in response to climate change" (IPCC, 2014, AG5 WGII, p. 871).

Numerous checklists and frameworks laying out the steps of adaptation planning have been put forth. Operationally, the process of climate adaptation planning can be summarized as "translating scientific projections of future climate conditions into tangible impacts on local operations through risk and vulnerability assessments, and selecting from potentially costly and controversial adaptation options in the face of uncertain climate impacts over long planning horizons" (Shi, Chu, & Debats, 2015, p. 193). Susskind (2010) emphasizes the collaborative, iterative nature of determining when, whether, and how to respond to climate risks. After a municipality identifies problems likely to occur based on local climate forecasts and vulnerability assessments, key stakeholders in the city need to collectively decide what steps to take to reduce vulnerability and enhance resilience, and lastly, continuously monitor and revise adaptation plans in light of new information (Susskind, 2010). Similarly, the National Climate Assessment sets forth a collaborative, iterative approach to climate adaptation planning (shown in Figure 3.1 below), with a focus on stakeholder engagement throughout the entire process of 1) identifying risks and vulnerabilities, 2) planning, assessing, and selecting options, 3) implementation, 4) monitoring and evaluation, and 5) revision of strategies (Bierbaum et al., 2013, p. 681).

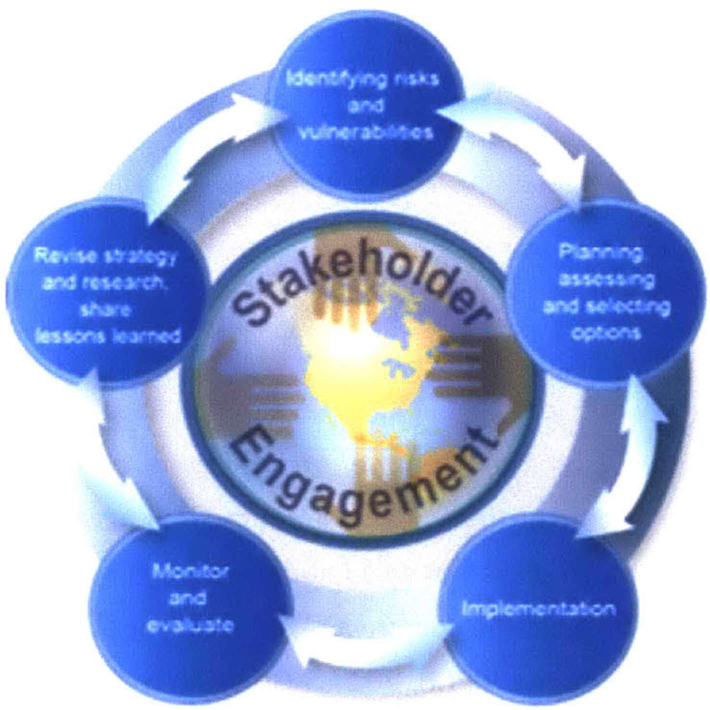

Figure 3.1. Generalized Adaptation Process (from National Climate Assessment 2014, p. 681)

Up to date, climate adaptation planning in the United States has primarily been a top-down effort, led by local governments in terms of creating strategies and plans. Local governments in 26 states have drafted local or regional climate adaptations plans, but have yet to start implementing what has been drafted ("State and Local Adaptation Plans" 2017). In a 2011 survey of 156 municipalities in the United States, 60% of the respondents had begun adaptation planning, with 24% in the initial scoping stage, 27% in the planning phase, and only 9% in the implementation stage (Shi et al., 2015, p. 192). In addition, while the early adapter cities' stories are encouraging, it is important to remember the larger picture, where less than 1% of municipalities in the U.S. overall are undertaking climate adaptation planning (Hansen et al., 2013). In short, while many cities have recognized the need for climate adaptation planning, a small number are actually planning to adjust to climate impacts, and among the cities that have started the process of identifying local risks and creating strategies to deal with climate change, few are actually implementing adaptation plans.

There is a wealth of literature on factors that enable and constrain local government climate adaptation activities. Previous climate-related disaster experiences, perceived climate change threats, and political leadership have been cited as drivers of local climate adaptation action (Anguelovski & Carmin, 2011; Betsill & Bulkeley, 2007; Bierbaum et al., 2013). In addition, larger population sizes, higher levels of commitment from elected officials, and higher municipal expenditures per capita have also been shown to be associated with U.S. cities pursuing adaptation planning (Shi et al., 2015). As Hughes (2015) notes, however, public support is rarely a driver for climate adaptation planning. Instead, public opinion is often considered an impediment by cities in planning to adapt to climate change (Hughes, 2015, p. 22).

The barriers to local governments pursuing climate adaptation action are multi-faceted and significant (Betsill & Bulkeley, 2007; Bierbaum et al., 2013; Moser & Ekstrom, 2010). Oft-cited barriers to climate adaptation action include 1) a lack of resources, such as financial resources or staffing capacity, 2) institutional barriers, including mismatched ecosystem and jurisdictional boundaries, a lack of legal mandates, political leadership, or operational control, 3) inherent difficulties in climate change decision-making, due to the complexity in and uncertainty about future climate impacts, the lack of accessibility or utility of existing climate information, and 4) cognitive barriers, including limited awareness or apathy of decision-makers and the public; divergent risk perceptions, cultures, values comprising various publics' views of climate change as a result of conflicting political beliefs and/or risk perceptions; and limited integration of local knowledge and needs with technical information (see Bierbaum et al. 2013, pp. 683-684 for a summary of adaptation barriers and references).

In particular, cities have found that most publics in the U.S. do not consider climate adaptation a political priority, even if they are aware of climate impacts and of its anthropogenic causes (Howe et al., 2015), highlighting the importance of conveying the necessity of climate adaptation to elected officials and other stakeholding publics (Carmin et al., 2012; Howe et al., 2015; Shi et al., 2015).

The framing of climate adaptation has been found to not only affect how adaptation planning is perceived relative to other municipal goals (Shaw, Burch, Kristensen, Robinson, & Dale, 2014), but also have implications for if and how adaptation plans are implemented (Dupuis & Knoepfel, 2013). While the steps of assessing climate risks and vulnerabilities and identifying adaptation options that will reduce vulnerability are presented separately in most climate adaptation planning frameworks, it goes without saying how a city defines the problem impacts the solution space (Rittel & Webber, 1973). Accordingly, problem identification impacts how the city will go about enhancing the awareness of individuals, organizations, and institutions about climate change as well (IPCC 2014, Chapter 16).

Urban climate change adaptation planning is most often framed as a necessary strategy for protecting a city's assets and reducing its vulnerability to hazards and disasters (Hughes, 2015). As a result, climate adaptation planning in coastal cities to date has focused on engineering protective structures to better withstand climate-related events (IPCC, 2014, Ch. 15). For instance, in New York City, adaptation strategies to climate change emphasize the installation of hard infrastructure measures, such as seawalls, groins, jetties, breakwaters, bulkheads, and piers (Gornitz, Couch, & Hartig, 2001). In London, storm-surge barriers have been put forth as a main adaptation strategy to protect against high water (UK Environment Agency, 2012). Softer infrastructure solutions include wetland and dune restoration, beach enhancement, and storm water management systems, as seen in the climate adaptation plan for New York City (DEP, 2008).

Consequently, with climate adaptation planning's current focus on protecting physical assets, critiques of climate adaptation planning have pointed out that adaptation plans rarely incorporate equity or social vulnerability (Hughes, 2015), and calls have emerged for climate adaptation planning to focus on *human vulnerabilities* instead (IPCC, 2014, Ch. 15; Rumbach & Kudva, 2011). IPCC (2012) notes that whether a climate vulnerability assessment starts from climate modeling outputs versus assessing existing risks and vulnerabilities of the community of interest results in fundamentally different problem orientations and solution spaces (IPCC, 2012). Therefore, it is not coincidental that currently, both the research and practice of climate adaptation planning tend to focus on climate impacts and the subsequent construction of defensive infrastructure responding to predicted climatic impacts, and is evident in a number of early adaptor cities' climate adaptation plans (Harries & Penning-Rowsell, 2011; Hofstede, 2008; IPCC, 2012; Rosenzweig et al., 2011).

Public Engagement in Climate Adaptation Planning

According to Tang et al. (2010), 85% of climate action plans in cities in the U.S. include policies for public engagement (Tang et al., 2010). Regardless of the high proportion of cities tangibly making public engagement a facet of their adaptation policies, there have been continuous calls to further enhance the participation of stakeholders, from assessing risks and vulnerabilities to designing and implementing operational approaches in adapting to climate change (Hughes, 2015; IPCC, 2014; Moser & Pike, 2015; Nordgren et al., 2016; Whitmarsh, O'Neill, & Lorenzoni, 2013), implying that there is room for more and better public engagement in climate adaptation planning. Indeed, a number of recent studies surveying local planners, managers, and officials involved with climate adaptation planning show that building capacity in community engagement around climate change is a pressing need for most municipalities in the United States (Moser & Pike, 2015; Nordgren et al., 2016).

For the purposes of this dissertation, I adopt Aslin and Brown (2004)'s definition of public engagement:

> "Engagement goes further than participation and involvement. It involves capturing people's attention and focusing their efforts on the matter at hand – *the subject means something personally to someone who is engaged and is sufficiently important to demand their attention*. Engagement implies commitment to a process that has decisions and resulting actions. So it is possible that people may be consulted, participate and even be involved, but not be engaged" (Aslin & Brown, 2004, p. 5, emphasis added).

In other words, public engagement in climate adaptation planning is the overarching process of involving the public in collective decision-making around adapting to climate change, and the acts of consultation, participation, communication, and involvement are but each one method or means to that process (Moser & Pike, 2015). In addition, an effective public engagement process would be one that results in a public that is "cognitively, emotionally, behaviorally, professionally, socially, spiritually, civically and/or politically involved and vested in the issues such that adaptation actions can advance" (Moser & Pike, 2015, p. 112).

Why engage the public in climate adaptation planning? A variety of rationales support the call for public engagement in climate adaptation planning. In addressing the numerous barriers to climate change discussed above, many have argued that cultivating public and political support for climate adaptation planning is vital. Hughes (2015) explains, "Public opinion is not typically a driver of adaptation planning; instead, city governments are often working to build public support for adaptation planning and projects" (Hughes, 2015, p. 24). According to the IPCC, deliberative public engagement processes help climate adaptation planning progress in cities (IPCC, 2014, Ch. 16). Enhancing public awareness of the impacts of climate change, engaging stakeholders in a city in identifying problems and solutions, and tailoring plans to fit the interests and needs of a community are critical in building public support for adaptation planning and implementation (Brunner & Nordgren, 2012; Ligeti, Wieditz, & Penney, 2007). While more effective public engagement alone is not enough to address all the barriers to cities face in local climate adaptation planning, better engagement is needed to overcome the numerous cognitive, cultural, political, and institutional barriers to climate adaptation planning outlined above.

In addition, as the IPCC's Special Report on Emissions Scenarios (2000) affirms, lifestyle and local development decisions will impact the climate more than any environmental policy, highlighting how the public conversation needs to go from a discussion of individual tweaking of behaviors or technical solutions, to a public conversation of alternative futures for the municipality, not withstanding potential discussions of relocation and retreat (IPCC, 2000; IPCC, 2001). Susskind (2010) also points out the need for a collective discussion within a city to tackle the difficult questions of weighing tradeoffs to manage collective risks (Susskind, 2010). The long-term planning horizons and the uncertainty around future impacts of climate change make any anticipatory response to climate change controversial (Dessai & Hulme, 2004; Tol, 2003), especially when appropriate responses are potentially expensive or require a radical shift in the status quo (Few, Brown, & Tompkins, 2007; Susskind et al., 2015).

Public engagement is also highlighted as facilitating community-based adaptation planning, and a more inclusive and deliberative approach to planning, by integrating local knowledge, opinions, and needs into an otherwise technical-rational planning process, where expertise and bureaucratic control wield policy and planning decisions (Few et al., 2007). Enhancing public engagement can be seen a way to focus on human vulnerabilities to climate change, as called for above, with a fuller consideration of equity and social vulnerability issues of the community of interest.

As can be seen, public engagement is promoted both principally as an end in itself, allowing communities to have more voice over decisions impacting their lives, and instrumentally as a means of collectively making better decisions (Few et al., 2007; Reed, 2008; Rowe & Frewer, 2000).

The proposed normative benefits of public engagement revolve around alleviating the marginalization of stakeholders on the periphery of a decision-making context, by having more relevant stakeholders be included in a decision-making process impacting them (Martin & Sherington, 1997). Participation can enhance trust in public sector decision-making processes (Rowe & Frewer, 2000). Consultation and collaboration can empower stakeholders by co-generating knowledge and enhancing their capacity to utilize knowledge

(Macnaghten & Jacobs, 1997; Reed, 2008). Local knowledge and varied perspectives enhance problem-solving capacities (de Souza Briggs, 2008). Public engagement also promotes social learning, where people learn from each other, resulting in increased trust and mutual understanding (Fung & Wright, 2003; Innes & Booher, 2004).

There are significant potential pragmatic benefits as well. Public engagement allows local governments and officials to identify the public's preferences to incorporate in decision-making processes (Benhabib, 1996; Fearon, 1998), which can subsequently increase adoption and diffusion among target groups (Martin & Sherington, 1997). Public engagement in environmental decision-making can also lead to an increased sense of ownership among participants, and also may enhance the perceived equity and fairness of decisions, by accounting for diverse values and needs in human-environmental interactions (Reed, 2008).

However, public engagement is not a solution to all planning and policy-making shortcomings, and has its limitations and drawbacks. Participation demands time and energy, and indeed, according to Bloomfield et al. (2001), the time and effort required to participate are the primary deterrents (Bloomfield, Collins, Fry, & Munton, 2001). Consequently, the people willing and able to participate, and effectively bear the costs, tend to be disproportionately extreme view-holders (Fiorina, 1999). Public engagement is constrained in addressing a fundamental lack of resources. For instance, in many science-intensive planning processes, community stakeholders have insufficient expertise to engage in technical debates (Fischer & Young, 2007). Solutions derived from a public engagement process may not be feasible (Day, 1997; Fiorina, 1999; Thompson III, 2005). Participation can reinforce existing inequalities (Kothari et al., 2001), and groupthink may prevent less popular perspectives from being considered (Nelson & Wright, 1995).

More importantly, people may not want to participate because of past relationships and previous negative experiences (Potter, 1985). Consultation fatigue is another common phenomenon (Duane, 1999; Wondolleck & Yaffee, 2000). In addition, self-confidence and respect for authority are known to influence people's decisions on whether to participate (Sanchez, Cronick, & Wiesenfeld, 1988).

Many typologies of public engagement have emerged, starting from Arnstein (1969)'s seminal "ladder of citizen participation," with rungs ranging from manipulation to informing to consultation to partnership to citizen control, based on the degree to which stakeholders are engaged and the role of the public in decision-making processes (Arnstein, 1969). White (1996) presents four types of participation based on the extent of participation among stakeholders at the top and grassroots movements at the bottom: nominal, instrumental, representative, and transformative, also based on the normative assumption that empowering individuals and organizations at the bottom results in more genuine forms of public engagement (White, 1996). Susskind (1987, 1996) presents a participatory and collaborative approach to public policy-making built around the mutual gains approach to negotiation, consisting of the four steps of preparation, value creation, value distribution, and follow-through (Carson, 2008; Susskind, 1987; Susskind & Field, 1996).

However, Few et al. (2007) probes how public engagement in climate policy is particularly difficult, with a fundamental tension between strategic, long-term planning and meaningful inclusion. They assert that climate planning cannot be a 'bottom-up' process of decision-making, as the most fundamental decision to respond to climate change has already been made. Few et al. (2007) caution that instead, narrower approaches to participation that solidify stakeholders' commitment to implementing climate adaptation plans are more likely to succeed, as long as the scope and limitations of public engagement in this context explicitly communicated from the beginning of the process (Few et al., 2007). On the more extreme end, Renn (2006) argues for an even narrower conception of public engagement in climate planning, with expert-led discussions and the public checking the value judgments of experts (Renn, 2006).

Rowe and Frewer (2000) focus on the direction of information flows in interactions among stakeholders in their typology of public engagement: communication (top to bottom, one-sided), consultation (bottom to top, one-sided), and participation (two-sided) (Rowe & Frewer, 2000). Farrington and Bebbington (1993) use an axis to locate forms of participation with depth as one axis indicating degrees of involvement, and breadth representing inclusion and exclusion as the other, indicating the tradeoff that many public engagement efforts face in involving the public in different planning processes (Cornwall, 2008; Farrington & Bebbington, 1993). For example, face-to-face public engagement efforts are high on the depth axis and may have more potential for transformative learning (Rumore et al., 2016; Susskind et al., 2015), but may find it difficult to secure broad-based participation beyond the "usual suspects" and score equally high on the inclusion axis (Beierle, 1999; Konisky, 2001). In contrast, public engagement using digital technologies pose lower costs and barriers to entry to participants, indicating more breadth, but questions remain on the level of depth possible with online forms of public engagement (Best & Krueger, 2005; Evans-Cowley & Hollander, 2010; Gordon & Baldwin-Philippi, 2014).

There has also been an extensive discussion of choosing the appropriate method of engagement. Arnstein (1969), Biggs (1989), and Pretty (1995) argue for using different methods for the different rungs of their ladder of participation (Arnstein, 1969; Biggs, 1989; Pretty, 1995). Similarly, Rowe and Frewer (2000) present a range of public engagement methods based on the direction information flows. When communicating with the public, information can be disseminated through mass media, pamphlets, hotlines, and public meetings. For consulting the public, consultation documents, opinion polls and referendums, focus groups, and surveys can be utilized. For participation, they discuss using citizen's juries, consensus conferences, task forces, and public meetings with voting (Rowe & Frewer, 2000). Susskind (2010) presents various tools for creatively engaging stakeholders in climate adaptation planning: conflict assessment with an emphasis on fostering readiness to participate in collaborative efforts and not just understanding technical issues, joint fact-finding, scenario planning, and role-play simulations (Rumore et al., 2016; Susskind, 2010). Along with findings indicating that different tools are appropriate for different contexts, research also indicates that there is no one preferred tool for public engagement, and that public engagement is best supported through the use of a range of participative tools (Carson, 2008; Few et al., 2007).

Payne (2016) identifies three primary ways cities in the U.S. currently engage with their publics in climate adaptation planning: 1) educating the public on climate risks, 2) including the public in the design of adaptation strategies, and 3) collaboratively problem-solving by tackling the long-term risks and tradeoffs of climate adaptation policies. She found that cities are actively incorporating either or both of the first two types of engagement. In addition, cities' education efforts tend to focus on conveying technical issues. Also, cities are not making significant progress on the third type, in having the difficult conversations needed for anticipatory climate adaptation (Payne, 2016).

How would we evaluate the outcomes of public engagement in climate adaptation planning? Beierle (1999) argues for using a set of social goals to evaluate the outcomes of public participation in environmental decisions: 1) educating the public; 2) incorporating public values, assumptions, and preferences into decision making; 3) increasing the substantive quality of decisions; 4) fostering trust in institutions; 5) reducing conflict; and 6) making decisions cost-effectively (Beierle, 1999, p. 81). In contrast, Mandanaro (2008) argues for a consideration of both social and environmental outcomes in evaluating engagement in collaborative environmental planning efforts. She presents a framework weighing 1) outputs (high-quality documents, such as plans, and collaborative science), 2) social outcomes (increases in social, intellectual, and/or political capital, innovation, institutional change), and 3) environmental outcomes (changes in environmental parameters, such as land cover or water quality, and perceptions of environmental quality) (Mandarano, 2008, p. 459).

Taken together, the wealth of literature on public engagement broadly, and on environmental planning and climate planning more narrowly, stresses the importance of public engagement as a key feature of climate adaptation planning, but research on how to go about engaging the public in the climate adaptation planning is relatively limited. Moser and Pike (2015) summarize the status quo succinctly: "Current local adaptation efforts are thus faced with (1) a growing and persistent need for effective communication and public engagement, (2) a pervasive lack of capacity to do so, and (3) limited opportunities to date for building that capacity" (Moser & Pike, 2015, p. 112). Hughes (2015) also highlights this gap both in practice and research: "We require a better understanding of the role that the public is and should be playing in urban climate change adaptation planning and how this role affects capacity for action" (Hughes, 2015, p. 24).

This dissertation project responds to Hughes' (2015) and Moser and Pike (2015)'s call for evidence-based research in exploring how city governments can best engage the public in adaptation planning (Hughes, 2015, p. 24; Moser & Pike, 2015, p. 112), by developing, implementing, and evaluating three methods of better engaging citizens to build public support for climate adaptation planning in Cambridge, Massachusetts.

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Chapter 4

Improving Public Engagement with Climate Change

Almost every local government in the U.S. with a climate adaptation plan has also committed to educating the public on the likely impacts of climate change and finding more productive ways to engage stakeholders in climate planning processes (Payne 2016; Hughes, 2015; Tang, Brody, Quinn, Chang, & Wei, 2010). Despite this commitment of financial and technical resources, a Pew Research Center (2015) poll found that while 87% of experts said the earth was getting warmer because of human activity, only 50% of the public in the U.S. agreed (Stokes, Wike, & Carle, 2015). In addition, even if people perceive climate change as a sizable risk, they tend to think climate change will impact people and places that are geographically and temporally distant (Leiserowitz & Smith, 2017). While public engagement has always been a challenge for local governments in diverse policy domains, there are unique challenges to cities engaging with their publics and motivating action on climate adaptation, due to the magnitude, complexity, and uncertainties of climate change (Moser & Pike, 2015; Susskind, 2010). These inherent difficulties are only intensified by low levels of scientific literacy and education (Sterman, 2011; Sterman & Sweeney, 2007), concerted efforts at misinforming the public (Oreskes & Conway, 2010), political polarization around the issue (Kahan et al., 2012; Kahan, Peters, Dawson, & Slovic, 2013; Leiserowitz, 2006), and lack of political leadership (Anguelovski & Carmin, 2011; Bulkeley & Betsill, 2005; Williams, Green, & Kim, 2017).

This chapter will first review research to date on the issue-specific challenges to public understanding of climate change that any city trying to move forward on climate adaptation planning will need to confront. Then the rest of this chapter will examine the prescriptive research on ways to enhance the public understanding of the likely impacts of climate change. The public engagement methods in this dissertation project were designed to address the specific barriers to understanding climate change discussed in this chapter, and furthermore, were informed by the reviewed best practices on overcoming the challenges to improving public awareness of and engagement with climate change.

Thinking, feeling, and acting around climate change

Climate change is hard for anyone to understand and engage with (Weber & Stern, 2011). Its causes are invisible and its impacts are geographically and temporally distant (National Research Council 2009; Moser, 2010). The key cognitive obstacle to processing climate change information has been conceptualized as a psychological distance consisting of four dimensions: temporal distance, geographical distance, social distance, and uncertainty (Spence, Poortinga, & Pidgeon, 2012). As the climate is a complex dynamic system, with multiple feedbacks, time delays, accumulations and nonlinearities, Sterman has found that people have difficulty grasping even the basics of how the climate operates, and systematically underestimate the extent to which greenhouse gas emissions will need to be reduced to stabilize the climate. Most people believe that steadying emissions near current rates will be sufficient, when in fact it would lead to continued overall increases in greenhouse gas concentrations, leading to even more climate change (Sterman, 2011; Sterman & Sweeney, 2007; Weber & Stern, 2011).

Kahneman presents two parallel ways of thinking that can be used to understand public perceptions of climate change risks: System 1 thinking is fast, automatic, and unconscious, while System 2 thinking is slow, deliberative, and conscious. He states that, as cognitive misers, we primarily rely on System 1 thinking in daily life: "Most people do not take the trouble to think through a problem" (Kahneman, 2011, p. 45). While System 1 thinking enables cognitive efficiency, its use of simplifying strategies, or heuristics, leads to systematic biases and errors in judgment and decision-making. The substitution principle, as Kahneman defines it, guides the way we use heuristics to make sense of what is happening around us: "If a satisfactory answer to a hard question is not found quickly, System 1 will find a related question that is easier and will answer it" (Kahneman, 2011, p. 97). Therefore, relying on System 1 thinking makes one even more vulnerable to systematic errors in understanding climate change.

When facing climate change-related risks, particularly those posed by natural hazards or extreme weather events, many people rely on what is called the availability heuristic. We estimate the likelihood of an event occurring by thinking in terms of what we can readily imagine or recall (see Kahneman, 2011, Chapter 12 for availability bias). However, climate change is not a phenomenon that most laypeople can detect. If we depend on observation and inference, we are likely to miss very gradual changes in the climate. Extreme weather events are inherently infrequent and require a long time to detect a change in the probability of an event that occurs about once in 100 years (Weber & Stern, 2011).

Even if we were to observe increased climate change and variability, we are bad at computing basic probabilities, especially with low probabilities, and are not likely to revise our beliefs based on Bayesian statistics (Camerer & Kunreuther, 1989; Huber, Wider, & Huber, 1997; Kahneman, 2011; Kunreuther, Novemsky, & Kahneman, 2001). Rather than using Bayesian statistics to gauge the potential of future events and update our forecasts with new information, we respond to uncertainty with System 1, rather than System 2 thinking (Loewenstein, Weber, Hsee, & Welch, 2001), and also respond differently depending on whether we perceive the uncertain events to be good or bad (Smithson, 2008). In short, we tend to underestimate uncertainty (see Kahneman, 2011, Chapter 24 for overconfidence bias), consider desirable outcomes more likely to occur than undesirable outcomes (see Kahneman, 2011, Chapters 9, 10 for wishful thinking), and tend to believe we can influence the outcome of random events (see Kahneman, 2011, Chapter 24 for the illusion of control).

We also place too much weight on more salient information, especially information from our personal experiences (Kahneman, 2011, see Chapters 9, 12, 13 for availability bias and base rate fallacy). When extreme weather events do occur, this overweighting of recent, more salient events leads to what Weber describes as "general under-concern and greater volatility" of climate change risk perceptions (Weber, 2010, p. 334). As a result, our perception of climate change risks might temporarily increase drastically after extreme events, but we will generally come back to underestimating the future adverse consequences of climate change (Li, Johnson, & Zaval, 2011).

System 1 thinking translates uncertainty into affective responses, such as worry, dread, or anxiety, representing risk as a feeling (Loewenstein et al., 2001). This is in stark contrast with System 2 thinking about risk, which uses probabilities, Bayesian updating, and formal logic. For example, "mad cow disease" leads to more public fear than "bovine spongiform encephalitis (BSE)" or "Creutzfeld-Jacob disease," the more abstract and technical name for the same condition (Sinaceur, Heath, & Cole, 2005). In other words, we estimate the magnitude of risk differently based on the way information is presented (see Kahneman, 2011, Chapter 34 for framing effects).

When outputs from the two systems clash, System 1 thinking tends to dominate, as System 2 thinking requires concerted effort and time. Lowenstein writes about System 1 thinking prevailing in phobic reactions, where people continue avoidance behavior they know to be ineffective and possibly harmful (Loewenstein et al., 2001). Similarly, Weber views climate change as an example where the dissonance between System 1 and 2 thinking results in less concern than warranted; she argues that System 2 thinking suggests to most people that climate change might be a serious risk, but System 1 thinking overrides, ultimately leading us to avoid early warning signals (Weber, 2006).

Climate risks and benefits of mitigation tend to lie in the long-term future. Trope and Liberman (2003) argue that we interpret future events fundamentally differently from events taking place now. In particular, whereas events in the distant future are thought of in abstract ways, we express events closer in time in more concrete terms. Importantly, the difference in the abstract versus concrete representation of the consequences of possible actions is related to the affective impacts on thinking. Abstract representations of consequences in the distant future fail to evoke the same levels of fear, dread, or anxiety as present or near-present events (Trope & Liberman, 2003). This can also be seen as another ramification of Kahneman's availability bias: tangible, concrete consequences matter more than abstract outcomes (see Kahneman, 2011, Chapter 12 for availability bias).

Weber and Stern (2010) argue that climate denialist narratives effectively leverage psychological theories of risk perception, by questioning the accuracy of isolated pieces of evidence and effectively destroying the overall perceived legitimacy of climate change (Pollack, 2007; Weber & Stern, 2011). They note that denialists also successfully depict climate risks as familiar phenomena, inducing low risk perceptions and levels of concern (Slovic, 2000; Weber & Stern, 2011).

Improving Public Engagement with Climate Change

The judgment and decision-making literature is divided into two camps in terms of prescriptions to address cognitive biases (see Shafir et al. (2013) for a comprehensive collection of essays from both camps). One camp argues for correction of System 1 intuition with System 2 analysis to "debias" judgment and decision-making, while the other camp argues that reliance on System 1 thinking cannot be overcome; instead they say that decision-making environments should be structured so our System 1 thinking tendencies can be harnessed to facilitate better decisions (Brest, 2013).

Debiasing System 1 with System 2 Thinking

With the debiasing System 1 with System 2 approach, one of the more commonly discussed debiasing strategies involves increasing knowledge of probability, statistics, and scientific principles. Another debiasing strategy involves increased awareness of one's own cognitive biases or reliance on System 1 thinking.

As an example, Sterman argues for the necessity of experiential learning environments that allow people to probe the inner workings of complex systems like the climate or the economy. Sterman and his team developed the C-ROADS model at MIT, an online learning tool people can use to enhance their understanding of the scientific principles behind climate change, by seeing how changing assumptions embedded in a simplified climate model results in different climate outcomes (Sterman, 2011).

This approach has many parallels with the knowledge deficit model in science communication, where ignorance is seen to be at the root of social disagreements on science (Nisbet & Scheufele, 2009, p. 1767). Accordingly, science communication within the conceptual confines of this model is defined as a one-way process of transmitting expert knowledge to the lay public, with the underlying premise that once citizens possess a more sophisticated understanding of the science, the gap between expert and public views will naturally dissipate. It is also important to note that in this model, science literacy is viewed as the central force shaping public perceptions, and subsequently, decisions regarding science-intensive planning and policymaking (Nisbet & Scheufele, 2009).

However, it is important to note that attempts to correct mischaracterizations of the science of climate change, are necessary, but not sufficient, to shift public perceptions and policy support for action. Research shows the limitations of enhancing science literacy, or improving public understanding with the aim of aligning expert and public views regarding scientific or technical matters, as knowledge tends to account for a smaller proportion of the variation in how different publics view controversial scientific issues, such as nuclear energy, genetically modified foods, and nanotechnology (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008), than value dispositions, such as political ideology and religion (Gaskell, Ten Eyck, Jackson, & Veltri, 2004; Hornsey, Harris, Bain, & Fielding, 2016; Nisbet & Goidel, 2007). Therefore, Nisbet and Scheufele (2009) argue that public engagement around science-intensive topics must structure and promote conversations with the public that "recognize, respect, and incorporate differences in knowledge, values, perspectives, and goals" (Nisbet & Scheufele, 2009, p. 1777).

More strikingly, Kahan et al. (2012) shows the shortcomings of the debiasing of System 1 or knowledge deficit model in public engagement with climate change with his concept of "motivated numeracy," where we see that people with high numeracy, or quantitative capacities, tend to use their higher-than-average capabilities to interpret data in ways that are most consistent with their political outlooks. Their experiments found that among people with similar quantitative reasoning skills are given the same data on gun fatalities, participants reached vastly different interpretations and conclusions with the data, depending on their pre-existing stances on gun control (Kahan et al., 2012). Therefore, while improving self-awareness of cognitive shortcuts and enhancing public understanding of climate change is important, as Kahan et al. (2017) say, "both intrinsically and practically for empirically informed collective action," cities cannot expect the mere provision of information about common heuristic shortcuts behind misunderstandings of climate change, or transmission of more knowledge about climate change as a scientific phenomenon, to be effective in generating support for meaningful policy action (Kahan, Peters, Dawson, & Slovic, 2017, p. 17).

Harness System 1 Thinking

Instead, we can structure public engagement processes with the knowledge we have of System 1 thinking (inherent cognitive biases towards climate change) tendencies outlined above, to increase public understanding of and concern for climate change. In other words, cities should design their climate change public engagement and education efforts to incorporate pre-existing knowledge, value dispositions, and policy priorities of different publics, with the aim of transcending conflicting views of climate change. This will catalyze greater interest in and concern for climate change, and ultimately, lead to more empirically informed collective action (Kahan et al., 2017; Nisbet & Scheufele, 2009).

The climate science communication literature is based on premises of structuring communication to best work with our System 1 thinking processes. Research in this arena has also been shifting from a focus on information transmission to two-way communication. For instance, research shows that public engagement and education needs to address pre-existing conceptions that conflict with scientific understanding to help people adopt mental models that are more aligned with expert understanding (National Research Council, 2000).

According to Kahneman (2011), we favor narratives, or stories with explanatory power, over numbers (see Kahneman, 2011, Chapter 11). Science communication research has also found that using narratives, or accounts of events with temporal or causal coherence, enhances communication, learning, and understanding (László & Ehmann, 2012). These narratives can be presented in a non-verbal format as well. In particular, for climate change education and engagement, visualization of potential climate impacts has been found to be particularly effective (Burch, Sheppard, Shaw, & Flanders, 2010; Majeed, 2015; Shaw et al., 2009; Sheppard et al., 2011).

Narratives can also bridge scientific knowledge and local understandings of climate change, often by working with multiple stakeholders to explore potential solutions (Paton & Fairbairn-Dunlop, 2010; Susskind, 1987, 2006; Tschakert, Dietrich, & others, 2010; Turner & Clifton, 2009). In particular, narratives should actively incorporate local knowledge. Traditional ecological knowledge (TEK) is indigenous, historical knowledge that has been accumulated locally, and is considered more salient and relevant for decision-making in environmental realms (Berkes, Colding, & Folke, 2008; Usher, 2000). A further emphasis on leveraging local conceptions of climate change should be used to enhance public understanding.

Based on previous findings in risk communication, climate communication guidelines from Moser and Dilling (2004), Fischhoff (2007), and Weber and Stern (2011) recommend harnessing the impact of information framing, anchors, and heightening the availability and salience of examples by focusing on people's deepest concerns (Fischhoff, 2007; Moser & Dilling, 2004; Weber & Stern, 2011). Nisbet and Scheufele (2009) agree: "Effective communication will necessitate connecting a scientific topic to something the public already values or prioritizes, conveying personal relevance. And in people's minds, these links are critical for making sense of scientific information" (Nisbet & Scheufele, 2009, p. 1774).

As an example, Robert Watson (2005) draws on his experience as an IPCC scientist working with policymakers to emphasize the importance of connecting environmental issues with issues of more immediate concern to people, such as the economy, security and human health. Highlighting climate damages to the economy and health, or focusing on the tangible and concrete co-benefits of climate mitigation and adaptation, such as increased employment or improved air quality, are effective strategies in reframing how climate change is viewed and understood (Watson, 2005). For instance, some economists, including William Nordhaus, argue that climate mitigation initiatives should not viewed as an economic burden, but rather as an economic opportunity, utilizing an economic development frame to appeal to people otherwise disinterested in climate change matters. Furthermore, scientists such as E. O. Wilson, advocate for climate change action as a matter of environmental stewardship, utilizing religious morality and ethics arguments (Nisbet & Scheufele, 2009).

Conclusion

As can be seen, the challenges to cities better communicating and engaging with their publics around climate change are substantial. Relying on inherent System 1 tendencies runs counter to proactively planning for climate change and implementing adaptation strategies in our communities. However, mere provision of information about common heuristic shortcuts that lead to misunderstandings of climate change, or transmission of more knowledge about climate change as a scientific phenomenon, are also unlikely to be effective in generating support for meaningful climate policy action. Therefore, cities should harness the knowledge we have of System 1 thinking outlined above to structure public engagement and education efforts with, increasing public understanding of and concern for climate change. Cities should also design their public engagement processes based on empirical research delineating more effective ways to further understanding of and engagement with climate change. These two points underscored the design of the three engagement methods used in this dissertation project. The following chapters will delve into each of the methods developed and tested.

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Chapter 4.5

Climate Change, Public Health, and Public Engagement in Cambridge, MA

The city of Cambridge, Massachusetts is located in the greater Boston metropolitan area. With about 110,000 residents, Cambridge is the tenth densest incorporated city in the United States. Cambridge is known for its relatively high levels of education among its residents, with 75% of the population over 25 having either a four-year bachelor degree or a graduate degree. In addition, Cambridge is home to many institutions of higher education, including Harvard University and Massachusetts Institute of Technology (MIT). A significant portion (31%) of the city's population 18 and above is enrolled in college or a graduate program (U.S. Census Bureau, 2015).

With a median household income of $79,416 in inflation-adjusted dollars, Cambridge is a relatively affluent city, against the national median income of $53,889 and Massachusetts state median income of $68,563. The largest industries in the city of Cambridge are Computer, Engineering, and Science (20.5%), Higher Education (15.5%), and Management (12.8%) (U.S. Census Bureau, 2015).

Climate Change Planning in Cambridge, MA

Cambridge is connected to the Atlantic Ocean through the Charles River and Alewife Brook (City of Cambridge, 2017). The figure below (Figure 4.5.1) depicts Cambridge's proximity to its surrounding rivers and the ocean.

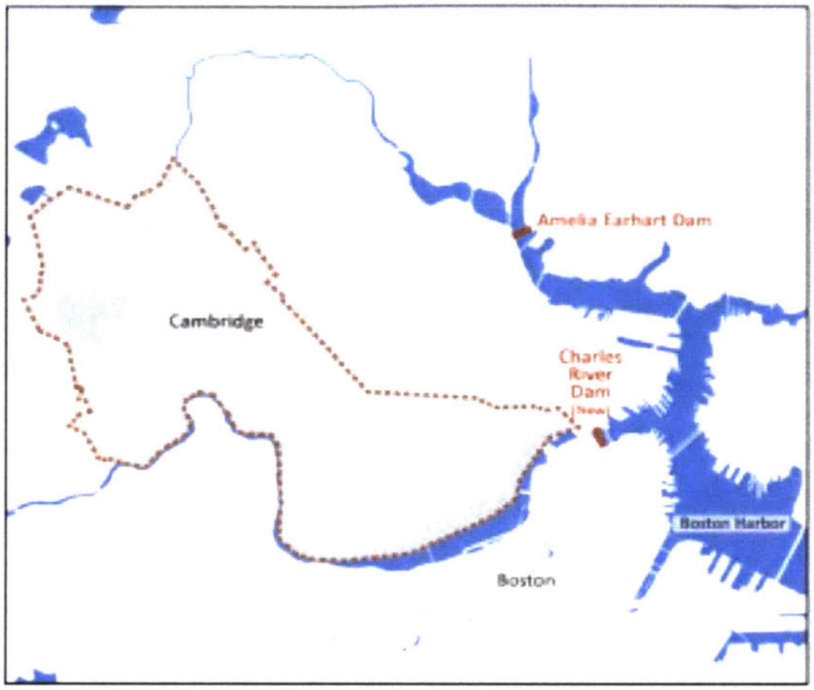

Figure 4.5.1. Cambridge's proximity to rivers and the Atlantic Ocean via Boston Harbor (Source: CCVA 2017, City of Cambridge, p. 4)

Cambridge's primary focus has been on climate change mitigation, or reducing greenhouse gas emissions. In 1999, Cambridge joined ICLEI - Local Governments for Sustainability, the network of over 1,200 communities around the world that are tackling climate change (CCVA 2015, City of Cambridge, p. 4). In 2002, the Cambridge City Council adopted the Cambridge Climate Protection Plan, which aims to achieve an 80% reduction in greenhouse gas emissions by 2050. As 80% of Cambridge's emissions comes from buildings, the Climate Protection Plan was intended mostly at reducing building-related energy use, while enhancing energy efficiency in buildings and increasing on-site solar energy generation (Climate Protection Plan, City of Cambridge, 2002). In 2015, the City Council of Cambridge adopted the Net Zero Action Plan, setting a target of net zero annual emissions from Cambridge buildings by 2040. The Net Zero Action Plan called for five actions: 1) enhancing energy efficiency in existing buildings, 2) construction of net zero new buildings, 3) creation of a local carbon fund investing in other net zero activities, 4) renewable energy production capacity generation, and 5) capacity building through industry training (Net Zero Action Plan, City of Cambridge, 2015). The aforementioned climate mitigation activities in Cambridge have been or are currently organized by the Climate Protection Action Committee, which consists of about 20 community members appointed by the City Manager to implement the Climate Protection Plan. The Committee meets once a month, and its meetings are open to the public (Climate Protection Action Committee, CDD, City of Cambridge, accessed March 10, 2017). The City of Cambridge has committed $22,000 of its reserve funds to the Net Zero Task Force contract as of date (City of Cambridge, 2017b, V-38).

While climate planning in Cambridge has revolved around mitigation, adaptation is slowly gaining traction as an important planning concern. In 2010, the City Manager of Cambridge initiated the climate planning process for the municipality, by having city departments produce a climate change vulnerability assessment and preparedness plan. The goal was to prepare the city for inevitable climate risks. In a three-stage plan, Cambridge produced locally downscaled climate scenarios, completed the first part of its vulnerability assessment in 2015, the second part of the vulnerability assessment in early 2017, and has started to formulate a climate preparedness plan, drawing on the climate scenarios and the vulnerability assessments. The vulnerability assessment and preparedness planning process is currently being coordinated with a master plan update called Envision Cambridge, also being implemented at the same time (CCVA 2015, City of Cambridge, pp. 4-5). In the annual budget submitted for 2017-2018, the City allocated $500,000 annually (for the next five fiscal years, total of $2.5 million) of sewer bond proceeds for stakeholder outreach and additional modeling projects for Cambridge's planning process (City of Cambridge, 2017b, VI-63).

As the technical foundation of the forthcoming preparedness and resilience plan, the vulnerability assessment gauges risks and vulnerabilities caused by increasing temperatures, coastal storms and flooding, and sea level rise. These risks and vulnerabilities are being used to identify planning priorities. Uncertainty is factored into the assessment by using thirty-year averages for temperature and precipitation for each of the three planning horizons for measuring vulnerabilities: present day, 2030, and 2070. The vulnerability assessment explicitly states that uncertainty and complexity surrounding future climate impacts forecasts will prevent the city from being able to provide precise estimates, and urges readers to view the assessment as a "climate stress test." Or as they explain: " In other words, what would happen to the City's built environment and its people if we see higher temperatures and more flooding, and what would that mean to our economy[2], public health, and wellbeing?" (CCVA 2015, City of Cambridge, p. 4).

In the near future, or until 2030, according to the Vulnerability Assessment, Cambridge is more vulnerable to increasing heat and precipitation-driven flooding than sea level rise and coastal storm surges and flooding (CCVA 2015, City of Cambridge, p. 4). The risks of coastal storm surges reaching Cambridge remain low until 2030, due to existing coastal defenses, namely the Charles River and Amelia Earhart Dams and the specific topography between Cambridge and Boston Harbor. However, in the medium to long term, Amelia Earhart Dam is projected to be bypassed around 2045, and the Charles River Dam by 2055 (City of Cambridge, 2017).

In contrast to its surprisingly low risk of coastal storm surges in the short term, Cambridge is much more exposed to precipitation-driven flooding in the near future, as such flooding is likely to become more frequent and extreme. Modeling results from Part I of the Vulnerability Assessment indicate that the surface area of Cambridge exposed to the risks of precipitation-driven flooding will double between now and 2070 for a 100-year rainstorm (or a one percent probability rainstorm) (City of Cambridge, 2015).

In addition, with climate change, Cambridge is extremely vulnerable to more frequent and longer-lasting episodes of extreme heat. The city currently experiences about 15 days recording over 90 degrees Fahrenheit (90 °F). By 2030, the number of days going over 90 °F is expected to triple, to about 45 days per year. By 2070, Cambridge is projected to have about three entire months (about 90 days) each year go over 90 °F (City of Cambridge, 2015).

We see geographical and social differentiation in vulnerability to these climate impacts in Cambridge. With flooding, low-lying neighborhoods, such as the Alewife-Fresh Pond area,

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[2] The Vulnerability Assessment presents an estimate of economic losses from a flood event or a citywide power loss event of about $43 million in daily economic losses, resulting more from disruption of economic activities than property damage.

along with East Cambridge and Kendall Square, are exposed to higher risks of flooding from sea level rise and storm surges, relative to other neighborhoods in Cambridge (City of Cambridge, 2015, pp. 30-31). The city of Cambridge also assessed social vulnerability to climate impacts by ranking census tracts on income, age, education levels, isolation, and English proficiency. According to Kleinfelder, the consulting firm that undertook the exercise, these five proxy indicators were picked as they are correlated with sensitivity and adaptive capacity in the vulnerability literature (Vulnerable Population Scoring Memorandum 2015, City of Cambridge). The assessment identified parts of the Alewife-Fresh Pond area, parts of East Cambridge, and the Central Square area to have higher proportions of residents considered more vulnerable to climate impacts, relative to other neighborhoods in Cambridge. It is notable that some of the socially vulnerable neighborhoods are also located in the areas predicted to have the highest rates of exposure to flooding from sea level rise and storm surges (City of Cambridge, 2015, pp. 30-31).

As mentioned, the social vulnerability assessment was conducted by using proxy indicators of social vulnerability on the census tract level (Vulnerable Population Scoring Memorandum 2015, City of Cambridge). Figure 4.5.2 below depicts the geospatial distribution of the calculated social vulnerability to climate risks; the census tracts are depicted in varying shades of orange and red. While this vulnerability ranking exercise is a valuable starting point, with this level of data granularity, it is difficult to ascertain the specific neighborhoods or sub-populations within each census tract that are more vulnerable to different health risks of climate change in the city of Cambridge. Subsequently, while this data can be used to prioritize certain areas in climate adaptation planning and policymaking processes, their utility in crafting policies to reduce excess mortality or morbidity from climate change are limited. To facilitate effective health-oriented climate adaptation planning processes, (social) vulnerability assessment processes need to be informed by the goal of reducing excess mortality and morbidity from climate change to collect and analyze data that is relevant to the aforementioned overarching goal (Patz et al., 2008; Turner et al., 2013).

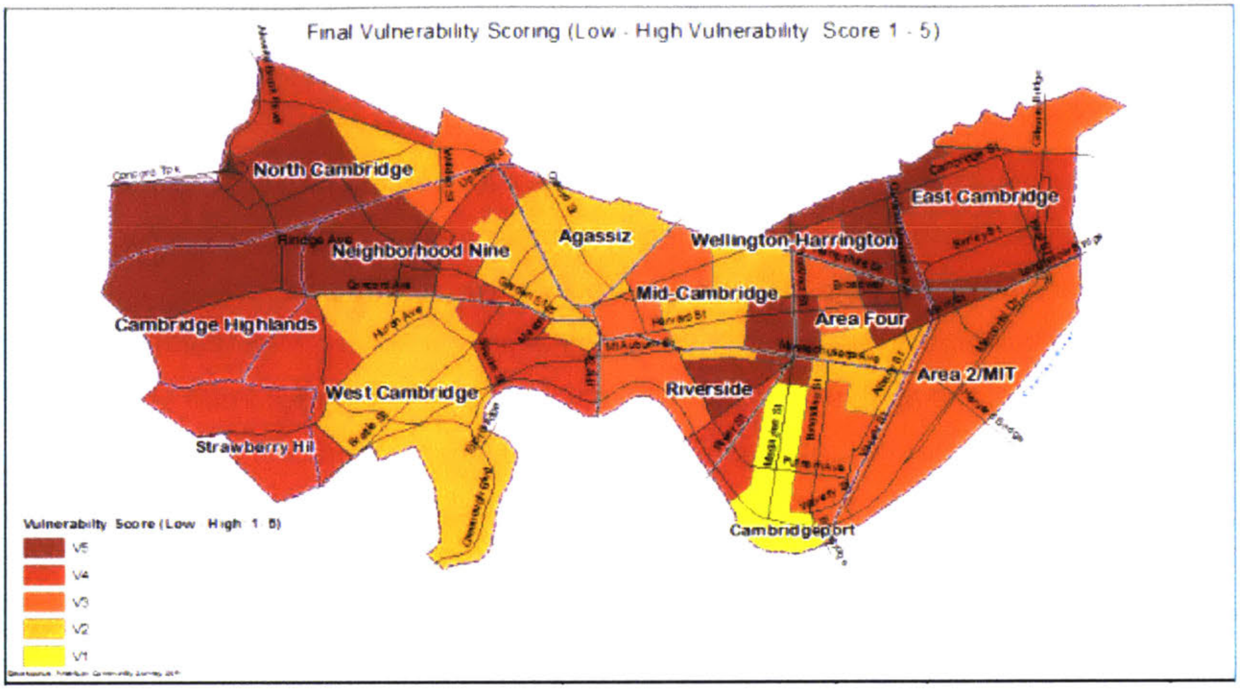

Figure 4.5.2. Vulnerability Scoring Map (from Vulnerable Population Scoring Memorandum 2015, City of Cambridge, p. 6)

As part of the climate planning process, the city of Cambridge ran a stakeholder engagement effort, including 40 public workshops. The workshops focused on direct outreach to community organizations, including neighborhood associations, business organizations, and other groups. City officials and consultants from Kleinfelder, the firm tasked with conducting the vulnerability assessment, explained the vulnerability assessment results at the public engagement workshops. Their presentations focused on highlighting that extreme heat and precipitation-driven flooding are bigger threats to the city than sea level rise and storm surges (CCVA 2015, City of Cambridge, p. 4).

This dissertation project complemented these public engagement efforts by developing new tools that cities can use, based on what makes individual and public learning about climate risks most effective. The engagement tools were also designed to foster active, experiential, and problem-based learning, going beyond what typical learning venues in public engagement in planning processes tend to offer.

Community Health in Cambridge, MA

In 2013, the Cambridge Public Health Department launched a Community Health Assessment to better understand the health needs of the community, and subsequently, use the information to develop a community health improvement plan for Cambridge residents. The assessment consisted of secondary data analysis, administration of a community health assessment survey (n = 1,627), and focus groups and interviews involving a range of stakeholder groups, including especially vulnerable populations, such as low-income residents, youth, senior citizens, and immigrants (Community Health Assessment, City of Cambridge, May 2013, pp. i-ii).

The assessment applied the social determinants of health framework, with the aim of informing future efforts to advance health equity in the city of Cambridge (Community Health Assessment, City of Cambridge, May 2013, pp. 3-4). In other words, the assessment sought to probe the socio-economic, cultural, and environmental conditions that impact individual and community health in Cambridge, with a focus on the disproportionate impacts of these factors on vulnerable sub-populations within the city. The results of this assessment provide further insight into groups of residents within the city that may be more at risk to the health impacts of climate change. As the assessment delineates existing health inequities within Cambridge, it does not capture current disease burdens of climate-sensitive health outcomes or calculate expected increases in adverse health outcomes from climate change. Instead, the assessment illuminates existing community health issues, of which a number are weather- or climate-related, that are examined below.

As noted before, Cambridge's main climate risks stem from increasing temperatures and precipitation-driven flooding, but other health stressors associated with climate change are air pollution, vector-borne diseases, and water or food-borne illnesses (P. Kinney, Little, Petkova, & Chen, 2015). The Community Health Assessment shed light on current climate and weather-related individual and community health issues, which are expected to worsen with the continued impacts of climate change.

Many interviewees and focus group participants pointed to chronic illnesses, such as heart disease, diabetes, asthma, and cancer, as the most salient and relevant health issues affecting them and their families (Community Health Assessment, City of Cambridge, May 2013, pp. 29–32). In addition, a significant number of residents cited asthma, especially residents living in public housing, due to poor air quality and housing conditions (Community Health Assessment, City of Cambridge, May 2013, pp. 36–41). The assessment also noted that food-borne infections, such as Campylobacteriosis and Salmonellosis, are already the most frequently occurring illnesses among the Cambridge resident population, even without the likely future impacts of climate change (Community Health Assessment, City of Cambridge, May 2013, pp. 53–54).

In terms of accessing health care services, most of the Cambridge residents surveyed and interviewed rated both the quantity and quality of health care service facilities positively. The city has six primary care facilities and two acute care hospitals (Community Health Assessment, City of Cambridge, May 2013, p. 56).

However, in the survey, the assessment notes: "30% of Asian respondents identified cultural differences with their healthcare providers as a concern in accessing care, 23% of African-American respondents cited discrimination by their provider, and 26% of Hispanic respondents said that they were afraid to go to the doctor" (Community Health Assessment, City of Cambridge, May 2013, p. iv). In addition, focus group and interview participants frequently pointed to cultural and linguistic differences posing barriers for immigrants trying to access health services (Community Health Assessment, City of Cambridge, May 2013, pp. 59–63). As a point of reference, the report notes that almost one-third (32%) of Cambridge's population speaks a non-English language at home, and the most common languages are Spanish, Chinese, French or French Creole, and Portuguese (U.S. Census Bureau, 2015). While health care services available to Cambridge residents seem to be on average, of high quality, the differential perceptions of accessibility of Cambridge health care services according to race, culture, and/or English proficiency indicates that there are barriers to ensuring access to health and well-being resources to all residents (Community Health Assessment, City of Cambridge, May 2013).

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Chapter 5

Issue Framing of Climate Change

Background

Issue framing and public opinion

Chong (1993) suggests that issue framing is the "essence of public opinion formation" (Chong, 1993, p. 870). Indeed, framing is one of the primary means policymakers can use to influence public opinion; the way an issue is framed matters for how publics think about it (Sniderman & Theriault, 2004). As Entman (1993) summarizes the phenomenon: "To frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described" (Entman, 1993, p. 52). In other words, a framing effect occurs when in the course of describing an issue or event, "emphasizing a subset of potentially relevant considerations causes individuals to focus on these considerations when constructing their opinions" (Druckman, 2001b, p. 230).

For example, framing the discussion about a Ku Klux Klan rally as a public safety or free speech issue shapes public opinion in widely diverging ways (Druckman, 2001b). Similarly, even with the same policy details, public acceptance of a potential policy designed to curb the spreading of a disease is higher when the policy solution is framed as saving a number of lives, when compared to the policy being framed as losing others (Tversky & Kahneman, 1981). Framing effects are primarily known as the product of heuristic information processing (Kühberger, 1997; McElroy & Seta, 2003). Kaufman et al. (2003) explain that frames are cognitive shortcuts that people use to help make sense of complex information (Kaufman, Elliott, & Shmueli, 2003).

Druckman (2001) distinguishes between two types of framing effects. The first, the equivalency framing effect, results in people modifying their preferences when "different, but logically equivalent" words or phrases are used to describe the same phenomenon (Druckman, 2001b, p. 228). In other words, depending on whether the glass is described as half-full or half-empty, people view the glass of water differently. In the aforementioned seminal study of the equivalency framing effect, the Asian disease task paper, Tversky and Kahneman (1981) elicited different policy preferences from people by framing the same problem as either an issue of saving lives or minimizing expected deaths, showing that the framing of questions as losses or gains systemically reverses people's choices[3] (Tversky & Kahneman, 1981). The cognitive psychology and behavioral science fields have studied the equivalency framing effect extensively. They have found that frames that cast "the same critical information in either a *positive* or a *negative* light" cause people to have different preferences (Levin, Schneider, and Gaeth, 1998, p. 150; emphasis in original). For instance, people evaluate ground beef as better tasting when it is labeled as 75% lean, rather than 25% fat, even though the substance of the beef is equivalent, regardless of the description (Levin & Gaeth, 1988).

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[3] Participants in the positive frame condition received a description of lives saved (e.g., 200 out of a total of 600 people will be saved), whereas participants in the negative frame group were informed about lives lost (e.g., 400 out of a total of 600 people will die) in making a decision. Despite the equivalency of the two versions, people are more likely to be risk-averse when outcomes are framed as gains, and more risk-seeking when outcomes are framed as losses.

The second type of framing effect, known as the emphasis framing effect, occurs when "emphasizing a subset of potentially relevant considerations causes individuals to focus on these considerations when constructing their opinions" (Druckman, 2001b, p. 230). For example, when government spending for the poor is framed as increasing the chances of the poor leading fuller lives, people tend to support increased spending. However, when government spending is framed as leading to higher taxes, people will oppose the same increase in government spending. While the issue is the same, Sniderman and Theriault (2004) explain that the "enlarging opportunity" and the "higher taxes" frames diverge in symbolic appeal according to underlying political principles (Sniderman and Theriault, 2004).

Nelson et al. (1997) are careful to distinguish this type of framing, or emphasis framing, from priming, or merely presenting new information. Priming, through making particular considerations more accessible temporarily, influence spur-of-the-moment decision processes. Unlike priming, frames tell people how to weight existing information differently, by placing more emphasis on the particular considerations made more salient through a specific frame of the issue (T. E. Nelson, Oxley, & Clawson, 1997, p. 226). In summary, attitudes regarding an issue can be shifted by 1) adding new information to one's considerations about the issue (belief change), 2) making particular considerations temporarily more accessible (priming), or 3) by altering the weight of particular considerations (framing) (T. E. Nelson et al., 1997, p. 236). It is the last method of framing, encouraging citizens to attach greater weight to particular considerations, which we are interested in.

Frames and climate change

As an advocate of using framing techniques to overcome barriers to public understanding of the sources and impacts of climate change, Nisbet (2009) argues for the use of carefully tailored frames that take account of existing attitudes and values, and will furthermore, amplify the personal relevance of climate change for different publics (Nisbet, 2009). Furthermore, Nisbet and Scheufele (2009) argue that "framing should not be seen as a strategy for 'selling' the public on science, but rather as a means for constructively shifting the conversation about an issue" (Nisbet & Scheufele, 2009, p. 1771).

Research to date on issue framing of climate change has tended to focus on testing the effects of equivalent framing, by highlighting either the positive or negative attributes of climate mitigation efforts and seeing its effects on attitudes around climate change. Studies have found that positive frames that highlight gains (in terms of avoided negative impacts) resulted in more positive attitudes towards climate mitigation actions, than negative frames that highlight losses (in terms of likely climate impacts without mitigation) (Morton, Rabinovich, Marshall, & Bretschneider, 2011; Spence & Pidgeon, 2010). In addition, messages that frame the collective benefits of climate action, rather than highlighting costs in terms of necessary sacrifices, were found to result in higher perceived capacity to deal with climate change and stronger behavioral intentions regarding climate mitigation (Gifford & Comeau, 2011).

Framing climate change as a public health issue

A public health framing of climate change, which is central to this dissertation project, is a potential way of fostering public awareness of and increasing public engagement with the issue. This frame emphasizes the potential of climate change to increase the occurrence of health problems that are already perceived as important, such as infectious diseases, asthma, allergies, and heat stroke (USGCRP, 2016). A public health frame also tends to heighten the geographic proximity of impacts, by substituting conceptions of remote regions and abstract populations with one's own neighbors and places. In the process of making climate change easier to understand, a public health framing can also increase its salience, or the relevance of the information, and legitimacy, or the consideration of appropriate values and concerns (Cash et al., 2002; Frumkin, Hess, Luber, Malilay, & McGeehin, 2008; Maibach et al., 2010; Nisbet, 2009).

There is a research gap, however, on how a public health framing of climate change risks impacts perceived knowledge and concern for climate change, and subsequently affects policy support for climate adaptation planning (Leiserowitz et al., 2013; Maibach et al., 2010; Nisbet, 2009). As seen above, previous research in issue framing of climate change has tended to focus on the effects of equivalent framing (positive versus negative frames; benefits versus costs) on knowledge of and engagement with climate mitigation efforts.

As an exception, Myers et al. (2012) studies the emphasis framing effect by testing the effects of considering the environmental, public health, or national security implications of climate change and how they elicit different emotions regarding climate change. They found the public health frame is more effective than the environment frame in eliciting hope, while the national security frame actually elicited anger (Myers et al., 2012). As they focused on emotional outcomes, they did not examine whether focusing on public health impacts of climate change might make it more understandable, salient, or personally relevant. They also did not study how frames of climate change might affect the way residents think, feel, and act regarding climate adaptation planning efforts in their own community. In addition, their research focused on emotional responses across a nationally representative sample; variations in opinion and behavior among subgroups of the population were not studied. In summary, there has yet to be a study that analyzes the emphasis framing effects of different frames of climate change on local climate adaptation efforts.

In response, this study evaluated the influence of two ways of framing climate change risks (i.e. in terms of environmental impacts or public health impacts). How does each framing of the issue of climate change affect perceived levels of knowledge about climate change, the perceived severity of the threats posed, concern for local climate risks, confidence in the capacity of local governments to undertake effective climate adaptation planning, willingness to pay higher taxes for local climate adaptation planning, and policy preferences regarding climate planning? In answering this question, this study focused on two distinct populations: 1) residents of Cambridge, MA and 2) mTurk participants from coastal states in the Northeast (Massachusetts, New York, New Jersey, Connecticut, Rhode Island and Maine).

As mentioned, this study is part of a larger dissertation project exploring how issue framing influences Cambridge residents' perceptions of local climate risks and their policy priorities in climate adaptation planning. Furthermore, this study was initiated with the main hypothesis that an emphasis on the health impacts of climate change would increase residents' understanding of and concern for climate change, and furthermore, increase policy support for climate adaptation planning efforts.

Methods

This study employed a randomized, controlled message experiment. Participants were randomly assigned to one of two experimental conditions. Participants read one of two differently framed vignettes about climate change, each of approximately 300 words, emphasizing either the risks to the environment or the risks to public health. Other than the environment and health considerations being highlighted, the messages were structured identically. The vignettes used in the survey are shortened versions of the environment and health framing articles used by Myers et al. (2012). The two vignettes are presented in Appendix A.

After reading the randomly assigned vignette of either the environment or health frame of climate change, participants answered a series of questions about possible responses to climate change. Participants also answered questions gauging their perceived levels of knowledge about climate change, sense of threats it poses, level of concern over local climate risks, level of confidence in effective local climate adaptation planning, willingness to pay higher taxes to support local climate adaptation planning, and policy preferences for climate adaptation planning. Lastly, in the mTurk sample, the participants answered questions regarding demographic information, including age, gender, education, income, and political orientation. The survey questions are in Appendix B. Figure 5.1 shows the Qualtrics platform used to implement the online framing survey experiments.

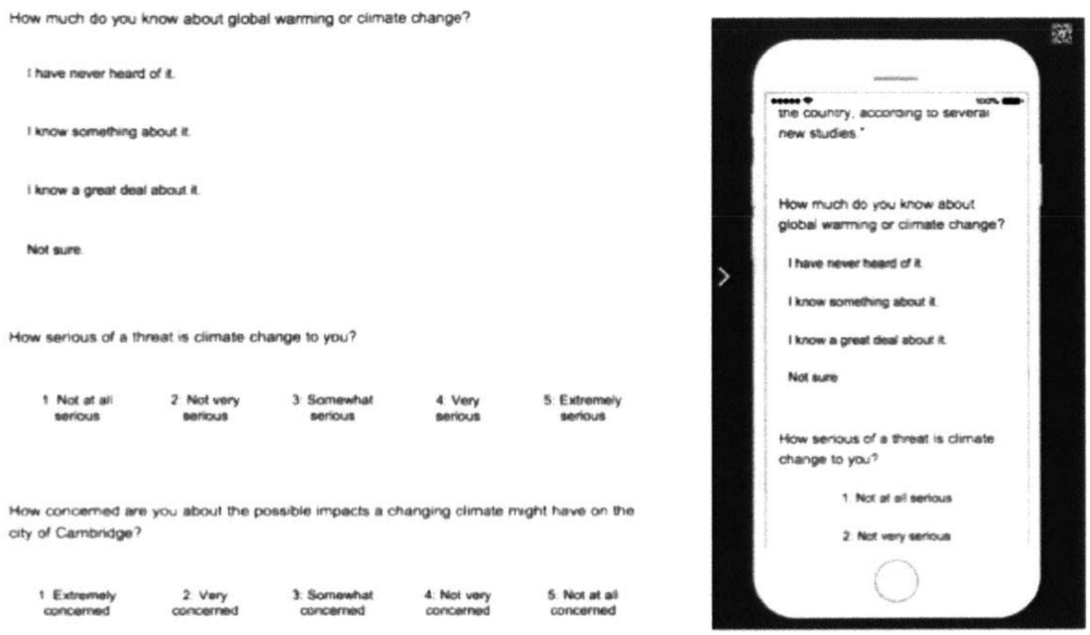

Figure 5.1. Qualtrics Survey Platform (desktop version on left; mobile version on right)

In particular, the following questions were posed to participants in all groups to gauge cognition, affect, and behavioral intentions regarding local climate adaptation in their municipality:

a) a three-point Likert scale question gauging the level of perceived knowledge of global warming or climate change[4] [cognition]
b) a five-point Likert scale question gauging the perceived seriousness of the threat climate change poses[5] [affect]
c) a five-point Likert scale question gauging the level of concern for climate impacts on their municipality[6] [affect]
d) a five-point Likert scale question gauging the level of confidence in effective local climate adaptation in their municipality[7] [affect]
e) a five-point Likert scale question gauging the willingness to pay higher taxes for their municipality to reduce climate risks[8] [behavior]

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4 5 validated and tested questions from Lee et al. (2015)

6 7 validated and tested questions from Rumore et al. (2016)

8 question adapted from the General Social Survey (GSS) on environmental behavior [GRNTAXES]

f) a six-option question asking which climate risk their municipality should prioritize most in its climate adaptation policies [behavior]

Hypotheses

Compared to the participants that exposed to an environment frame of climate change or no frame, participants exposed to a health frame of climate change were expected to have, on average,

a) a higher score on a three-point Likert scale question gauging the level of knowledge of global warming or climate change. [cognition]
b) a higher score on a five-point Likert scale question gauging the perceived seriousness of the threat climate change poses. [affect]
c) a higher score on a five-point Likert scale question gauging the level of concern for climate impacts on their municipality. [affect]
d) a higher score on a five-point Likert scale question gauging the level of confidence in effective local climate adaptation in their municipality. [affect]
e) a higher score on a five-point Likert scale question gauging the willingness to pay higher taxes for their municipality to reduce climate risks. [behavior]
f) a higher proportion of the group respondents picking "increased risks of disease, hospitalization, and death" as the climate risk their municipality should prioritize in its climate adaptation policies. [behavior]

I. Cambridge residents

A total of 169 residents participated in the Qualtrics online survey experiment between September 2015 and May 2016. They were recruited through email advertisements, either directly or through local partners organizations, including Humanist Hub, Green Cambridge, and Cambridge Innovation Center. The residents were randomly assigned to two groups, and were exposed to either the environment frame or the health frame. The environment frame group consisted of 85 randomly assigned participants, and the health frame group consisted of 84 participants.

II. Northeast mTurk participants

A total of 139[9] mTurk participants took the Qualtrics online survey experiment between July 17th and July 31st, 2017. The mTurk workers were compensated $0.50 each for their participation. The participants were randomly assigned to three groups, and were exposed to 1) the environment frame of climate change, 2) the health frame of climate change, or 3) no frame for the control group. The environment frame group consisted of 37 randomly assigned participants, the health frame group 48 participants, and the control group consisted of 43 participants. No significant demographic differences existed among the three groups.

Results

I. Cambridge residents

A series of independent t-tests[10] were run on the sample of 169 Cambridge residents to determine if there were differences in their knowledge, affect, or behavioral intentions regarding local climate adaptation based on frame type exposure (i.e. the environment frame or the public health frame).

[9] 11 entries were dropped because they were less than 75% complete.

[10] This study acknowledges the debate around using parametric tests on Likert scale data. While principled stances such as Jamieson (2004, p. 1217) forbid conducting parametric analyses on ordinal data as "intervals between values cannot be presumed equal," empirical studies of the robustness of tests of central tendency, including t-tests and ANOVA, find that parametric tests on differences in means for sample sizes greater than 5 show robustness with respect to ordinality and non-normality (Norman, 2010; Boneau, 1960; Pearson, 1931). In addition, Wilcoxon signed-rank tests were also conducted with similar results, enhancing confidence in the parametric test outcomes.

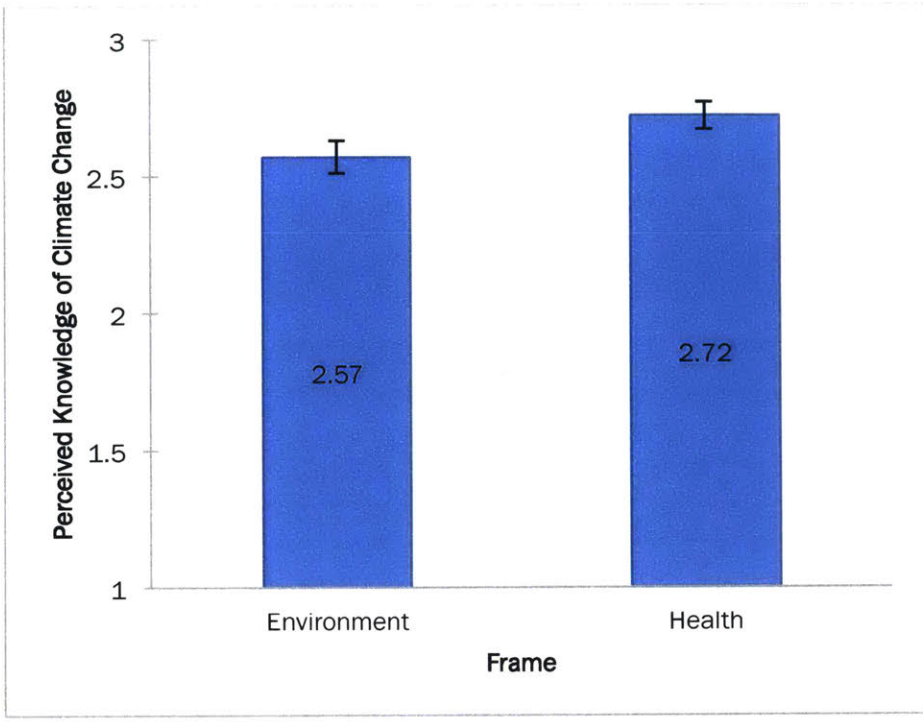

Figure 5.2. Perceived Knowledge of Climate Change, by Frame (mean ± sem)

The results show that participants exposed to the health frame had statistically significantly higher levels of perceived knowledge about climate change (2.72 ± 0.1 levels, out of 3 levels ranging from 1 = "I have never heard of it" to 3 = "I know a great deal about it") compared to participants given the environment frame (2.57 ± 0.12 levels, out of 3 levels ranging from 1 = "I have never heard of it" to 3 = "I know a great deal about it"), t (164) = 1.953, p = 0.026, d = 0.303. The results are presented in Figure 5.2 above.

The results also show that participants exposed to the health frame had statistically significantly higher levels of concern for local climate risks in Cambridge (3.93 ± 0.18 levels, out of 5 levels ranging from 1 = "Not at all concerned" to 5 = "Very concerned") compared to participants given the environment frame (3.58 ± 0.27 levels, out of 5 levels ranging from 1 = "Not at all concerned" to 5 = "Very concerned"), t (167) = 2.144, p = 0.017, d = 0.33. The results are presented in Figure 5.3 below.

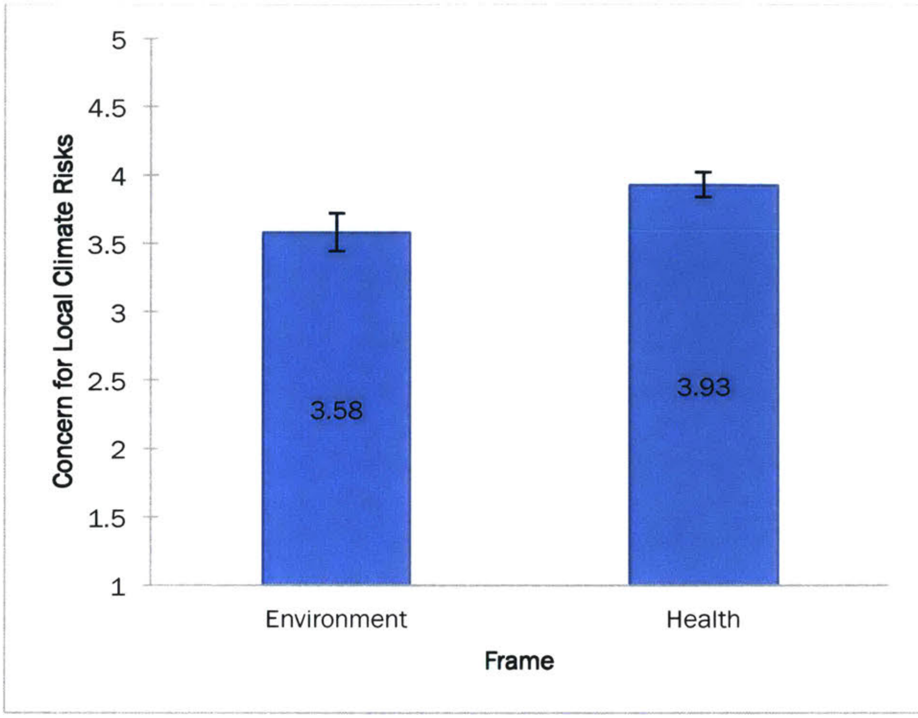

Figure 5.3. Concern for Local Climate Risks, by Frame (mean ± sem)

Finally, the results show that participants exposed to the health frame of climate change had statistically significantly higher levels of confidence in the prospect of climate adaptation planning in Cambridge reducing risks to the public (2.87 ± 0.25 levels, out of 5 levels ranging from 1 = "Not at all confident" to 5 = "Very confident") compared to participants given the environment frame (2.36 ± 0.27 levels, out of 5 levels ranging from 1 = "Not at all confident" to 5 = "Very confident"), $t(75) = 2.76$, $p = 0.004$, $d = 0.629$.[11] The results are presented in Figure 5.4 below.

[11] For this question, the control group consisted of 39 randomly assigned participants, and the treatment group consisted of 38 participants, for a total of 77 participants.

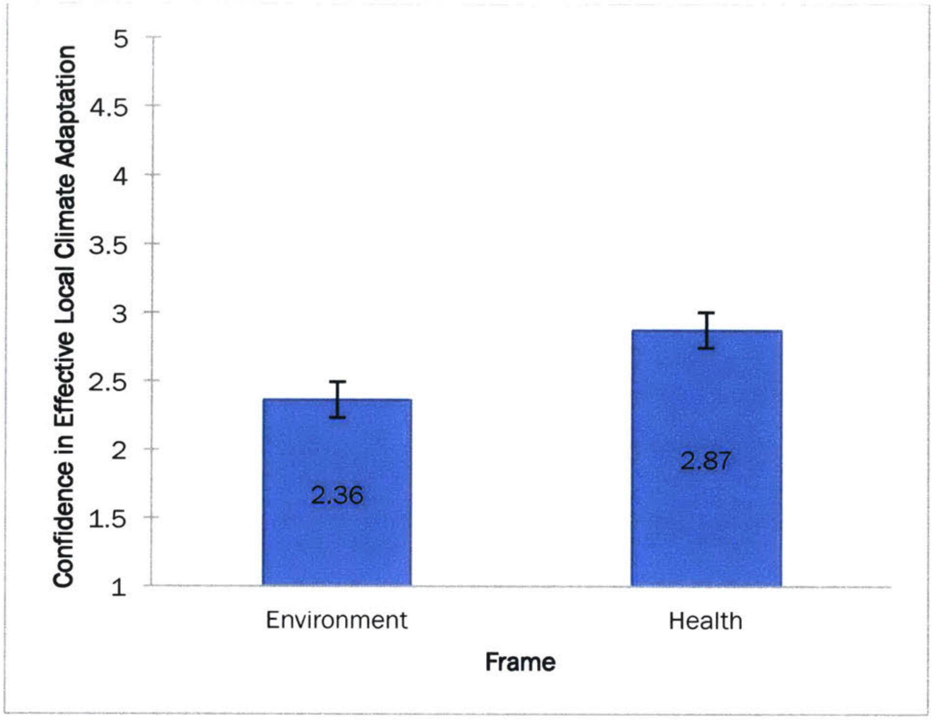

Figure 5.4. Confidence in Effective Local Climate Adaptation, by Frame (mean ± sem)

All other t-tests conducted to determine whether the mean differences between the two groups exposed to different frames of climate change are statistically significantly different from zero for the levels of perceived threat from climate change (Q2), support for Cambridge incorporating 50 year climate projections into planning decisions (Q5), and willingness to pay higher taxes for climate adaptation (Q6), were statistically insignificant.

Effects of Framing on Key Dependent Variables

Table 1 below sums up the main effects of framing on key dependent variables for the Cambridge, MA resident population. As noted above, on average, participants exposed to a health frame showed statistically significant higher levels of perceived knowledge of climate change, concern for local climate risks, and confidence in the city of Cambridge's ability to effectively plan for the impacts of climate change, when compared to the participants exposed to the environment frame of climate change.

Table 1. Main Effects of Framing on Key Dependent Variables

Dependent variables (n = 169)	Framing Effect Δ Health-Env	Cohen's *d*
Perceived knowledge of climate change (1-3)	**0.148**** (0.076)	0.303
Perceived personal threat of climate change (1-5)	0.005 (0.118)	0.006
Concern for local climate risks (1-5)	**0.351**** (0.164)	0.33
Confidence in city's effectiveness in climate adaptation[12] (1-5)	**0.509***** (0.104)	0.629
Agreement with city incorporating climate risks into everyday planning (1-5)	0.009 (0.096)	0.014
Willingness to pay higher taxes for climate adaptation (1-5)	-0.015 (0.148)	0.015

Note: Standard errors in parentheses. All mean comparisons significant at *p<0.5 (bold face), **p<0.1 (bold face), ***p<0.01 (bold face). Unequal variances assumed (t-test). Cohen's *d* is a standardized measure of effect size; values between 0.3 and 0.6 are considered "moderate" effect sizes in behavioral sciences (Cohen, 1988).

Therefore, we see that exposure to a health frame of climate change (compared to an environment frame of climate change) results in higher levels of perceived knowledge of climate change, higher concern for local climate risks, and higher levels of confidence in the local government's capacity to deal with climate risks in the Cambridge, MA population. In other words, considering the health considerations of climate change leads to enhanced knowledge of, concern over, and engagement with local climate adaptation planning efforts.

II. mTurk participants

Table 1 below presents the demographic information on the mTurk participants. We can see that the mTurk sample is fairly similar to the demographic makeup of Cambridge, MA, but is slightly more educated, but with lower household incomes.

[12] n=56

Table 1. mTurk Sample Characteristics (n=128[13])

Variables		mTurk Sample	City[14] Statistics
Gender	Male	48.0%	48.4%
	Female	51.2%	51.6%
Age	19 or under	0.8%	18.1%
	20-29	29.9%	30.5%
	30-39	33.9%	18.1%
	40-49	17.3%	9.7%
	50-59	11.0%	8.4%
	60+	7.1%	15.3%
Political Viewpoint[15]	Conservative	26.0%	26.7%
	Moderate	22.8%	36.6%
	Liberal	51.2%	32.5%
Education	High school graduate (or equivalent)	0.8%	9.3%
	Some college or associate's degree (AA)	11.0%	9.9%
	Bachelor's degree (BA, BS, AB, etc.)	26.0%	29.5%
	Master's degree (MA, MSc) Professional or doctoral degree (MD, PhD, etc.)	60.0%	45.2%
Industry	Agriculture, forestry, fishing and hunting, mining	0.8%	0.2%
	Construction	4.7%	0.9%
	Manufacturing	4.7%	5.4%
	Wholesale trade	0.8%	1.1%
	Retail trade	7.9%	5.4%
	Transportation, warehousing, and utilities	3.9%	1.6%
	Management and administrative services	12.6%	20.5%
	Information, finance, insurance, real estate	0.8%	9.9%
	Educational services and healthcare	15.0%	41.8%
	Arts, entertainment, recreation, hospitality	11.0%	6.4%
	Public administration	11.0%	3.2%
	Other	17.3%	3.7%
Household Income[16]	Less than $14,999	8.9%	13.0%
	$15,000 to $24,999	8.1%	7.2%
	$25,000 to $34,999	8.9%	6.7%

13 n=139; 11 dropped because entries less than 75% complete

14 2010-2014 American Community Survey 5-Year Estimates

15 Statewide (MA) statistics from Gallup State of the States 2015 used as proxy for city statistics

16 Workshop sample n = 94 for optional question on household income in 2014; city statistics given in 2014 inflation-adjusted dollars

	$35,000 to $49,999	26.0%	8.6%
	$50,000 to $74,999	16.3%	14.0%
	$75,000 to $99,999	19.5%	12.3%
	$100,000 to $149,999	10.6%	16.6%
	$150,000 or more	1.68%	21.6%

A series of one-way ANOVA[17] were conducted on the sample of 128 mTurk participants to determine if there were differences in knowledge, affect, or behavior around climate adaptation based on frame type, either an environment frame or a public health frame of climate change.

Perceived threat from climate change

A one-way ANOVA was conducted to determine if one's perceived threat from climate change was different for participant groups exposed to different frames of climate change. Data is mean ± standard error. Participants were classified into three groups: no frame (n=43), environment frame (n=37), and health frame (n=48). There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2,125) = 3.72$, $p = 0.027$). A Tukey post-hoc test[18] revealed that one's perceived threat from climate change was statistically significantly higher in the health frame group compared to the no frame control group (0.59 ± 0.23 levels, $p = 0.03$). However, there were no statistically significant differences between the environment frame and no frame control groups (0.51 ± 0.25 levels, $p = 0.102$), or the health frame and environment frame groups (0.09 ± 0.24 levels, $p = 0.934$).

Figure 5.5 below shows the results. While the difference between the magnitude of perceived threats from climate change between the environment and health groups is not statistically significant as hypothesized, we can see that participants exposed to the health frame of climate change perceive climate change to be a significantly bigger threat than the participants that were in the control group and not exposed to a frame. While this does not robustly identify the magnitude of the framing effects between the two frames, we can see

[17] The one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of three or more independent groups.

[18] When there is a statistically significant difference between the groups, it is possible to use a (Tukey) post hoc test to determine which specific groups were significantly different from each other.

that the framing effect of the health frame is indeed significant, when compared to not framing climate change in terms of the health considerations involved.

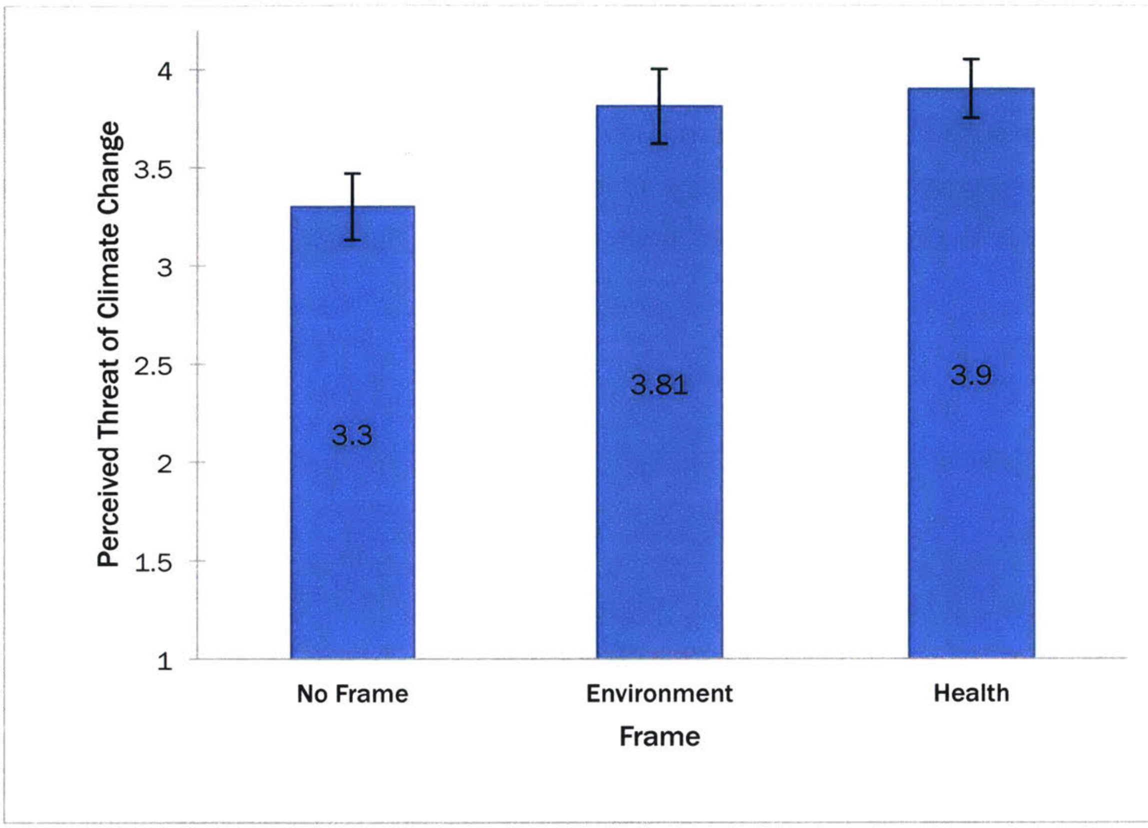

Figure 5.5. Perceived Threat of Climate Change, by Frame (mean ± sem)

Willingness to pay for climate adaptation

A one-way ANOVA was conducted to determine if willingness to pay higher taxes to support climate adaptation was different for participant groups exposed to different frames. Data is mean ± standard error. Participants were classified into three groups: no frame (n=43), environment frame (n=37), and health frame (n=48). There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2,125) = 5.87$, $p = 0.004$). A Tukey post-hoc test revealed that one's willingness to pay higher taxes for climate adaptation was statistically significantly higher in the health frame group compared to the no frame control group (0.78 ± 0.24 levels, $p = 0.004$). In addition, one's willingness was also statistically significantly higher in the environment frame group compared to the no frame control group (0.62 ± 0.25 levels, $p = 0.04$). However, there were no statistically significant differences between the health frame and environment frame (0.16 ± 0.25 levels, p = 0.788).

Figure 5.6 shows the results. Again, while the difference in willingness to pay for climate adaptation between the health and environment frame groups was not significant, we can see that being exposed to the health frame leads to a higher willingness to pay increased taxes for climate adaptation, when compared to not being exposed to any frame. Similarly, being exposed to the environment frame leads to similar results, albeit of a lesser magnitude.

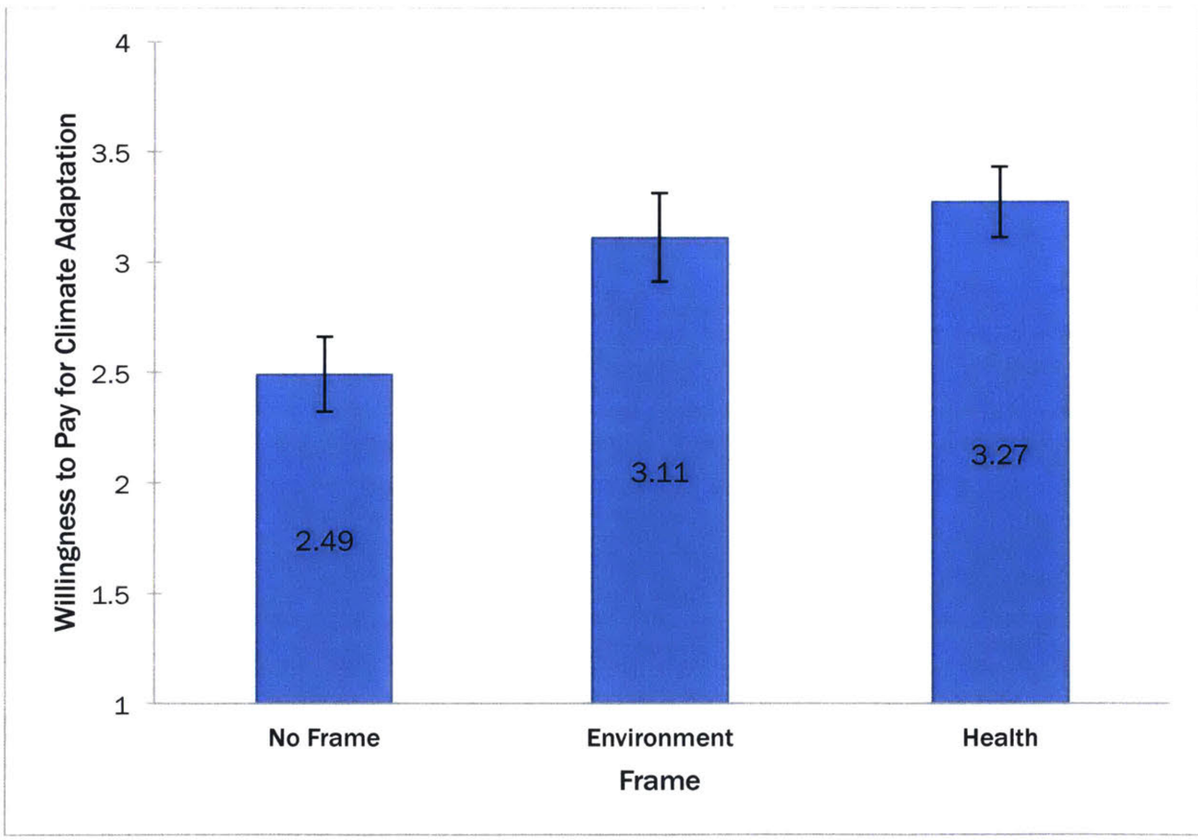

Figure 5.6. Willingness to Pay for Climate Adaptation, by Frame (mean ± sem)

All other one-way ANOVA tests conducted to determine whether exposure to an environment or health frame resulted in differences in levels of perceived knowledge of climate change (Q1), concern for climate risks (Q3), confidence in effective local climate adaptation planning (Q4), and support for one's municipality incorporating 50 year climate projections into planning decisions (Q5), were statistically insignificant.

Prioritization of Climate Risks in Climate Adaptation Planning

Exposure to different ways of framing the issue of climate change was also associated with statistically significant differences in the mTurk sample participants' opinions on the actions their local governments should take to adapt to climate change. Table 2 below depicts the differences in the proportions of respondents' prioritization of climate risks to focus on in their city's climate adaptation planning, depending on the frames their group was exposed to. The percentages represent the proportion of the group that selected each climate risk as their first priority in Cambridge's management of climate risks. In other words, we see that people chose different climate risks as their first priority in climate adaptation planning, depending on whether one received information highlighting climate change as an environmental concern or a public health concern.

We can see a sizable difference in the no frame control group's prioritizing individual property damage at 16.3% (bolded below), compared to the environment frame group's 5.4% and the health frame group's 2.1%. It is profound that without framing climate change as an environmental or health issue, the mTurk participants wanted their local governments to focus on minimizing risks to individual property damage above all. More research is called for to investigate the extent to which people's default positions are to focus on individual property damage risks without concerted efforts to frame climate change and highlight the social ramifications of the issue.

There is also a significant difference in the environment frame group's picking of watershed, forest, and ecosystem degradation as the most important climate risk for local governments to manage (27.0%, bolded), compared to the no frame control group's 11.6% and the health frame group's 6.3%. It seems fairly intuitive that exposure to an environmental frame would result in prioritizing ecosystem degradation.

Lastly, we see that significantly more people in the health frame group wanted to prioritize infrastructure damage (56.3%, bolded), compared to the no frame control group's 11.6% and the health frame group's 6.3%. As the study was conducted with a hypothesis that exposure to a health frame would result in prioritizing increases in risks of disease, hospitalization, and death in climate adaptation planning, this result is fairly surprising. However, this could be from considering the health risks of infrastructure disruptions, and in particular, the risk of cascading infrastructure failures (USGCRP, 2016), such as blackouts during extreme events.

All other marginal proportions are similar, regardless of whether the participants were in the no frame control, environment frame, or health frame groups. Results of a chi-square goodness-of-fit test[19] show that the marginal proportions are statistically significantly different from each other *(chi-square = 23.06; p = 0.01).*

Table 2. Prioritization of Local Climate Risks in Climate Adaptation Planning, by Frame

	No Frame	Environment	Health
Individual property damage	**16.3%**	5.4%	2.1%
Local business disruption	0.0%	2.7%	4.2%
Increased risks of disease, hospitalization, and death	27.9%	35.1%	25.0%
Disproportionate impacts to vulnerable populations	11.6%	2.7%	6.3%
Water, energy, and transportation infrastructure damage	32.6%	27.0%	**56.3%**
Watershed, forest, and ecosystem degradation	11.6%	**27.0%**	6.3%
Total		100%	

Note: Proportions in bold face have contributions to the chi-square value larger than 3.0, in rows that contribute more than 5.0 to the total; total chi-square = 23.06.

[19] The chi-square goodness-of-fit test is a statistical test used on contingency tables to determine whether the row and column marginal frequencies are equal. If the p score is low enough ($p < 0.05$), this provides sufficient evidence to reject the null hypothesis and state that the marginal proportions are statistically significantly different from each other.

Limitations and Future Research

This project has a number of limitations. First, the external validity of this study has limitations. The survey experiment was conducted with residents of Cambridge, Massachusetts and mTurk participants in the Northeast region of the United States. The residents in Cambridge and the larger Northeast region may or may not reflect how other members of the public in the United States engage with issue framings of climate change and climate adaptation planning in their communities. Future work should aim to replicate and evaluate the effectiveness of framing climate change as a health issue in other cities and regions.

Second, the framing experiments do not test other potential frames of climate change, such as economic development or national security. Future research should test the impact of the health framing of climate change against these other frames as well.

Conclusion

To address the research gap on how issue framing of climate risks affects attitudes around climate adaptation planning, this study evaluated the influence of framing climate change risks (i.e. in terms of environmental impacts or public health impacts) on knowledge about climate change, concern for local climate risks, and policy support for climate adaptation planning. While previous research in framing and climate change has tended to focus on the effects of equivalent framing (positive versus negative frames) on climate mitigation, this study is the first to analyze the emphasis framing effects of climate change on local climate adaptation efforts.

Overall, the results of this study provide support for the main hypothesis of this study. Namely, framing climate change in terms of public health risks is likely to increase public concern for climate change and increase public support for greater investment in climate adaptation planning. In the Cambridge, MA pool, we saw that focusing on the health impacts of climate change increased perceived knowledge of climate change, concern for local climate risks, and confidence in one's local government's capacity to effectively plan for climate risks. In the Northeast mTurk pool, we saw that highlighting the health implications of climate change increased the perceived severity of the threats posed by climate change, as well as one's willingness to pay for their municipality to adapt to a changing climate. Not framing the issue at all, which is arguably the status quo of most cities and towns grappling with climate impacts, is likely to lead to lower levels of public concern for climate risks and public support for climate adaptation planning efforts.

All these results provide proof-of-concept that a public health framing of climate risks, as compared to an environmental framing, and certainly compared to no framing at all, increases public concern and commitment to climate adaptation planning. These findings indicate that cities have much to gain from framing climate change as a public health issue, in terms of perceptions of the severity of the problem and levels of support for climate policy action. The next two chapters will delve into two public engagement methods that cities can use to operationalize the public health framing of climate change that has been tested in this study.

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Chapter 6

Role-Play Simulations

Background

According to Hulme et al. (2007), social barriers to climate adaptation primarily operate at the individual and collective decision-making levels (Hulme et al., 2007). For instance, at the individual level, a perceived lack of self-efficacy may hinder some from preparing for climate change. At the collective level, climate adaptation planning tends to be characterized by a status quo bias, often catalyzed by the lack of perceived collective efficacy (Bandura, 1998; Hulme et al., 2007). In response to these deep-seated personal and collective barriers to climate adaptation planning, Rumore, Schenk, & Susskind (2016) argue for the need to enhance communities' readiness to adapt to climate change. In their view, acquiring substantive knowledge, or what they call adaptation literacy, at both the individual and community level, is necessary, but not sufficient for a community to achieve climate readiness. Collaborative capacity, or the ability to work together to solve common problems, is key (Rumore et al., 2016). A ready community would possess a "shared sense of the risks that communities collectively face, how they might prepare for and manage aforementioned risks, and different decision-making approaches to respond collaboratively and adaptively to emerging threats" (Rumore et al., 2016, p. 746). However, current public engagement practices in planning, centered around "death by PowerPoint" (Winn, 2003) in town hall meetings or information sessions, are woefully inadequate in their collective technical and political learning processes for climate-ready planning (Argyris & Schon, 1978; de Suarez et al., 2012; Susskind, 2001).

How can we accelerate individual and collective learning to advance readiness in climate adaptation? In terms of learning, based on decades of research, we know that learning experiences are most effective when they are active, experiential, and have shorter feedback loops (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Kolb, 2014). Accordingly, serious games, or games with an explicit purpose of learning complex material or decision-making methods through play, have been gaining attention as a potentially powerful tool for transformative learning and engagement (Abt, 1987; de Suarez et al., 2012; Gee, 2003; Shaffer, 2006; Squire, 2003, 2006).

As experiential exercises presenting fictional challenges within clear constraints (Abt, 1987), serious games can be used to induce people to take a long-term perspective, to use systems thinking, and to experiment with problem-solving strategies (McGonigal, 2011). Serious games have also been found to be effective in conveying complex information and enabling perspective-taking (Abt, 1987). These games have been used to attempt to shift behaviors and attitudes in various areas of public policy, including health, environmental policy, and climate change (de Suarez et al., 2012; Dolin & Susskind, 1992; Rumore et al., 2016; Sawyer & Smith, 2008; Wu & Lee, 2015). Far from being a recent development however, games have been utilized in planning throughout history (Light, 2008), including the Model Cities Program (Berkeley, 1968), and more recent game-based approaches to participatory planning (Gordon & Baldwin-Philippi, 2014).

Role-play simulations are a type of serious game where participants engage in a face-to-face mock decision-making process, bounded by instructions delineating role-specific interests and strategies. Each participant receives two sets of instructions: 1) general instructions with the background of the policymaking process in the context of the locality and 2) role-specific instructions with further details on the interests and positions of the role the player will assume for the game (Rumore et al., 2016). Role-play simulations offer interactive ways of mastering technical information within fixed rules and constrained outcomes. In addition, role-play simulations have been shown to help participants not only learn technical knowledge, but also process-based knowledge, such as existing social norms and institutional arrangements within a policy realm (Rumore et al., 2016).

Role-play simulations have been highlighted as particularly promising tools for education and public engagement. First, role-play simulations immerse people in scenarios where a sense of "here and now" is crucial, such as medical, negotiation, and military training, and enable them to learn to deal with high-stakes circumstances in a safe and low-cost sandbox environment (Rumore et al., 2016; Schenk, 2015). Well-designed games can prepare people for critical situations where certain decisions with its subsequent life or death outcomes in the real world, like that of dealing with climate change (de Suarez et al., 2012).

In addition, in the planning and policymaking context, role-play simulations help different stakeholders understand others' viewpoints and interests regarding the policy realm featured in the game. By forcing participants to take on a role different from the roles they occupy in real life, role-play simulations foster perspective-taking and empathy for others' viewpoints, and subsequently can increase participants' capacity to work collectively to problem-solve in their communities (Rumore et al., 2016).

With regards to climate change, role-play simulations can facilitate learning and engagement with the issue in various ways, including collectively considering local climate risks, acknowledging differing interests of various stakeholders in local climate policymaking, and experimenting with new policy tools and approaches without real-world political, social, or financial consequences (de Suarez et al., 2012; Rumore et al., 2016; Schenk, 2015). The average citizen has limited incentives to and experiences with incorporating the likely impacts of climate change in their daily lives (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Howe, 2013). By introducing hypothetical climate adaptation community challenges to participants and pushing them to respond with and to other stakeholders, role-play simulations can foster an appreciation of planning processes in which local adaptation decisions are made, not withstanding competing policy priorities and limited resources (Schenk, 2015).

Playing games is increasingly linked to several distinct learning outcomes. According to Wouters, van der Spek, and Oostendorp (2009), playing games can result in four kinds of learning outcomes: cognitive learning outcomes, consisting of knowledge and cognitive skills; motor skills, affective learning outcomes; and communicative learning outcomes (Wouters, Van der Spek, & Van Oostendorp, 2009). Despite the optimism about the potential of games for learning, some have noted that there is insufficient empirical evidence to support most of these claims (Bellotti et al., 2013; Gosen & Washbush, 2004; Wu & Lee, 2015), calling for more rigorous studies examining the effectiveness of games in fostering readiness to climate risks, particularly those that compare game-based participation to other more commonly used engagement tools and methods (de Suarez et al., 2012).

Over two years from 2013 to 2014, the New England Climate Adaptation Project (NECAP) tested the effectiveness of role-play simulations as a civic education and engagement tool for climate adaptation with 555 participants in four towns in coastal New England. Participation in the NECAP role-play simulations was found to be associated with increases in participant concern for local climate change risks, sense of need for local adaptation action, and confidence in the prospects of effective local adaptation action (Rumore et al., 2016; Susskind et al., 2015). The NECAP project developed and tested four role-play simulations, each tailored to the specific climate risks and policy constraints of each town.

As of date, a role-play simulation exercise that engages participants within a specific community to learn about the local health impacts of climate change has not yet been designed and implemented. Subsequently, the efficacy of an intervention of the sort to bolster community awareness of the shared climate risks and enhance support for local climate adaptation planning has not been probed. This study expands on the findings of the New England Climate Adaptation Project by exploring the potential of using face-to-face multi-stakeholder role-play simulations highlighting the local health effects of climate change to mobilize publics to respond to the impacts of climate change.

Methods

This study consisted of the following steps. First, the MIT Science Impact Collaborative designed a role-play simulation tailored to the specifics of the city of Cambridge. The role-play simulation was designed according to best practices in role-play simulation design, building on over a decade's experience at the MIT Science Impact Collaborative and the Consensus Building Institute. The role-play simulation also integrated the likely local health impacts of climate change into the role-play simulation, based on the results of the aforementioned Climate Change Vulnerability Assessment undertaken by the city of Cambridge (see pages 66-73). The role-play simulation was pilot-tested with MIT student volunteers in October 2015 to test game mechanics before deployment in public engagement workshops.

The face-to-face role-play simulation used in this study is a game set in the fictional city of Mapleton with six different assigned roles: City Manager, the Director of Public Health, the Director of Public Housing, President of the local Chamber of Commerce, Executive Director of a local environmental advocacy organization, and a local university planner. With the help of a neutral facilitator, participants debate and recommend policy decisions to local officials in Mapleton to help prepare the city for the likely health impacts of climate change. Each participant assumed one of six roles in the game. Every participant was given a set of common general instructions and role-specific confidential instructions that outlined their role's interests and positions within a climate adaptation planning and policymaking process.

The role-play simulation induced participants to learn about local climate risks in Cambridge through studying the heat and precipitation-driven flooding data from the city's climate projections presented in the game. Participants also learned about the adverse health outcomes likely to occur in the city, with the projected increases in frequency and duration of extreme heat events, along with increases in the frequency and intensity of extreme precipitation events. Finally, the role-play simulation structured participants' deliberations around policy approaches available to local governments to alleviate the health risks of climate change. These approaches served as a starting point in the role-play simulation groups' discussions. Policy experimentation through modifying existing approaches and creating hybrid strategies was explicitly encouraged. As can be seen in the figure below (Figure 6.1), the role-play simulation's instructions present each policy approach with a description of the activities associated with the approach and its public health benefits. The full version of the general instructions given to all role-play simulation participants is in Appendix C.

	Option	Description	Public Health Benefits
A	**Information-Based Strategy** *Low Expense*	Aimed at sharing information about how the public can remain safe during a climate emergency. Potential activities include: public awareness campaigns about the link between climate change and health, and a mobile alert system that will be activated during emergencies.	• Discourages community members from engaging in hazardous activities, thereby preventing unnecessary injuries • Notifies community members with chronic illnesses of health advisories during extreme climate events • Provides information on how to avoid health threats during extreme heat and flooding
B	**Emergency Preparedness** *Medium Expense*	Focused on improving response time and organizing services to help people in need during climate-related emergencies. Activities include: evacuation drills, clarifying emergency medical response team responsibilities, and adding emergency responder trainings for current public health staff, first responders, and neighborhood activists.	• Reduces emergency response time, reduces the number of deaths • Helps first responders identify climate-related health risks and respond effectively • Trains residents to assist their neighbors and communicate urgent medical needs to first responders, insuring that those in the greatest need are helped first
C	**Resource Allocation** *High Expense*	Ensures that city officials have additional funds and capacity to address short-term emergencies and long-term public health impacts of climate change. Activities include: hiring additional public health professionals, adding more program coordinators, and investing in necessary equipment and supplies. Supporting climate adaptation programs.	• Funds ongoing research into viable policy solutions for climate-related illnesses • Facilitates coordination between various city agencies to implement policies that prevent climate-related illness, providing wide-scale health benefits. • Creates long-term strategy for city to manage public health issues of climate change.
D	**Rules and Regulations** *Low Expense*	Enforces and adds legislation and regulations to ensure the safety of city infrastructure and core services during extreme weather events. Includes: changes to building codes and zoning laws; changes in operating procedures Places requirements on private property owners.	• Cool design and green infrastructure reduce heat levels within and around buildings, limiting heat stroke and dehydration. • Reduces risk of water damage to buildings and improves indoor air quality, reducing risk of worsening respiratory illnesses • Reduces risk of personal injury within the home, workplace, and other private property during flooding.
E	**Prevention** *High Expense*	This involves actions to promote long-term improvements in sustainability and limit greenhouse gas emissions. This focuses on long-term reduction of climate risks. Actions include: supporting the construction of "green infrastructure" (like rooftop gardens on all public buildings and adopting cool design improvements) to city-owned buildings; encouraging green infrastructure on private property.	• Cool design and green infrastructure reduces heat levels within and around buildings, limiting heat stroke and dehydration. • Reduces risk of water damage to buildings and improves indoor air quality, reducing risk of worsening respiratory illnesses • Cool design and green infrastructure will be placed on publicly owned land, providing greater access to vulnerable populations and improving their health outcomes

Figure 6.1. Policy Approaches to Public Health-Oriented Climate Adaptation Planning in RPS

A total of 118 residents played the face-to-face role-play simulation in six workshops during November 2015 – May 2016. These participants were primarily recruited through email advertisements, either directly or through local partners organizations, including Humanist Hub, Green Cambridge, and Cambridge Innovation Center.

Before participating in the role-play simulation workshops, the participants were invited to complete a before-survey of questions about their perceived knowledge of climate risks, their concern for climate impacts, and their policy priorities for local climate adaptation, among other things. The before-survey questions are in Appendix D.

Participants spent about two hours playing the face-to-face role-play simulation. About half an hour was spent reading the role-specific instructions, then about an hour playing the game and trying to reach agreement, and finally, the last half-hour was spent with the entire workshop group in debriefing the game results and how they would apply in their communities. After playing the role-play simulation, the participants completed an after-survey, with many of the same questions from the before-survey, to gauge the efficacy of the role-play simulation in effecting change in local climate change cognition, affect, and behavior. Additional variables of interest are demographic variables and other correlates with environmental and climate change-related cognition and behavior. The after-survey questions are in Appendix E.

In particular, the before- and after- surveys posed the following questions twice, to measure shifts in cognition, affect, and behavioral intentions regarding local climate adaptation in Cambridge, from participating in the face-to-face role-play simulation highlighting the likely health impacts of climate change within their community:

a) a three-point Likert scale question gauging the level of perceived knowledge of global warming or climate change[20] [cognition]
b) a five-point Likert scale question gauging the perceived seriousness of the threat climate change poses[21] [affect]

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[20] [21] validated and tested questions from Lee et al. (2015)

c) a five-point Likert scale question gauging the level of concern for climate impacts on the city of Cambridge[22] [affect]

d) a five-point Likert scale question gauging the level of confidence in effective local climate adaptation in Cambridge[23] [affect]

e) a five-point Likert scale question gauging the willingness to pay higher taxes for Cambridge to reduce climate risks[24] [behavior]

f) a six-option question asking which climate risk the city of Cambridge should prioritize most in its climate adaptation policies [behavior]

g) a five-option question asking which policy approach the city of Cambridge should use primarily to manage the health impacts of climate change [behavior]

Hypotheses

Compared to before participating in the face-to-face role-play simulation, participants are expected to have, on average, after playing the role-play simulation:

a) a higher score on a three-point Likert scale question gauging the level of knowledge of global warming or climate change. [cognition]

b) a higher score on a five-point Likert scale question gauging the perceived seriousness of the threat climate change poses. [affect]

c) a higher score on a five-point Likert scale question gauging the level of concern for climate impacts on the city of Cambridge. [affect]

d) a higher score on a five-point Likert scale question gauging the level of confidence in effective local climate adaptation in Cambridge. [affect]

e) a higher score on a five-point Likert scale question gauging the willingness to pay higher taxes for Cambridge to reduce climate risks. [behavior]

f) a higher proportion of the respondents picking "increased risks of disease, hospitalization, and death" as the climate risk the city of Cambridge should prioritize in its climate adaptation policies. [behavior]

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[22] [23] validated and tested questions from Rumore et al. (2016)

[24] question adapted from the General Social Survey (GSS) on environmental behavior [GRNTAXES]

g) a higher proportion of the respondents picking "emergency preparedness" as the policy approach the city of Cambridge should use primarily to manage the health impacts of climate change. [behavior]

Out of the total of 118 people who participated in the role-play simulations, after-surveys were collected for 112 participants; 6 surveys were not collected from participants that had either not completed the role-play simulation in its entirety, or had chosen not to submit their after-surveys. Participants identified themselves on both surveys, allowing for matched-pairs analysis. A series of paired t-tests[25] were run on the sample of 112 role-play simulation participants to determine if there were statistically significant differences in knowledge, affect, or behavior around local climate adaptation before and after participation in the role-play simulation focusing on the health impacts of climate change. The results are presented in the following section. A particular emphasis was placed on how participants of differing political viewpoints (conservative, moderate, liberal) showed differences in learning through the role-play simulation experience.

Figure 6.2 below presents an overview of the face-to-face role-play simulation and introduces three additional data sources, aside from the before- and after-surveys, from the role-play simulation workshops analyzed in this study.

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[25] This study acknowledges the debate around using parametric tests on Likert scale data. While principled stances such as Jamieson (2004, p. 1217) forbid conducting parametric analyses on ordinal data as "intervals between values cannot be presumed equal," empirical studies of the robustness of tests of central tendency, including t-tests and ANOVA, find that parametric tests on differences in means for sample sizes greater than 5 show robustness with respect to ordinality and non-normality (Norman, 2010; Boneau, 1960; Pearson, 1931). In addition, Wilcoxon signed-rank tests were also conducted with similar results, enhancing confidence in the parametric test outcomes.

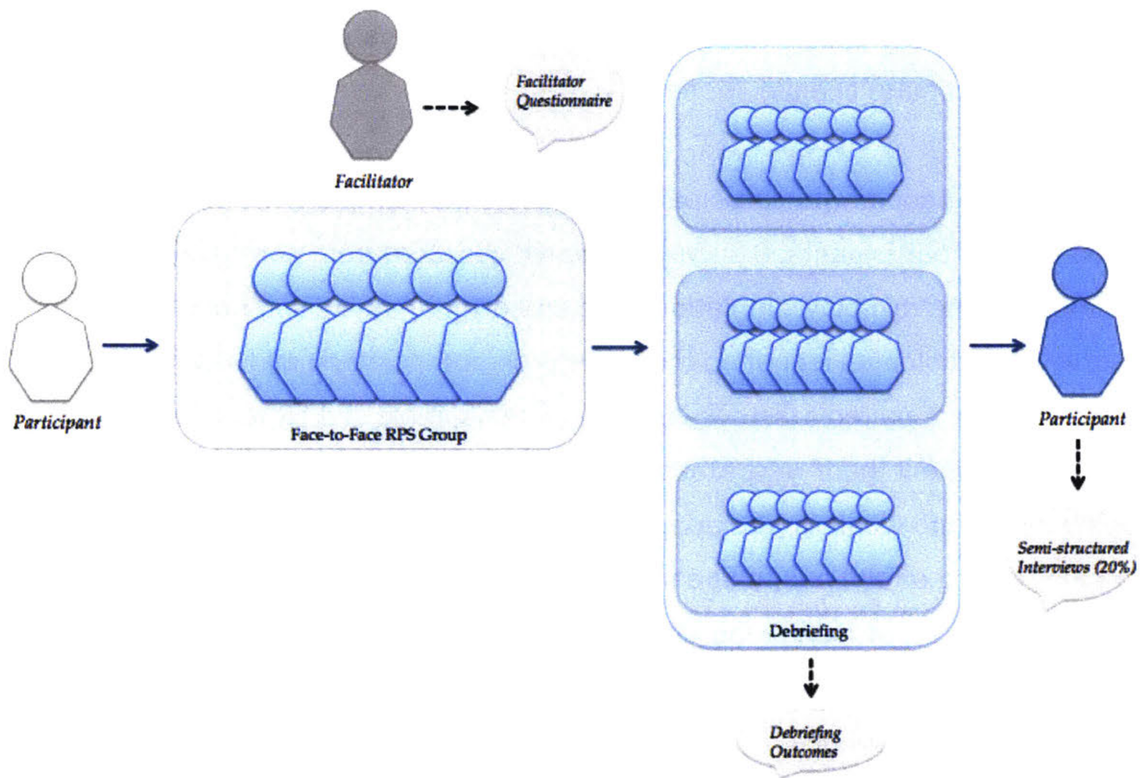

Figure 6.2. Overview of Face-to-Face Role-Play Simulation and Data Collection

Additional data collected during and after the role-play simulation were used to triangulate the pre-/post-survey results (Creswell & Clark, 2007), and provide a richer narrative with qualitative evidence on how the role-play simulation impacted participants' views of climate risks and local climate adaptation planning efforts.

First, each role-play simulation group (consisting of six participants) had a trained facilitator aiding the group in collectively constructing a policy recommendation. Each facilitator filled out a questionnaire with their observations of their group's outcomes, which process- or substance-related arguments carried weight in their group, and how different stakeholders worked to craft the final policy bundle of choice within the role-play simulation. The facilitator questionnaire is in Appendix F.

Second, when all participants at the workshop gathered back to debrief the game results and step back into their real-life roles as residents of Cambridge to discuss how the game principles apply to their community, extensive notes were taken during the debriefing for subsequent qualitative analysis. During the debriefings, participants reflected on what happened at their group in terms of process and substance, compared their results to that of other groups within the entire workshop population, and related the game to their own realities in in terms of local climate risks and opportunities in and barriers to climate adaptation planning in Cambridge. The debriefing script is in Appendix G.

Third, semi-structured interviews were conducted with 21 (about 20%) role-play simulation participants, to not only measure learning outcomes over time, but also to examine if and how the face-to-face role-play simulation modified their perceptions of climate risks and local climate adaptation planning priorities. The interviews typically took about 30 minutes to an hour each. The interviews were recorded, transcribed, and coded to identify patterns within interview responses and extract quotes exemplifying key themes. The semi-structured interview questions are in Appendix H, and findings from the interviews are presented in the following section.

Results

Table 1 below compares the role-play simulation participant sample characteristics with the city of Cambridge's statistics. Compared with Cambridge's citywide statistics, the role-play simulation participant sample skews to older, more politically liberal, more educated, and relatively higher-income residents.

Table 1. RPS Workshop Sample Characteristics (n=112)

Variables		**RPS Workshop Sample**	**City[26] Statistics**
Gender	Male	47.6%	48.4%
	Female	52.4%	51.6%
Age	19 or under	1.0%	18.1%
	20-29	13.5%	30.5%
	30-39	18.3%	18.1%
	40-49	15.4%	9.7%

[26] 2010-2014 American Community Survey 5-Year Estimates, U.S. Census Bureau (2015)

	50-59	21.2%	8.4%
	60+	30.8%	15.3%
Political Viewpoint[27]	Conservative	11.5%	26.7%
	Moderate	7.7%	36.6%
	Liberal	80.8%	32.5%
Education	High school graduate (or equivalent)	2.9%	9.3%
	Some college or associate's degree (AA)	2.9%	9.9%
	Bachelor's degree (BA, BS, AB, etc.)	24.0%	29.5%
	Master's degree (MA, MSc) Professional or doctoral degree (MD, PhD, etc.)	70.2%	45.2%
Industry	Agriculture, forestry, fishing and hunting, mining	0%	0.2%
	Construction	3.1%	0.9%
	Manufacturing	1.0%	5.4%
	Wholesale trade	0%	1.1%
	Retail trade	0%	5.4%
	Transportation, warehousing, and utilities	2.1%	1.6%
	Management and administrative services	3.1%	20.5%
	Information, finance, insurance, real estate	13.5%	9.9%
	Educational services and healthcare	36.5%	41.8%
	Arts, entertainment, recreation, hospitality	3.1%	6.4%
	Public administration	5.2%	3.2%
	Other	32.3%	3.7%
Household Income[28]	Less than $14,999	3.5%	13.0%
	$15,000 to $24,999	10.3%	7.2%
	$25,000 to $34,999	2.3%	6.7%
	$35,000 to $49,999	5.8%	8.6%
	$50,000 to $74,999	12.6%	14.0%
	$75,000 to $99,999	12.6%	12.3%
	$100,000 to $149,999	25.2%	16.6%
	$150,000 or more	27.6%	21.6%

27 Statewide (MA) statistics from Gallup State of the States 2015 used as proxy for city statistics

28 Workshop sample n = 94 for optional question on household income; city statistics given in 2014 inflation-adjusted dollars.

Role-Play Simulation Outcomes

A total of twenty groups of six roles each participated in the role-play simulation in the workshops held. Out of the twenty groups, 12 groups reached unanimous agreement on a final policy recommendation to city officials in Mapleton within the allotted game sessions, while five groups had five out of six participants agree with the final recommendations voted on, and three out of the twenty groups did not reach agreement. In terms of the policy approaches selected to manage the health impacts of climate change, emergency preparedness was the most popular (15; out of 20 groups total), and prevention was a close second (12; out of 20 groups total).

According to the facilitators that guided the groups through the role-play simulation exercise, several substance and process factors impacted their groups' outcomes in particular. In terms of process, many facilitators noted that their groups mostly consisted of participants invested in the role-play simulation, and in their group's success. One facilitator remarked that he had worked with a "congenial group overall," and his group shared an "early agreement that something had to be done." Another facilitator stated that her group had been "generally cooperative and interested in reaching consensus," and "coalitions formed early on in the group for each of the two [policy] priorities that prevailed, which helped focus the discussion."

In addition to the facilitators, some groups had participants exhibiting political leadership, or "people help[ing] shepherd others to [the] outcome." One facilitator described the "shepherding" as the following: "a couple of proactive participants would note out loud when it seemed like there was relative consensus (or minimal opposition) to a particular strategy as we moved down the list, making the ultimate process of formulating agreement relatively smooth and easy because they had already noted a number of common interests and positions."

All groups reached agreement after modifying the proposed options and creatively adapting the strategies to meet the group's interests, or in one facilitator's words, "hybridization and specialization of strategies." Another facilitator noted that funding sources carried weight at his table in reaching the final outcome, remarking that his table “only reached a solid agreement after mentioning the evolving or adapting nature of funding,” and emphasized that his group’s policy recommendations were very much reliant on funding outcomes.

Several themes emerged during the debrief sessions of the role-play simulation workshops, in which participants related game dynamics to their real-life situations as residents in Cambridge.

1. Approximately half of the participants indicated that they had never thought about the public health impacts of climate change prior to the role-play simulations. For those more skeptical or less willing to act on the findings of environmental science, alleviating the health impacts of climate change offered a tangible benefit of taking action, facilitating greater consensus among participants. One participant commented that focusing on public health helped to connect climate research and activism by blending science, policy, and social justice. Furthermore, because health is something all people can relate to and identify with, a focus on public health adds value to public engagement on climate policy by making the impacts of climate change seem more tangible.
2. Participants argued that a shift in public opinion of climate change is necessary to facilitate climate adaptation planning. In three of the six workshops held, at least one participant noted the similarities in shifting the public perception of climate risks and smoking in the 20^{th} century. It takes substantial effort and time to alter public perceptions of health risks and furthermore, encourage people to adjust their personal and political choices. In this sense, participants thought highlighting the health risks of climate change could help illustrate the dangers of inaction in climate adaptation.
3. Public health is an effective framing mechanism to motivate climate action. They discussed that public health is an effective frame for communicating the severity of climate change and the urgency to mitigate and prepare for it. Participants have noticed the positive ways in which the frame communicates that climate change is a local issue, and how the frame connects it to quality-of-life issues, which are easier for the general public to understand. This frame can help with outreach and

connecting to more members of the population. In addition, the public health frame of climate change emphasizes the negative health outcomes occurring now, heightening a sense of temporal proximity.

4. A public health focus highlights the disproportionate impacts on low-income and vulnerable populations. Participants mentioned that focusing on public health was a relevant way of thinking about how climate change will affect these populations, and how public policies and investments are critical to protecting the most vulnerable community members from the health risks of climate change. Some participants expressed that they have the social and financial capital to reduce risks for themselves, but are concerned their neighbors do not. Thus, they argued that the city of Cambridge should help the most vulnerable prepare for climate change, and this shared responsibility should be reflected in a common financial burden to ensure collective well-being.
5. Participants recognized that climate change is causing both short- and long-term impacts on health, and expressed a near universal acceptance that local climate adaptation planning should seek to both mitigate the anticipated short-term public health impacts of climate change, while planning for long-term community needs in the context of shifting environmental conditions. One participant noted that the focus on public health highlighted the need to think about short-term responses to the health risks today, and not just the long-term mitigation of climate change likely to arise in the future. All groups included some focus on emergency preparedness to address the short-term impacts on health, and most included additional strategies to mitigate longer-term impacts.
6. Participants believed that climate adaptation would be most effective if the city works with existing community organizations, such as institutions of faith, community-based organizations, and tenant associations to strengthen resilience and improve public health outcomes. In addition, climate change poses an opportunity for strengthening community ties. Many of the creative strategies that emerged from the role-play simulation included collaborative initiatives with local businesses and universities to spur innovation in climate adaptation. Furthermore, participants also noted that health is already a focus across different government functions and scales, and a

focus on the health impacts of climate change can help provide government agencies and staff a focus to gravitate towards.

7. Participants argued that local governments and residents need to be well informed of the local climate risks and relevant health impacts to make appropriate decisions. A focus on public health also drives an interest in city-supported means for helping the public protect themselves. Many participants noted that public information is a critical component of emergency preparedness.
8. Many participants discussed the importance of co-benefits, such as public space improvements with health benefits, in identifying strategies to recommend. Strategies with co-benefits address more than one issue and can be viewed as win-wins. Participants stressed prioritizing the numerous opportunities to adapt while increasing social capital and beauty. Other strategies with co-benefits suggested were green infrastructure projects and partnering with universities to run pilot programs that could be replicated elsewhere in the city. Participants agreed that Cambridge should strive to find solutions that build on community assets, improve the urban landscape, and make the city a more enjoyable and desirable place to live.

Post-RPS Interviews

Role-Play Simulation Experiences

Out of the 21 role-play simulation workshop participants interviewed, a majority found the role-play simulation interesting and enjoyable. Furthermore, some articulated in detail how the role-play simulation helped them learn about climate adaptation planning within their own city.

Many participants remarked that they gained process-based knowledge of how planning and policymaking works in a city like Cambridge through the role-play simulation. One participant described the dynamics within her role-play group and how they contributed to her learning about multi-party stakeholder dynamics in the public context: "One person took their role very strongly, and was not going to be moved. I was struck by how effective that person was in blocking further progress." She then explained that her group persevered in trying to "find interesting strategies to attempt to join interests, rather than have something that was solely divisive." As a result, she "got a sense that even with intractability, you can work to find shared concerns." Another participant noted that he "found the discussion of figuring out how we were going to compromise" and "the give and take, and forming alliances around issues to be very interesting." Finally, one participant remarked that "what playing the game did for me was to help me understand again how important activism is, because the wheels of bureaucracy don't turn quickly," and described how she reflected on her role within these processes in the city of Cambridge, noting that "the idea of doing these role-play processes is very powerful... what kind of an impact can we have?"

In addition, participants stated that the role-play simulation was a valuable perspective-taking exercise. A participant elaborated on the process, stating: "Being there, being a participant made you set aside your own perspective and think about it from the character you were playing." For instance, one participant remarked, "articulating the positions of the Chamber of Commerce forced me to learn about relevant interests." Another participant said, "I think the low-income housing representative had strong feelings about things I wouldn't have thought were important before."

Finally, participants remarked on how the role-play simulation helped them learn from and about their fellow residents of Cambridge. In particular, seeing other residents interested and engaged in the issues presented in the role-play simulation stuck out to many. One participant remarked, "It highlighted there are a lot of interested stakeholders who want to be engaged, which is positive. Normally it is hard to find a lot of people engaged in science, but it seems like there are a lot of people that are interested in climate risks in Cambridge, and that's something the city should take note of as they craft their preparedness plan, that they have a lot of stakeholder support." There were several participants that noted the role-play simulation exercise stoked their pride for their city, such as one remarking, "I have deep affection that this [role-play simulation workshop] is happening. I'm proud to be from here!" Another commented that other cities in the U.S. benchmark Cambridge's initiatives, saying: "Cambridge is such a highly visible city. People pay attention to what happens here." The place identity and attachment of the city's population seems to be an important strength on which future climate adaptation planning and policymaking efforts should build.

However, as the role-play simulation is a simplification of the real world, some participants pointed out that certain elements felt less than real. Some participants felt that the role-play simulation presented unrealistic goals of collaboration or a group gathering to reach agreement. One participant went on to say, "In the context of any type of collaboration, it can only happen if parties are working in good faith. It's simply not possible to work with climate change deniers. That's the nature of the problem." Another participant said that she felt the role-play simulation was unrealistic because the goals were already set, as "it's really easy to work with people as long as the goal is set."

Also, several participants commented on how role-playing is much easier for certain people than others. One participant, a scientist in real life, remarked that he found it particularly difficult to play the role he was assigned. He stated, "I speak from facts and logic, and I can't pretend to be a role that doesn't do that." Another participant observed that some of her fellow participants found stepping into the roles easier than others: "If you didn't have the personality for the role, it made it more difficult. [...] To the average person not used to drama, it can be challenging."

Lastly, one participant mentioned that she noticed a certain demographic to be more likely to attend the role-play simulation workshops, saying: "I don't think the people in the room represented a cross-section of 'Mapleton.' [...] I think everyone in the room was a fairly privileged, articulate, educated person. There was some racial diversity, but I don't think it is representative of Cambridge." This serves to underscore the difficulties of overcoming the "usual suspects" dilemma in public engagement.

Public Health Impacts of Climate Change

Most participants interviewed thought that climate change should be framed as a public health challenge, but some strongly opposed this frame.

People supported the use of the health framing of climate change or an emphasis on the health impacts of climate change for different reasons. One participant advocated for additional information and engagement initiatives focused on the health impacts of climate change from a right-to-know principle: "I know it may seem alarmist to some people, who are not open to hearing about the health risks that climate change poses, but I think everyone has the right to be aware of health impacts that may threaten your health, and individuals are best equipped to take care of themselves or take actions to lessen the risks."

Others pointed to the potential of the health frame of climate change to resonate with people in terms of what they already think is important in their lives. One participant working with vulnerable populations argued, "When you go to communities and start talking about the things that concern them, issues like asthma resonate. That affects people very tangibly. It affects more low-income, people of color, poor housing conditions, etc. By starting with what concerns people, and helping to address it immediately, you can also broaden into other areas."

Finally, many participants interviewed pointed to how they thought the health frame of climate change could politically motivate fellow residents on climate adaptation planning. In particular, the interviewees noted that despite public engagement efforts to communicate climate risks to the public, a substantial portion of the public (about 30%, according to Leiserowitz et al., 2013) remain disengaged or dismissive about climate change. In this landscape, one interviewee specified the health frame's efficacy in transcending the skepticism around climate change: "I'm very hopeful that people are willing to talk about climate change in ways that seem to disengage the 'shields' that have been built around it in the last 8-10 years, where some people in certain fields just don't want to listen to anything about it anymore. But I think health is way to maybe get around that."

This interviewee went on to explain that he realized other people were just as interested in climate change for health and well-being reasons as well: "I was encouraged that there are other people saying, 'The reason I'm interested in climate change is because I'm interested in the health of my children.' And I'm not about climate change as my first goal. My first goal is a healthy environment for my children and for the animals on the planet, for the whole biosphere. And that's really what we're fighting for. For health."

One interviewee, also an environmental advocate in Cambridge, talked about an analogous experience in successfully using a public health framing for a campaign to reduce idling in cars and trucks: “In terms of public health, I thought of asthma. I would go to the drivers and say, ‘I’m concerned about asthma in our kids’ and people would say ‘Oh thank you’ and turn off their engines. If I said anything about climate change, the response would be much worse. The more we can put a face to all this stuff, the more powerful it is." She went on to say, "I find that talking about climate change in terms of health is a new idea to most people. When people hear about the co-benefits of reducing carbon emissions, they tend to roll their eyes because they think we’re talking about benefits occurring one hundred years from now, or how it’ll affect people in Bangladesh, and people think ‘Well, I have problems here today.’ So we talk about how these activities impact your health today, the air you breathe today, and the water you drink today."

Opponents of the public health frame had a variety of arguments. Some people interviewed wanted to highlight the risks of climate impacts more directly. One interviewee remarked, “New terms are needed. Public health is too clinical. Neighborhoods don’t even talk about rats, even though no one likes them. Discussing public health doesn’t help. We need to get to the specifics [of climate change].” Similarly, another interviewee argued, “’Public health’ is a weasel word used to not upset the populace. Don’t use that! Say what is real! This stuff is non-partisan if you help people understand what is involved and what will happen, in plain English. That will really have an impact.” It seems like the phrase “public health” conjures certain images to people, and how people think of the field of public health, and whether that influences how they perceive the health impacts of climate change will need to be further investigated.

Others felt that a public health frame would cause fear and disengagement. One interviewee explained that she intentionally chooses to discuss climate change with a select audience of like-minded friends or colleagues because she is afraid of scaring people away: “Doing things that make us fearful isn’t always helpful either… I only really talk about [health impacts of climate change] with my climate buddies because most people don’t really want to talk about it. It is so big, it is so devastating." Another interviewee emphasized that a public health frame needed to be coupled with what governments are doing to alleviate the health risks; otherwise, it would be better not to present just the dangers or the risks at all: "We need to keep stakeholders informed, but also with the assertion that the city is proactive and trying to keep ahead of these developments."

Finally, others felt that a frame of economic losses or property damage would be more effective. One interviewee asserted, "A better [framing] would be in terms of loss of property values. Flooded property becomes zero in value, a zero tax base. People will move away. If you can't sustain your city, then you don't have a city."

RPS Pre-Post Survey Analyses

As mentioned, statistical analyses were conducted on the before- and after- survey responses to gauge changes in cognition, affect, and behavior regarding local climate adaptation planning in Cambridge from participating in the face-to-face role-play simulation. The results are as follows.

Perceived knowledge of climate risks

Participants stated they were more knowledgeable on climate risks after the role-play simulation (2.7 ± 0.08 levels, out of 3 levels ranging from 1 = "I have never heard of it" to 3 = "I know a great deal about it") compared to before (2.62 ± 0.1 levels, out of 3 levels ranging from 1 = "I have never heard of it" to 3 = "I know a great deal about it"); a statistically significant increase of 0.07 (95% CI, 0.012 to 0.135) levels, $t(108) = 2.36$, $p = 0.01$, $d = 0.226$. These results are presented in Figure 6.3 below.

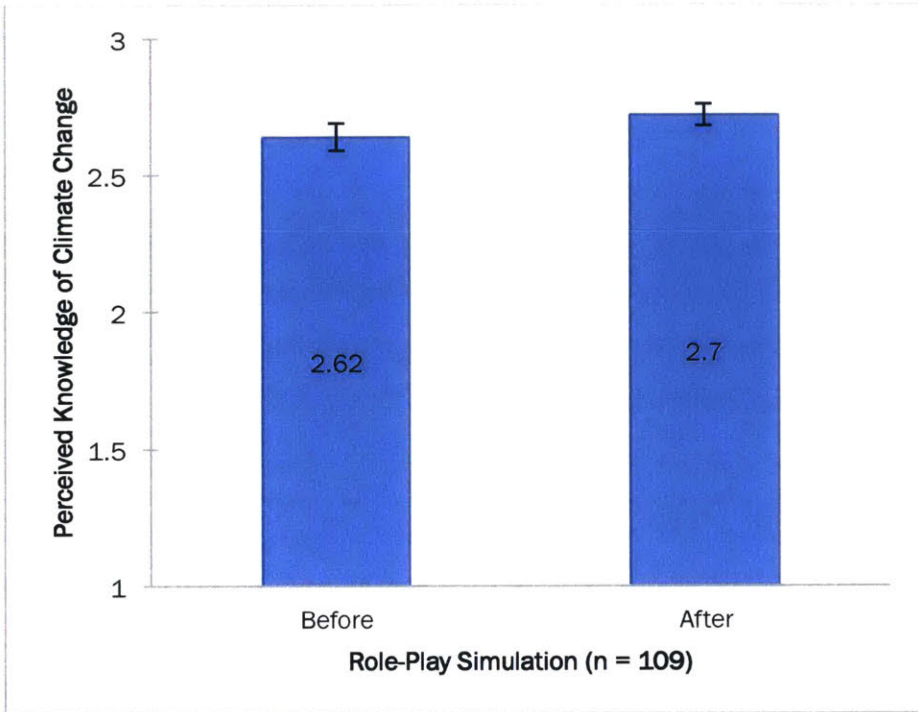

Figure 6.3. Effect of RPS on pre-post difference in perceived knowledge of climate change, before and after the RPS (mean ± sem)

Concern regarding local climate risks

Participants were more concerned about local climate risks in Cambridge after the role-play simulation (4.16 ± 0.16 levels, out of 5 levels ranging from 1 = "Not at all concerned" to 5 = "Very concerned") compared to before (3.9 ± 0.2 levels, out of 5 levels ranging from 1 = "Not at all concerned" to 5 = "Very concerned"); a statistically significant increase of 0.26 (95% CI, 0.063 to 0.455) levels, $t(111) = 2.62$, $p = .005$, $d = 0.25$. These results are presented in Figure 6.4 below.

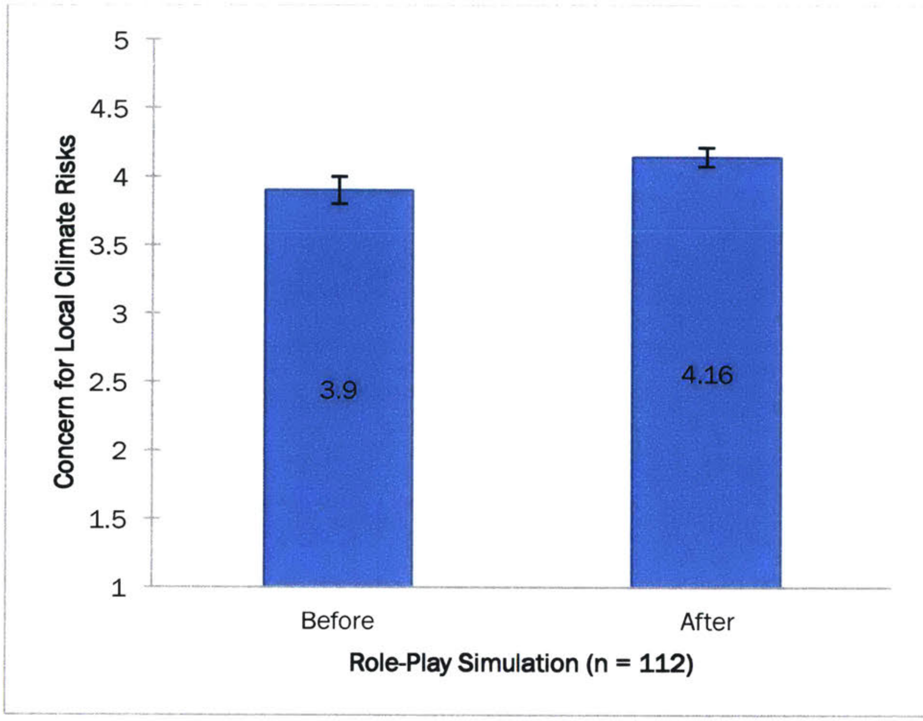

Figure 6.4. Effect of RPS on pre-post difference in stated concern for local climate risks, before and after the RPS (mean ± sem)

Confidence in community's ability to plan for climate change

Lastly, participants were more confident in the city of Cambridge's ability to effectively implement climate adaptation planning efforts after the role-play simulation (2.77 ± 0.22 levels, out of 5 levels ranging from 1 = "Not at all confident" to 5 = "Very confident") compared to before (2.55 ± 0.23 levels, out of 5 levels ranging from 1 = "Not at all confident" to 5 = "Very confident"); a statistically significant increase of 0.214 (95% CI, 0.006 to 0.423) levels, $t(55) = 2.057$, $p = .022$, $d = 0.275$. These results are presented in Figure 6.5 below.

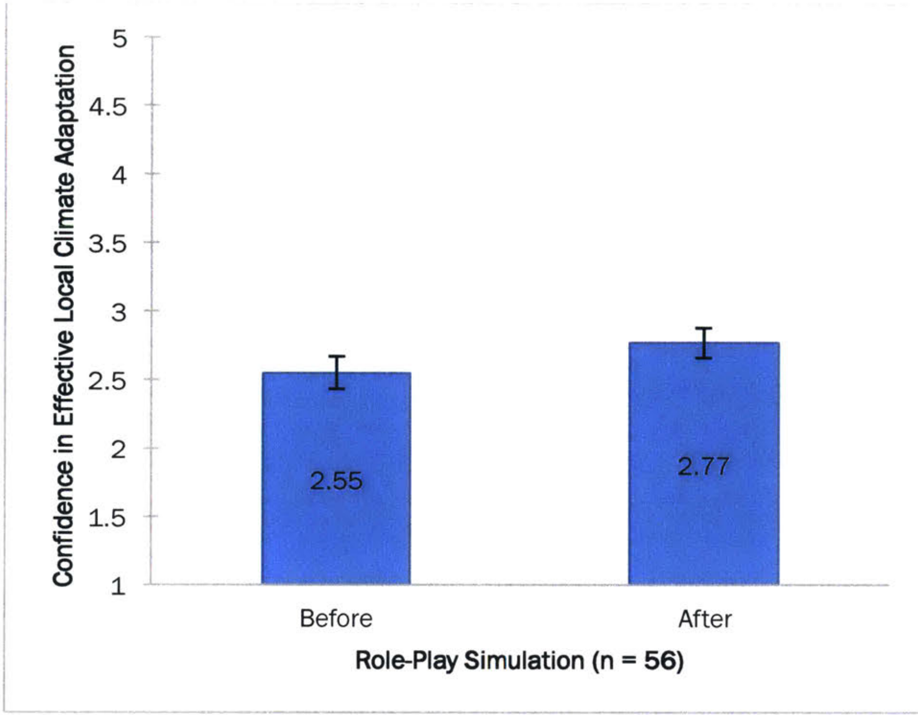

Figure 6.5. Effect of RPS on pre-post difference in confidence in effective local climate adaptation, before and after the RPS (mean ± sem)

All other paired t-tests conducted to determine whether mean increases before and after participating in the role-play simulation for the levels of perceived threat from climate change (Q2), support for Cambridge incorporating 50 year climate projections into planning decisions (Q5), and willingness to pay higher taxes for climate adaptation (Q6), were statistically insignificant.

Effects of Role-Play Simulation on Key Dependent Variables

Table 2 below sums up the main effects of the role-play simulation on key dependent variables. As noted above, on average, participants showed statistically significant increases in their perceived knowledge of climate change, concern for local climate risks, and confidence in the city of Cambridge's ability to effectively plan for the impacts of climate change after playing the role-play simulation, when compared to before participating in the role-play simulation.

Interestingly, the participants also unexpectedly showed a statistically significant decrease in their average level of agreement with the following statement: "The city of Cambridge should incorporate projections of what the climate might be like in 50 years in everyday planning and infrastructure decisions." Needless to say, this is a puzzling and counter-intuitive result. Does the statement signify a reliance on accurate and reliable climate data to emerge, and make people nervous about a delay in climate action? More research is called for to investigate why playing a role-play simulation focused on the health impacts of climate change within their community might result in feeling less strongly about local governments using climate projections in their planning processes.

Table 2. Main Effects of RPS on Key Dependent Variables

Dependent variables (n = 112)	**Role-Play Simulation Δ Post-Pre**	**Cohen's *d***
Perceived knowledge of climate change (1-3)	**0.073*** (0.031)	0.226
Perceived personal threat of climate change (1-5)	0.008 (0.051)	0.016
Concern for local climate risks (1-5)	**0.259**** (0.099)	0.247
Confidence in city's effectiveness in climate adaptation[29] (1-5)	**0.214*** (0.104)	0.275
Agreement with city incorporating climate risks into everyday planning (1-5)	**-0.128*** (0.058)	0.21
Willingness to pay higher taxes for climate adaptation (1-5)	-0.083 (0.076)	0.104

Note: Standard errors in parentheses. All mean comparisons significant at *p<0.5 (bold face), **p<0.1 (bold face), ***p<0.01 (bold face). Unequal variances assumed (t-test). Cohen's *d* is a standardized measure of effect size; values between 0.3 and 0.6 are considered "moderate" effect sizes in behavioral sciences (Cohen, 1988).

Effects of Role-Play Simulation on Key Dependent Variables by Political Viewpoint

Table 3 below shows the effects of the role-play simulation on key dependent variables by political viewpoint. Research has shown that political orientation is the biggest determinant of belief in climate change (Hornsey et al., 2016) and that we are likely to selectively pick

[29] n=56

data most consistent with our political outlooks (Kahan et al., 2012; Kahan, Peters, Dawson, & Slovic, 2013). Accordingly, public engagement tools in climate education and engagement that lead to changes not only in moderates and liberals, but also in conservatives are crucial (van der Linden, Leiserowitz, & Maibach, 2016).

In terms of baseline means before playing the role-play simulation, conservative participants had the lowest means for perceived knowledge of climate change (2.2 vs. 2.57 and 2.64), concern for local climate risks (3.2 vs. 3.43 and 4.0), and confidence in their community to effectively plan for and respond to climate change (2.0 vs. 2.75 and 2.61). However, we can also see that politically conservative participants also showed the largest increases in perceived knowledge of climate change (0.2 vs. 0.143 and 0.07), concern for local climate risks (0.2 vs. 0.143 and 0.281), and confidence in their community to effectively plan for and respond to climate change (0.33 vs. 0.25 and 0.2). Therefore, the role-play simulation is not only effective in increasing conservative participants' thinking and feeling around local climate adaptation planning, it is arguably also most effective among conservatives, when compared to its effects on politically moderate and liberal residents.

Table 3. Main Effects of RPS on Key Dependent Variables by Political Viewpoint

Baseline pre-RPS means (average treatment effect)	**Average (n=112)**	**Conservative**	**Moderate**	**Liberal**
Perceived knowledge of climate change* (1-3)	2.624 (+0.073)	2.2 (+0.2)	2.57 (+0.143)	2.64 (+0.07)
Perceived personal threat of climate change (1-5)	4.446 (+0.009)	3.6 (+0.0)	4.14 (+0.143)	4.55 (+0.022)
Concern for local climate risks** (1-5)	3.901 (+0.259)	3.2 (+0.2)	3.43 (+0.143)	4.0 (+0.281)
Confidence in city's effectiveness in climate adaptation*[30] (1-5)	2.554 (+0.214)	2.0 (+0.33)	2.75 (+0.25)	2.61 (+0.2)
Agreement with city incorporating climate risks into everyday planning (1-5)	4.8 (-0.128)	4.6 (-0.4)	4.86 (-0.43)	4.84 (-0.11)
Willingness to pay higher taxes for climate adaptation (1-5)	3.862 (-0.083)	3.2 (-0.4)	3.0 (-0.143)	3.99 (-0.081)

Note: Dependent variables with asterisks have mean increases significant at *p<0.5,**p<0.1, ***p<0.01.

[30] n=56

Effects of Role-Play Simulation on Different Types of Learning

Table 4 depicts how the participants measured the relative amounts of learning in different dimensions of climate adaptation planning from the role-play simulation. We can see from the first column (Average) of Table 4 below, that the average participant said the role-play simulation helped them the most in learning about the viewpoints of different stakeholders in dealing with climate change in Cambridge (2.83), then imagining how stakeholders in Cambridge could reach agreement on how to proceed with climate adaptation (2.8), and finally, the health impacts of climate change. It is interesting to note that participants felt they learned the most about the views of other stakeholders, and the least about the health impacts of climate change (2.79).

For the substantive learning about the health impacts of climate change, we can see that politically liberal participants said to have learned the most, then the moderates, and finally the conservative residents. For learning about the various views of stakeholders in local climate adaptation planning, however, we can see that moderates said to have learned the most, and conservatives the least. Finally, for improving residents' ability to imagine how stakeholders in Cambridge could reach agreement on how to proceed with climate adaptation, we see a similar pattern, where moderate Cantabrigians stated to have experienced the most learning, then liberal residents, and conservatives last. These differences are visualized in Figure 6.6 below.

We can see that conservative Cambridge residents consistently stated on the after-surveys that they learned less than residents of other political viewpoints, which only accentuates the relatively large shifts in their perceived knowledge of climate change, concern for local climate risks, and confidence in the city of Cambridge's ability to effectively plan for the impacts of climate change after playing the role-play simulation, when compared to the shifts seen in moderate and liberal participants. The results suggest that conservative Cambridge participants may have discounted the amount of learning from counter-attitudinal material presented in the role-play simulation and discussed in concert with stakeholders with other viewpoints, but nonetheless, exhibited the largest increases in terms of perceptions of local climate risks and support for climate adaptation planning and policy action.

Table 4. Effects of RPS on Different Types of Learning by Political Viewpoint

Perceived learning (1-5)	Average (n=112)	Conservative	Moderate	Liberal
Health impacts of climate change	2.79	2.33	2.75	2.83
Views of other stakeholders in climate adaptation planning	2.83	2.33	3.25	2.83
Reaching agreement in climate adaptation planning	2.8	2	3	2.83

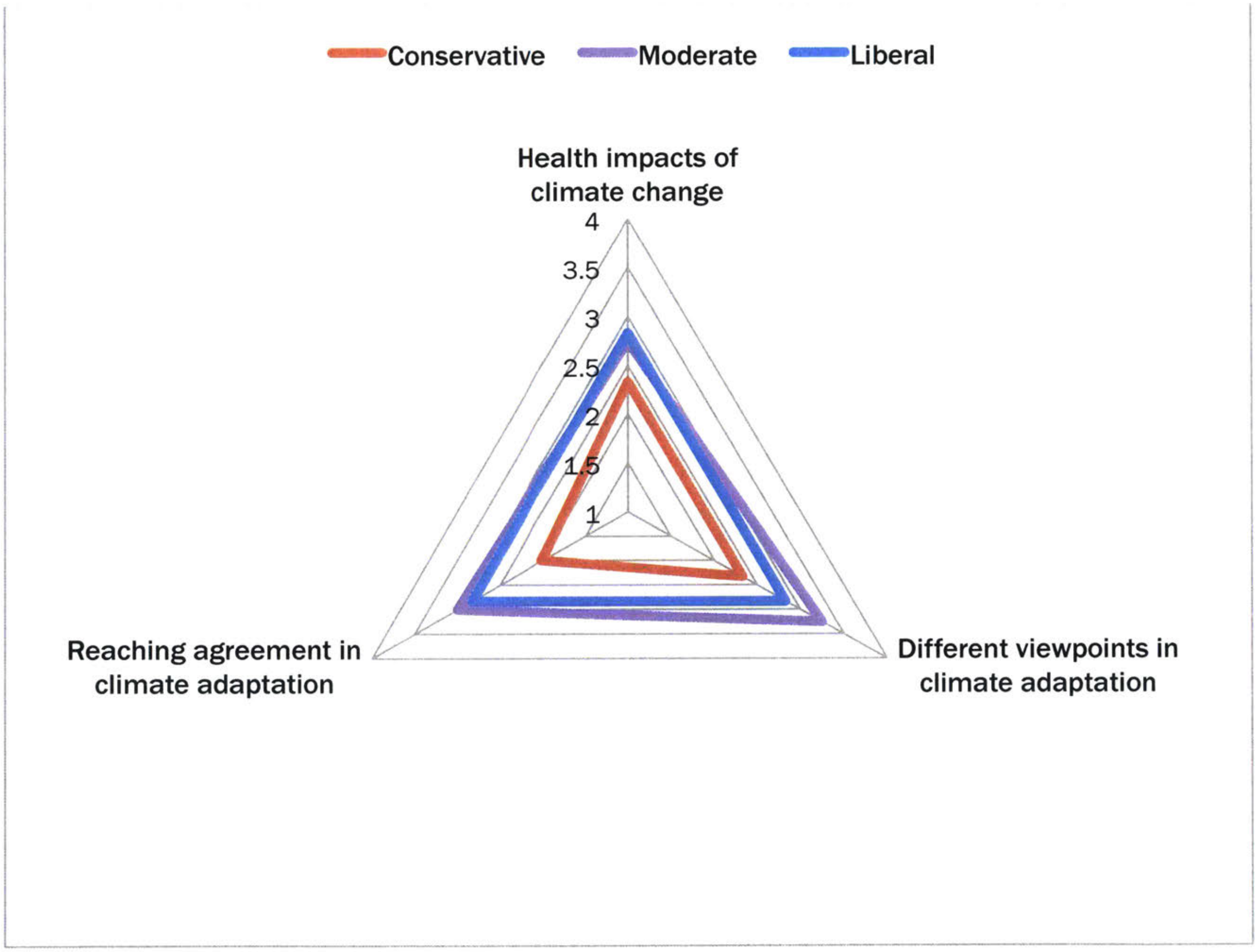

Figure 6.6. Effects of RPS on Different Types of Learning by Political Viewpoint

Prioritization of Local Climate Risks in Climate Adaptation Planning

Playing the role-play simulation also shifted participants' policy priorities on the actions the city of Cambridge should take to adapt to climate change. Table 5 below depicts the shift in the proportions of respondents' prioritization of local climate risks to focus on in their city's climate adaptation planning, before and after the role-play simulation. The percentages represent the proportion of the group that selected each risk as their first priority in Cambridge's management of climate risks. We can see a sizable shift in the sample's prioritizing the increased risks of disease and death, going from 14.0% to 41.9%, with a simultaneous decrease in prioritizing infrastructure damage from 60.5% to 34.9%, after the role-play simulation. All other marginal proportions are similar before and after the intervention. Results of a McNemar's test[31] show that the marginal proportions are statistically significantly different from each other (*Fisher's exact = 0.002).*

Table 5. Prioritization of Local Climate Risks in Climate Adaptation Planning, Before and After RPS

	Before	After
Individual property damage	2.3%	2.3%
Local business disruption	0.0%	0.0%
Increased risks of disease, hospitalization, and death	12.0%	41.9%
Disproportionate impacts to vulnerable populations	16.3%	16.3%
Water, energy, and transportation infrastructure damage	60.5%	34.9%
Watershed, forest, and ecosystem degradation	7.0%	4.7%
Total	100%	

Prioritization of Policy Approaches to Manage Local Climate Risks

Furthermore, the role-play simulation experience also shifted residents' preferred policy options for Cambridge to reduce climate-related risks. Table 2 below depicts the shift in the proportions of respondents' prioritization of policy approaches to manage local climate risks,

[31] The McNemar's test is a statistical test used on contingency tables with matched pairs of subjects, to determine whether the row and column marginal frequencies are equal. If the Fisher's exact score low enough ($p < 0.05$), this provides sufficient evidence to reject the null hypothesis and state that the marginal proportions are statistically significantly different from each other.

before and after the role-play simulation. Similarly, the percentages represent the proportion of the group that selected each policy approach as their first priority in Cambridge's climate policy. We can see a sizable increase in residents' preferences for emergency preparedness as the preferred policy approach (30.7% versus 9.7%), with a smaller increase in rules and regulations (17.7% versus 9.7%). We also see a significant decrease in residents ranking prevention as best policy approach, going from 59.7% to 33.9%. All other marginal proportions are similar before and after the intervention. Results of a McNemar's test[32] show that the marginal proportions are statistically significantly different from each other (*Fisher's exact = 0.003).*

	Before	**After**
Information provision	12.9%	12.9%
Emergency preparedness	9.7%	30.7%
Resource allocation	8.1%	4.8%
Rules and regulations	9.7%	17.7%
Prevention	59.7%	33.9%
Total	100.0%	

Table 6. Prioritization of Policy Approaches to Manage Local Climate Risks, Before and After RPS

Limitations

This project has a number of limitations. First, the external validity of this study has limitations. The role-play simulation was designed and implemented in Cambridge, Massachusetts, a particular city within the Northeast, known for its high educational attainment and progressive politics. While Cambridge was picked partly for its early adapter status within climate adaptation in the United States, it is also important to note that the residents in Cambridge may or may not reflect how other members of the public in the

[32] The McNemar's test is a statistical test used on contingency tables with matched pairs of subjects, to determine whether the row and column marginal frequencies are equal. If the Fisher's exact score is low enough ($p < 0.05$), this provides sufficient evidence to reject the null hypothesis and state that the marginal proportions are statistically significantly different from each other.

United States learn about and engage with climate adaptation planning in their communities. Cambridge should be viewed as a friendlier place well-suited to attempting and testing the value of new methods in public engagement, such as role-play simulations, but nonetheless, overgeneralizations should be avoided, and much more work is needed to deploy and evaluate the effectiveness of role-play simulations as a learning and engagement tool in other cities.

Second, the role-play simulation participant sample does not represent Cambridge's overall population. In terms of demographics, compared with Cambridge's citywide statistics, the role-play simulation participant sample skews to older, more politically liberal, more educated, and relatively higher-income residents. Recruiting difficulties, along with the critiques that public engagement workshop participants are not demographically representative of the general population, have highlighted difficulties with scaling up face-to-face role-play simulations (RPS) for larger audiences. Additional time and resources for recruitment would enable more robust sampling processes in future research.

Lastly, both the qualitative and quantitative analyses are restricted to a limited set of factors. While this enables a more detailed investigation of the observed variables and facilitates causal inferences and theory-building, this study does not account for other variables that could influence public learning and engagement in climate adaptation planning.

Conclusion

This study analyzed the results of designing and implementing a face-to-face role-play simulation focused on the health impacts of climate change in Cambridge, MA. Playing the role-play simulation was associated with increases in perceived knowledge of climate change, concern for local climate impacts, and confidence in the city's effectiveness in local climate adaptation planning. While the role-play simulation attracted the least politically conservative residents (versus moderate or liberal), the conservative residents that participated showed the largest increases in perceived knowledge of climate change, concern for local climate impacts, and confidence in the city's effectiveness in local climate adaptation planning. In other words, the face-to-face role-play simulation effected transformative counter-attitudinal learning.

In addition, qualitative data collected during and after the role-play simulation point to the potential of role-play simulations to facilitate learning of process-based knowledge of how planning and policymaking works in a city like Cambridge, perspective-taking of different stakeholders in climate adaptation planning, and strengthening place identity and attachment of participants. Further research is called for in comparing role-play simulation-based dialogue and participation and more conventional public engagement practices in climate adaptation planning.

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Chapter 7

Digital Games

Background

Local governments need to devote considerable money, time, and attention to civic ties for traditional public engagement practices (Lowndes, Pratchett, & Stoker, 2001). However, traditional public meetings, or any other institutionalizations of public engagement, are limited in the extent to which they can serve as a learning venue, where the public can deepen their understanding of a policy issue (Evans-Cowley & Hollander, 2010). Mostly, people tend to attend to express their views and hear the views of others. As a result, much attention is now being given to engaging the public online, as the resources needed to engage in traditional public engagement pose much less of a barrier (Best & Krueger, 2005). In addition, promises of online forms of public engagement's ability to "elevat[e] the public discourse in an unprecedented manner while providing an interactive, networked environment for decision-making" abound (Evans-Cowley & Hollander, 2010, p. 397).

In parallel, the education field has turned to various forms of engaging and educating people online. Digital learning games are hugely popular. In the United States, 63% of households has at least one person who plays video games regularly, or 3 hours or more per week (ESA, 2017). Digital learning games are defined as "an entertainment medium designed to bring about cognitive changes in its players" (Erhel & Jamet, 2013, p. 156), characterized by having both elements of serious learning and interactive entertainment (Erhel & Jamet, 2013; Prensky, 2003). Factors such as rules and constraints, dynamic responses to players' actions, appropriate challenges inducing perceived self-efficacy, and gradual increases in difficulty have been found to contribute to digital game-based learning (Mayer & Johnson, 2010).

Whether digital games can and do actually facilitate deep learning is under debate (Graesser, Chipman, Leeming, & Biedenbach, 2009). According to Graesser et al. (2009), digital games have innate constraints that "make it extremely difficult to integrate deep content, strategies, and skills" (Graesser et al., 2009, p. 12). Scholars have called for further empirical analyses that examine the efficacy of digital games in catalyzing motivation and learning outcomes (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Gee, 2005; Prensky, 2001; Shaffer, 2006). While digital games' efficacy in motivating players is less debated, how much digital games contribute to players' learning, when compared with more conventional teaching methods, has yet to be resolved (Erhel & Jamet, 2013). Regardless, we do know that the learning effects of digital games are modulated by various factors, including individual player characteristics, such as prior knowledge, motivation levels, or learning styles (Tsai, Kuang-Chao, & Hsiao, 2012; Vogel et al., 2006), learning environment features (Erhel & Jamet, 2013; Ke, 2009; Vogel et al., 2006), and subject matter (Hays, 2005; Huang, 2011; Ke, 2009; Randel, Morris, Wetzel, & Whitehill, 1992).

There are now many digital learning games that focus on climate change. A review conducted in 2015 found a majority of these games to be mini-games or simple simulations, geared towards younger audiences, such as NASA's *Climate Kids* (http://climatekids.nasa.gov). Most of these are also said to focus on climate mitigation practices (i.e. reducing greenhouse gas emissions) implementable in daily life, such as recycling or using public transit (Wu & Lee, 2015).

On the other hand, there are a few serious climate change games geared towards adults that are quite complex. These center on understanding the long-term impacts of climate change, and emphasize the geophysical and sociopolitical dimensions of the process of climate change. Wu and Lee (2015) cite *Clim'way* as an example, which is akin to a Sim City for climate change. Players make decisions regarding infrastructure in their cities, and see the impacts of their actions over the course of 50 years (Wu & Lee, 2015). In Wu and Lee (2015)'s review, all the digital learning games they highlighted were designed to facilitate learning about the impacts of climate change or climate mitigation practices on daily life. Not one digital learning game was aimed at increasing public engagement in climate adaptation efforts, or delineating strategies for managing the risks associated with climate change within one's own neighborhood, community, or city (Wu & Lee, 2015).

Lee, Ceyhan, Jordan-Cooley, and Sung (2013) summarize research on factors contributing to effective digital learning games on climate change. In particular, they emphasize the importance of presenting actionable knowledge in the form of practical everyday steps for making a difference in players' lives. They argue that increasing understanding of the broad conceptions of climate change does not tend to lead to behavioral changes, and that digital learning games should tangibly connect the elements of climate change with realistic steps players can take to change their lifestyles (Lee et al., 2013).

In addition, Lee et al. (2015) point to the effectiveness of increasing empathy in digital games in effecting behavior change. They cite the findings of Kim, Hong, and Magerko (2010), where game participants were more willing to reduce home electricity usage after seeing the impacts of their behavior on a virtual coral reef's health (Kim, Hong, & Magerko, 2010; Lee et al., 2013). The efficacy of previous empathy-based digital learning games was incorporated into the design of the digital learning game in this study as well.

Gordon and Baldwin-Phillipi (2014) designed and implemented an interactive online game aimed at fostering trust and empathy in planning called Community PlanIt (CPI), centered on what the authors call "civic learning," or engagement coupling participation with reflection. Community PlanIt is a multiplayer game that takes several weeks, motivating players with points and influence over fellow players. After studying the use of Community PlanIt in a planning process in the Boston public school system and as part of master plan update in Detroit, Gordon and Baldwin-Phillipi conclude that an online game can provide citizens with a deeper form of public engagement by creating lateral, social trust among players (Gordon & Baldwin-Philippi, 2014).

Expanding on their studies of Community PlanIt in Boston and Detroit in 2014, Community PlanIt was deployed in a version called Community Planit: Climate Smart Boston, in a partnership between the city of Boston, the World Wildlife Fund, and Emerson College's Engagement Lab (headed by Gordon) in 2016. The game ran for three weeks in March to April 2016, presenting a different mission each week: Mission One highlighted global climate issues, Mission Two emphasized climate change at the city level, and the third mission was about what Boston residents can do within their own households. The game was aimed at widening the scope of public engagement, gaining a better sense of the needs and vulnerabilities experienced by businesses and residents, and increasing public awareness of the programs and services already in place to assist in dealing with climatic impacts in Boston. The efficacy of a tailored game acting as a social media platform for public engagement, and how a shared sense of community cultivated by the game contributes to climate change planning, is yet to be analyzed and reported.

Based on previous findings regarding effective digital game-based learning in climate change, the potential for digital games to enhance public engagement, and the apparent lack of digital games focused on climate adaptation planning, this study designed an interactive place-based game for residents in Cambridge, MA, with a focus on fostering empathy and presenting actionable steps for players. The digital game also highlights the health impacts of climate change and the potential for integration of the public health impacts within climate adaptation planning.

Methods

This study consisted of the following steps. Through the collaborative freelancing platform Upwork, a game development firm called Double Coconut was hired to design and develop a game according to design specifications provided. Double Coconut has expertise in developing educational games. A notable game they have designed is called HYDO Land, which aims to educate players about Huntington's disease. As with the face-to-face role-play simulation described in Chapter 6, the digital game was based on the technical results of Part I of the city of Cambridge, Massachusetts' Climate Change Vulnerability Assessment and highlights the likely public health impacts of climate change within the municipality. The game was developed with three aims: 1) reach a broader public than is possible with conventional public engagement workshops or face-to-face role-play simulation workshops, 2) utilize in-game mechanics to assess changes in the cognition, affect, and behavior of game players, and 3) collect and process participant learning data with greater speed and quality.

In the digital game, participants assume the roles of hypothetical Cambridge residents who are more at risk to the health impacts of climate change because of where they live, their age, income level, or occupation. The game focuses on the increased health risks posed by rising temperatures, reduced air quality, increasing extreme weather, expanding water-related illness, and decreased food safety. The Environmental Protection Agency (EPA) highlighted these risks in a series of fact sheets on the health risks of climate change published to enhance public awareness and understanding (EPA, 2016).

Figure 7.1 below shows the home screen, with the four characters game players can delve into. The participants can choose to learn about the characters in any order of their choosing. Each character represents a unique subpopulation vulnerable to a specific climate-related health risk.

Figure 7.1. Home Screen of Digital Game (from left to right: Jake, Cora, Sofia, Martin)

As mentioned before, aligning with best practices for digital game-based learning in climate change, this game focuses on providing personal accounts of the health impacts of climate change, along with actionable steps players can take in their everyday lives to reduce the relevant health risks, or actions players can take in a caretaker role to someone who faces these increased health risks.

Each character is presented with three phases, each with distinct learning goals in mind. The first phase introduces the character and their existing health conditions, the second explains how climate change could impact the character through increased health risks, and the third and final phase features various readiness “tools” or actions, with corresponding explanations, that represent ways of alleviating some of the risks for the chosen character. After playing each character, the game presents one true/false question to determine whether the game player learned about climate risks and how they might affect the health of the character the player just delved into.

Figures 7.2, 7.3, and 7.4 below show selected screens in each of the three phases for Martin, a retired architect with a history of heart problems, facing increased health risks from more frequent and intense periods of extreme heat. The other Cambridge residents featured in the game are Cora, a young child with asthma, Jake, an amputee veteran, and Sofia, a recent immigrant. Each of these characters faces increased health risks caused by climate change. Appendix I presents more detailed character descriptions and Appendix J presents each of the character screens used in the game.

Figure 7.2. Phase 1 of Martin

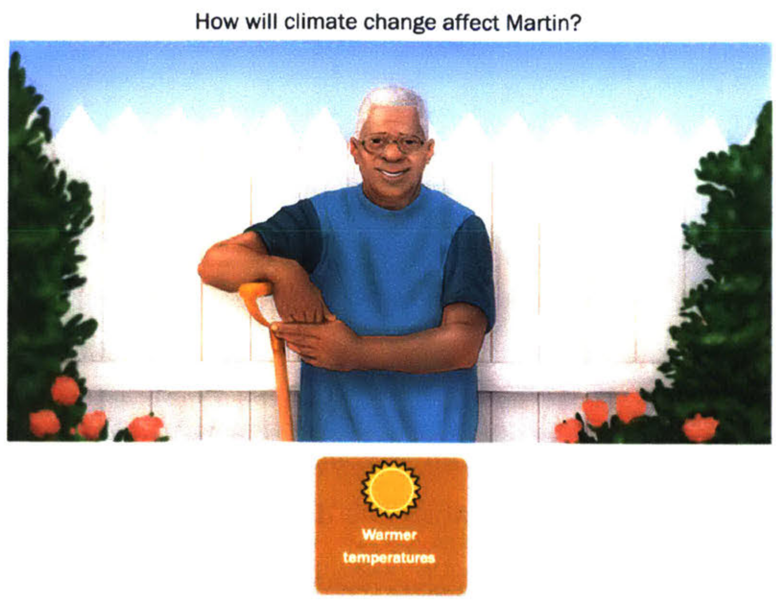

Figure 7.3. Phase 2 of Martin

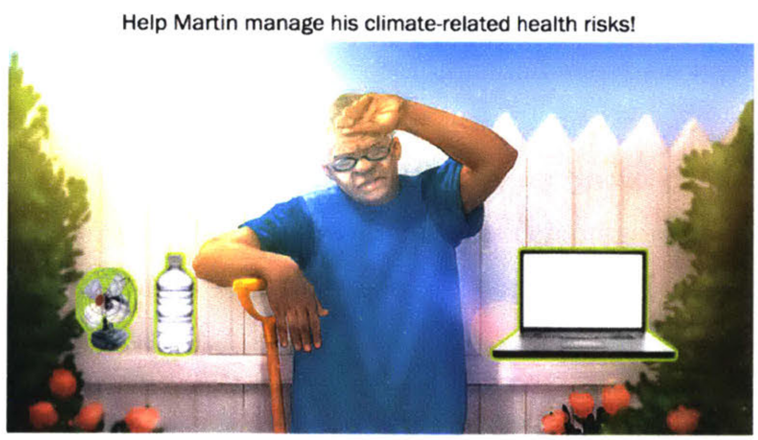

Figure 7.4. Phase 3 of Martin

From March 7, 2017 to May 2, 2017, during 57 days of game play, 229 players completed more than 10,400 game actions. These participants were primarily recruited online, either directly through social media platforms such as Facebook or Nextdoor, or through email advertisements from local partners and partner organizations, such as the Cambridge Community Development Department, Cambridge City Councilman Craig Kelley, and various neighborhood organizations, such as the Fresh Pond Residents' Alliance, Porter Square

Neighborhood Association, Agassiz Neighborhood Council, and Cambridgeport Neighborhood Association.

The digital game started by asking participants to fill out a before-survey of questions documenting their perceived knowledge of climate risks, their concern about climate impacts, and their policy priorities regarding local climate adaptation, among other things. The before-survey questions are in Appendix K.

After playing the digital game, the participants completed an after-survey, with the same questions from the before-survey, to gauge the extent to which the digital game shifted levels of local climate change cognition, affect, and behavior. Additional variables of interest are demographic variables and other correlates with environmental and climate change-related cognition and behavior. Finally, the last question asks for advice from game players regarding climate adaptation planning within their community with the question: "What specific actions would you recommend the City of Cambridge take to manage the risks of climate change?" The after-survey questions are in Appendix L.

The before- and after- surveys posed the following questions twice, to measure shifts in cognition, affect, and behavioral intentions regarding local climate adaptation in Cambridge, from playing the digital game highlighting the likely health impacts of climate change within their community:

a) a three-point Likert scale question gauging the level of perceived knowledge of global warming or climate change[33] [cognition]
b) a five-point Likert scale question gauging the perceived seriousness of the threat climate change poses[34] [affect]
c) a five-point Likert scale question gauging the level of concern for climate impacts on the city of Cambridge[35] [affect]

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[33] [34] validated and tested questions from Lee et al. (2015)
[35] validated and tested questions from Rumore et al. (2016)

d) a five-point Likert scale question gauging the willingness to pay higher taxes for Cambridge to reduce climate risks[36] [behavior]

e) a six-option question asking which climate risk the city of Cambridge should prioritize most in its climate adaptation policies [behavior]

Hypotheses

Compared to before participating in the digital game, participants are expected to have, on average, after playing the digital game:

a) a higher score on a three-point Likert scale question gauging the level of knowledge of global warming or climate change. [cognition]

b) a higher score on a five-point Likert scale question gauging the perceived seriousness of the threat climate change poses. [affect]

c) a higher score on a five-point Likert scale question gauging the level of concern for climate impacts on the city of Cambridge. [affect]

d) a higher score on a five-point Likert scale question gauging the willingness to pay higher taxes for Cambridge to reduce climate risks. [behavior]

e) a higher proportion of the respondents picking "increased risks of disease, hospitalization, and death" as the climate risk the city of Cambridge should prioritize in its climate adaptation policies. [behavior]

A unique ID was randomly generated for each IP address logged onto the game. Out of the total of 229 people who logged onto the game interface, 34 (14.9%) answered one or more of the before-survey questions, but played 0 of the 4 characters, 46 players (20.1%) played 1 of the 4 characters, 15 (6.6%) played 2 out of 4, 5 (2.2%) played 3 out of 4, and 129 (56.3%) players played all 4 characters to complete the game. Out of the 129 people who completed the game, 105 players completed the after-survey, providing demographic information and comparison points to their before-survey responses.

The game mechanics, in-game qualitative comments, the before- and after-survey results, and feedback on the game were used to assess the learning outcomes of playing the digital

[36] question adapted from the General Social Survey (GSS) on environmental behavior [GRNTAXES]

game. A series of paired t-tests[37] were run on the sample of up to 129[38] digital game participants that played all 4 characters to complete the game, and also completed both the before-survey and the after-survey, to determine if there were statistically significant differences in knowledge and concern about local climate risks and support for climate adaptation, before and after participation in the digital game focusing on the health impacts of climate change. The results are presented in the following section. A particular emphasis was on how participants of differing political viewpoints (conservative, moderate, liberal) showed differences in learning through the digital game experience.

In addition, semi-structured interviews were carried out with 2 digital game participants to examine if and how the digital game modified their perceptions of climate risks and local climate adaptation planning priorities. The interviews typically took about 30 minutes to an hour each. The interviews were recorded, transcribed, and coded to identify patterns within interview responses and extract quotes exemplifying key themes. The semi-structured interview questions are in Appendix M, and findings from the interviews are also presented in the following section.

Results

Table 1 below compares the digital game participant sample characteristics with the city of Cambridge's statistics overall. Compared with Cambridge's citywide statistics, the digital game participant sample skews to female, older, more politically liberal, and more educated residents.

[37] This study acknowledges the debate around using parametric tests on Likert scale data. While principled stances such as Jamieson (2004, p. 1217) forbid conducting parametric analyses on ordinal data as "intervals between values cannot be presumed equal," empirical studies of the robustness of tests of central tendency, including t-tests and ANOVA, find that parametric tests on differences in means for sample sizes greater than 5 show robustness with respect to ordinality and non-normality (Norman, 2010; Boneau, 1960; Pearson, 1931). In addition, Wilcoxon signed-rank tests were also conducted with similar results, enhancing confidence in the parametric test outcomes.

[38] 129 players completed playing the game; 105 players completed all the after-survey questions presented afterwards.

Table 1. Digital Game Sample Characteristics (n=105)

Variables		Digital Game Sample	City[39] Statistics
Gender	Male	28.6%	48.4%
	Female	70.5%	51.6%
Age	29 or under	7.7%	48.6%
	30-39	14.3%	18.1%
	40-49	19.1%	9.7%
	50-59	19.1%	8.4%
	60+	40.0%	15.3%
Political Viewpoint[40]	Conservative	21.9%	26.7%
	Moderate	19.1%	36.6%
	Liberal	59.1%	32.5%
Education	High school graduate (or equivalent)	1.0%	9.3%
	Some college or associate's degree (AA)	2.9%	9.9%
	Bachelor's degree (BA, BS, AB, etc.)	26.0%	29.5%
	Master's degree (MA, MSc, MBA, etc.) Professional or doctoral degree (MD, PhD, etc.)	88.5%	45.2%
Industry	Agriculture, forestry, fishing and hunting, mining	1.0%	0.2%
	Construction	1.9%	0.9%
	Manufacturing	0.0%	5.4%
	Wholesale trade	0.0%	1.1%
	Retail trade	1.0%	5.4%
	Transportation, warehousing, and utilities	10.0%	1.6%
	Management and administrative services	9.7%	20.5%
	Information, finance, insurance, real estate	8.7%	9.9%
	Educational services and healthcare	33.0%	41.8%
	Arts, entertainment, recreation, hospitality	7.8%	6.4%
	Public administration	8.7%	3.2%
	Other	28.2%	3.7%

Digital Game Pre-Post Survey Analyses

As mentioned, statistical analyses were conducted on the before- and after- survey responses to gauge changes in cognition, affect, and behavior regarding local climate adaptation planning in Cambridge. The results are as follows.

[39] 2010-2014 American Community Survey 5-Year Estimates
[40] Statewide (MA) statistics from Gallup State of the States 2015 used as proxy for city statistics

Perceived knowledge of climate risks

Participants stated they were more knowledgeable about climate risks after playing the digital game (2.63 ± 0.04 levels, out of 3 levels ranging from 1 = "I have never heard of it" to 3 = "I know a great deal about it") compared to before (2.58 ± 0.04 levels, out of 3 levels ranging from 1 = "I have never heard of it" to 3 = "I know a great deal about it"); a statistically significant increase of 0.05 (95% CI, 0.004 to 0.094) levels, $t(121) = 2.153$, $p = 0.017$, $d = 0.195$. These results are presented in Figure 7.4 below.

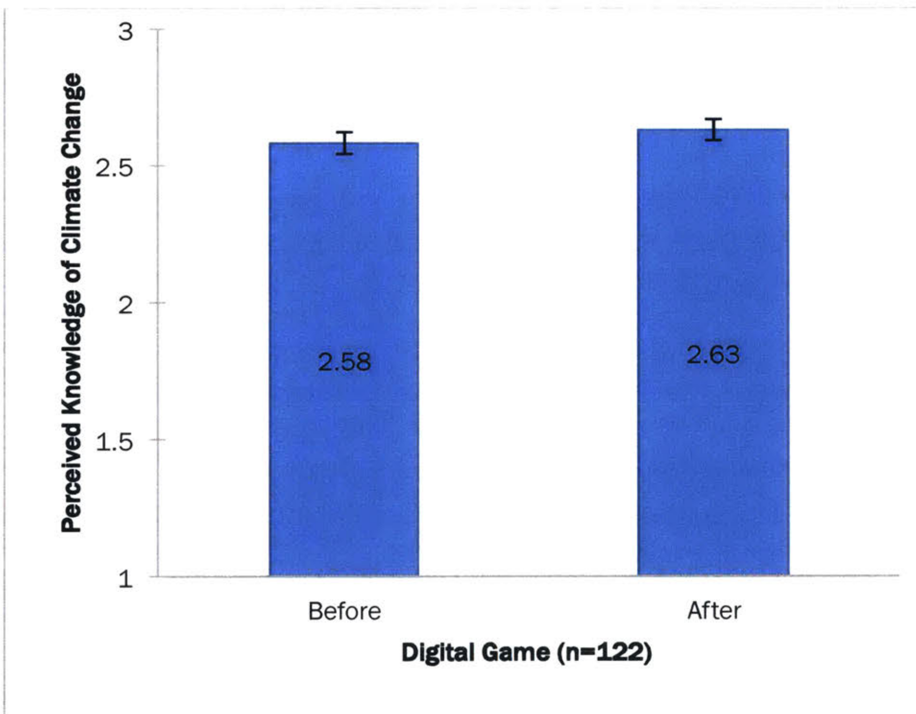

Figure 7.4. Effect of digital game on pre-post difference in perceived knowledge of climate change, before and after the game (mean ± sem)

Concern for Local Climate Risks

Participants were more concerned about local climate risks in Cambridge after the digital game (4.11 ± 0.08 levels, out of 5 levels ranging from 1 = "Not at all concerned" to 5 = "Very concerned") compared to before (3.93 ± 0.08 levels, out of 5 levels ranging from 1 = "Not at all concerned" to 5 = "Very concerned"); a statistically significant increase of 0.175

(95% CI, 0.082 to 0.268) levels, $t(119) = 3.74$, $p = 0.0001$, $d = 0.34$. These results are presented in Figure 7.5 below.

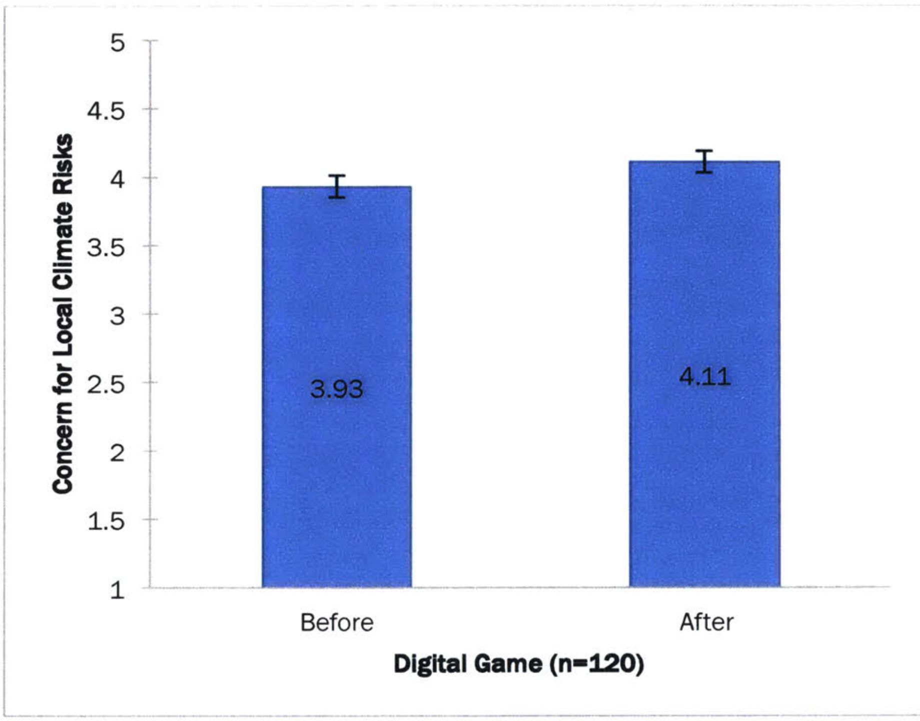

Figure 7.5. Effect of digital game on pre-post difference in stated concern for local climate risks, before and after the game (mean ± sem)

Willingness to Pay for Local Climate Adaptation

Lastly, participants were more willing to pay higher taxes for climate adaptation in Cambridge after playing the digital game (3.95 ± 0.08 levels, out of 5 levels ranging from 1 = "Not at all willing" to 5 = "Very willing") compared to before (3.89 ± 0.09 levels, out of 5 levels ranging from 1 = "Not at all willing" to 5 = "Very willing"); a statistically significant increase of 0.058 (95% CI, -0.005 to 0.122) levels, $t(119) = 1.825$, $p = 0.035$, $d = 0.167$. These results are presented in Figure 7.6 below. The t-test conducted to determine whether mean increases after participating in the digital game for the levels of perceived threat from climate change (Q2) were statistically insignificant.

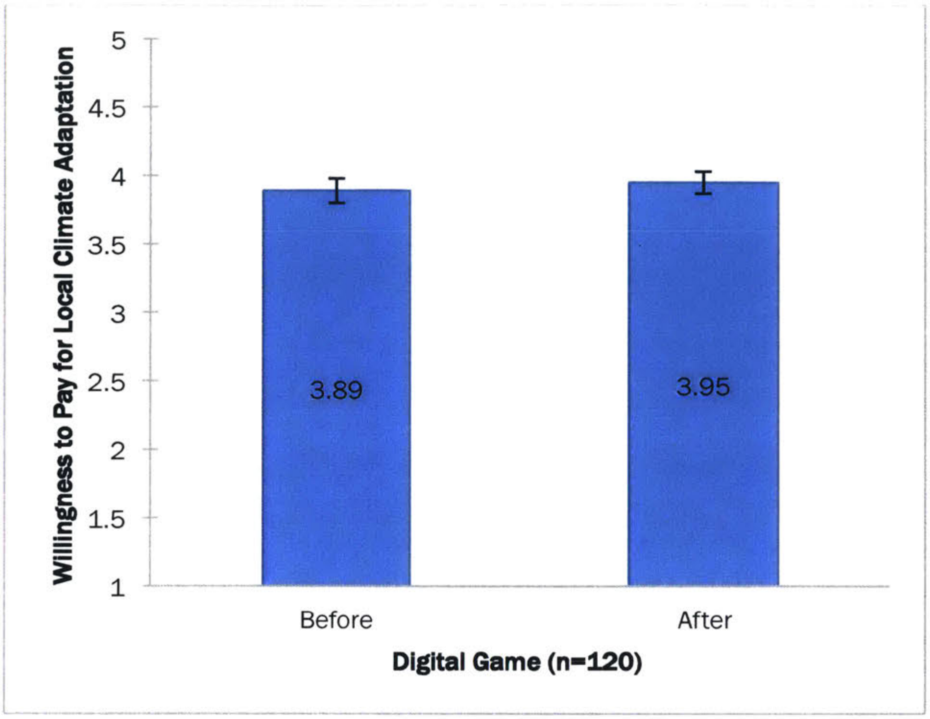

Figure 7.6. Effect of digital game on pre-post difference in willingness to pay for local climate adaptation, before and after the game (mean ± sem)

Effects of Digital Game on Key Dependent Variables

Table 2 below sums up the main effects of the digital game on key dependent variables. As noted above, on average, participants showed statistically significant increases in their perceived knowledge of climate change, concern for local climate risks, and willingness to pay higher taxes for Cambridge to plan for the impacts of climate change, after playing the digital game, when compared to before the digital game.

Table 2. Main Effects of Digital Game on Key Dependent Variables

Dependent variables **(n = 129)**	**Digital Game** **Δ Post-Pre**	**Cohen's *d***
Perceived knowledge of climate change (1-3)	**0.049*** (0.023)	0.195
Perceived personal threat of climate change (1-5)	-0.115 (0.07)	0.149
Concern for local climate risks	**0.175*****	0.34

(1-5)	(0.081)	
Willingness to pay higher taxes for climate adaptation	**0.058***	0.167
(1-5)	(0.032)	

Note: Standard errors in parentheses. All mean comparisons significant at *p<0.5 (bold face), **p<0.1 (bold face), ***p<0.01 (bold face). Unequal variances assumed (t-test). Cohen's *d* is a standardized measure of effect size; values between 0.3 and 0.6 are considered "moderate" effect sizes in behavioral sciences (Cohen, 1988).

Effects of Digital Game on Key Dependent Variables by Political Viewpoint

Table 3 below shows the effects of the digital game on key dependent variables by political viewpoint. As political orientation is the biggest determinant of belief in climate change (Hornsey et al., 2016) and furthermore, we are likely to selectively pick data most consistent with our political outlooks (Kahan et al., 2012; Kahan, Peters, Dawson, & Slovic, 2013), it is important for interventions in climate education and engagement to lead to changes not only in the views of moderates and liberals, but in the views of conservatives as well (van der Linden et al., 2016).

However, as can be seen in Table 3 below, showing the main effects of the digital game on key dependent variables by political viewpoint, the game was not associated with any shifts in perceived knowledge of climate change, concern for local climate risks, or willingness to pay higher taxes for climate adaptation in politically conservative residents. The game showed a slight effect on increasing the willingness of moderates to pay more in taxes for climate adaptation efforts, but did not result in any increases in the other dependent variables. We can see that a majority of the increases in the perceived knowledge of climate change, concern for local climate risks, and willingness to pay higher taxes for climate planning in Cambridge seen from the digital game participants after playing the game, when compared to before playing the game, actually come from the politically liberal residents that participated. Therefore, the digital game was effective in shifting the views of liberal residents who were already more likely to know about climate change, be concerned about local climate impacts, and more willing to pay for climate adaptation. However, the digital game's ability to effect counter-attitudinal transformational learning is more in question.

Table 3. Main Effects of Digital Game on Key Dependent Variables by Political Viewpoint

Baseline means before digital game (average treatment effect)	Average (n=129)	Conservative	Moderate	Liberal
Perceived knowledge of climate change*	2.612	2.333	2.2	2.618
(1-3)	(+0.039)	(+0.0)	(+0.0)	(+0.045)
Perceived personal threat of climate change	4.385	3.0	3.4	4.517
(1-5)	(-0.135)	(+0.0)	(+0.0)	(-0.124)
Concern for local climate risks***	3.942	3.0	3.2	4.045
(1-5)	(+0.144)	(+0.0)	(+0.0)	(+0.18)
Willingness to pay higher taxes for climate adaptation*	3.875	3.0	3.0	4.011
(1-5)	(+0.048)	(+0.0)	(+0.2)	(+0.045)

Note: Dependent variables with asterisks have mean increases significant at *p<0.5, **p<0.1, ***p<0.01.

Effects of Digital Game on Different Types of Learning

Table 4 depicts the relative amounts of learning from the digital game. We can see from the first column (Average) of Table 4 below, that the average participant said the digital game helped them the most in understanding the viewpoints of different stakeholders in dealing with climate change in Cambridge (3.12), then the substantive health impacts of climate change (2.86), and finally, imagining how stakeholders in Cambridge could reach agreement on how to proceed with climate adaptation (2.65). Considering how the digital game is a solitary game, played alone at home or through one's mobile phone, and that the game let users step into multiple hypothetical stakeholders' shoes, the findings that participants felt they learned the most about the views of other stakeholders, and the least about reaching agreement in climate adaptation planning, seemed fairly intuitive.

For the substantive learning about the health impacts of climate change, we can see that politically moderate participants said to have learned the most, then liberal participants, and finally the conservative residents. For learning about the various views of stakeholders in local climate adaptation planning, again, we see that moderates said to have learned the most, and conservatives the least. Finally, for improving residents' ability to imagine how stakeholders in Cambridge could reach agreement on how to proceed with climate adaptation, we see a similar pattern, where moderate Cantabrigians stated to have experienced the most learning, then liberal residents, and conservatives last. These differences are visualized in Figure 7.7 below.

Table 4. Effects of Digital Game on Different Types of Learning by Political Viewpoint

Perceived learning in digital game (1-5)	Average (n=105)	Conservative	Moderate	Liberal
Health impacts of climate change	2.86	2.33	3	2.92
Views of other stakeholders in climate adaptation planning	3.12	2.33	3.6	3.18
Reaching agreement in climate adaptation planning	2.65	2.33	2.8	2.7

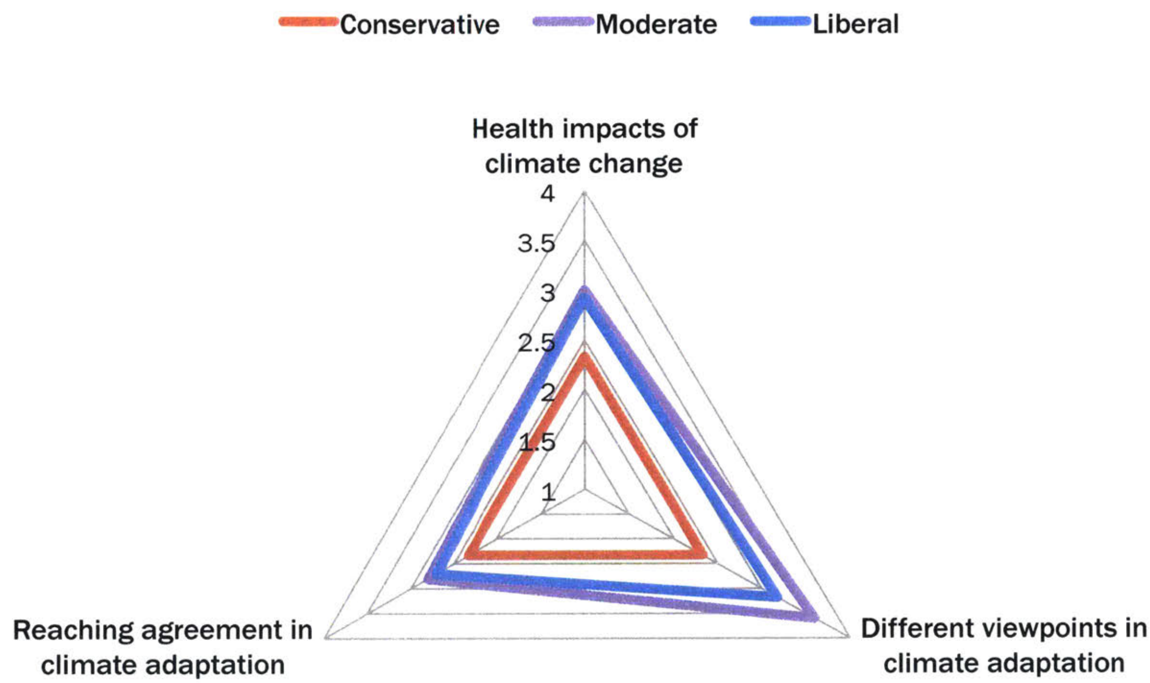

Figure 7.7. Effects of Digital Game on Different Types of Learning by Political Viewpoint

Prioritization of Local Climate Risks in Climate Adaptation Planning

Playing the digital game also shifted participants' opinions regarding the actions the city of Cambridge should take to adapt to climate change. Table 5 below depicts the shift in the proportions of respondents' prioritization of local climate risks to focus on in their city's climate adaptation planning, before and after the digital game. The percentages represent the proportion of the group that selected each climate risk as their first priority in Cambridge's climate management. We can see a modest shift in the sample's prioritizing the increased risks of disease and death, going from 16.1% to 22.9%, with a simultaneous decrease in prioritizing infrastructure damage from 65.3% to 60.2% and ecosystem degradation from 16.1% to 14.4%, after the digital game. The lack of participants choosing the alleviation of disproportionate impacts to vulnerable populations, despite the learning about different characters representing various sub-populations more vulnerable to the health impacts of climate change, is puzzling.

All other marginal proportions are similar before and after the intervention. Results of a McNemar's test[41] show that the marginal proportions are statistically significantly different from each other (*Fisher's exact = 0.000)*.

Table 5. Prioritization of Local Climate Risks in Climate Adaptation Planning, Before and After Digital Game

	Before	After
Individual property damage	1.7%	1.7%
Local business disruption	0.9%	0.9%
Increased risks of disease, hospitalization, and death	16.1%	22.9%
Disproportionate impacts to vulnerable populations	0.0%	0.0%
Water, energy, and transportation infrastructure damage	65.3%	60.2%
Watershed, forest, and ecosystem degradation	16.1%	14.4%
Total	100%	

[41] The McNemar's test is a statistical test used on contingency tables with matched pairs of subjects, to determine whether the row and column marginal frequencies are equal. If the Fisher's exact score low enough ($p < 0.05$), this provides sufficient evidence to reject the null hypothesis and state that the marginal proportions are statistically significantly different from each other.

True/False Questions in the Digital Game

As mentioned, while playing the game, to advance to the next character, participants were required to master the substantive material about a topic or instead, view the correct answer and corresponding explanation before moving on to the next step. Therefore, the progression of the participant from one character to another can be viewed as constituting substantive learning. Furthermore, the number of correct answers differentiates participants in terms of learning performance.

Table 6 below presents an overview of how many questions people answered in the game, and how they performed. We can see that 65 people did not answer any questions. A majority of the 225 participants (125) answered all four questions correctly. We also see that among the people who answered one, two, or three questions, most of them got all the questions they answered right. Overall, we can see that most of the digital game players successfully mastered the material presented in learning about each character's health risks, and how these risks are likely to be amplified with climate change.

We did have a total of four players who answered one or more questions incorrectly. We see that one player answered a total of two questions and got one right and one wrong. Another player answered four questions, and got two right and two wrong. Finally, two players both answered three questions correctly and one incorrectly, while answering all four questions. We can see the breakdown again in terms of the proportions of correct answers to the total number of answers given in the game session in Table 7. We see that out of the 164 players who answered at least one question, 1.22% (2 players) got half (0.5) the questions right, 1.22% (2 players) got three-quarters right, and finally, a significant majority (97.56%) got every question right. Again, we can conclude that almost every player did very well in terms of substantive learning in the digital game.

Table 6. Correct/Incorrect Answer Frequencies to True/False Questions

		# of T/F Questions Answered Incorrectly			
		0	1	2	Total
# Answered Correctly	0	65	0	0	65
	1	26	1	0	27
	2	8	0	1	9
	3	1	2	0	3
	4	125	0	0	125
	Total	225	3	1	229

Table 7. Proportions of Questions Answered Correctly to All Questions Answered

		Frequency	Percentage
(Right Answers / Total Answers Given)	0.5	2	1.22
	0.75	2	1.22
	1	160	97.56
	Total	164	100

In addition, a significant association exists between the proportions of questions the player answered correctly to the number of questions the player answered (number of questions answered correctly / number of questions answered overall = 0.5, 0.75, or 1) and the perceived level of substantive learning about the health impacts of climate change (1-5) (see Table 8; Fisher's exact = 0.038).

Table 8. Relationship between Proportions of Questions Answered Correctly and Perceived Learning of Health Impacts of Climate Change

		Perceived Learning of Health Impacts of Climate Change (1-5)					
		1	2	3	4	5	Total
(Right Answers / Total Answers Given)	0.5	1	0	0	0	0	1
	0.75	1	0	1	0	0	2
	1	5	31	38	29	12	115
	Total	7	31	39	29	12	118

Similarly, how many of the questions a player answered and got right is also significantly associated with the perceived level of learning about different viewpoints in climate adaptation planning in the city of Cambridge (see Table 9; Fisher's exact = 0.011). In contrast, the fraction of questions answered correctly was not found to be associated with the perceived learning about how to build a consensus or reach agreement in climate adaptation planning (Fisher's exact = 0.394).

Table 9. Relationship between Proportions of Questions Answered Correctly and Perceived Learning of Different Viewpoints in Climate Adaptation Planning

		Perceived Learning of Different Viewpoints in Climate Adaptation Planning (1-5)					
		1	2	3	4	5	Total
(Right Answers / Total Answers Given)	0.5	1	0	0	0	0	1
	0.75	1	0	1	0	0	2
	1	7	42	40	15	11	115
	Total	9	42	41	15	11	118

Proactive Learning

For two of the four characters, one preparedness "tool" available to game players provided a link to an external website, where the player could directly obtain more information. More specifically, for Martin, the architect mentioned above with a history of cardiac issues, climate change increases his heat vulnerability. One of the preparedness tools, or a caretaker action to alleviate risk, consisted of checking the heat index online. As humidity impairs the body's ability to cool itself, the heat index factors humidity and temperature to approximate how it actually feels. As can be seen below in Figure 7.8, after the player selects the tool of checking the Heat Index for Martin, they can actually click on the URL link to go to a popular weather website to check the heat index at the moment for their zip code.

Figure 7.8. Checking the Heat Index

Similarly, for Cora, the child with asthma, changes in air quality due to climate change are expected to increase the number and severity of asthma and allergies episodes. For Cora, one of the three preparedness tools entailed checking the Air Quality Index online before going outdoors or starting any strenuous activities. The link to the external website presented in the explanation for the caretaker action is shown below in Figure 7.9.

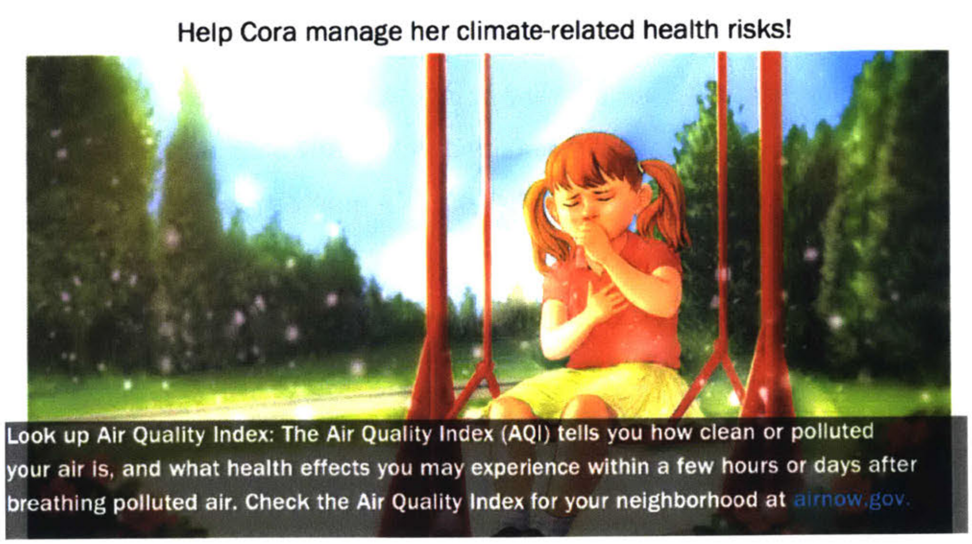

Figure 7.9. Checking the Air Quality Index

Table 10. Proactive Learning

		Frequency	Percentage
Number Of Times Player Obtained Information From External Website	0	116	94.31
	1	6	4.88
	2	1	0.81
	Total	123	100

We can see that a majority (94.31%) of the 123 participants did not click on either URL to be taken to a website to check the heat index or the air quality index for their neighborhood when playing the game. 6 people clicked on either of the URLs for Cora or Martin, and only one player clicked on both URLs for both characters. Overall, the participants did not engage in more proactive learning through the game, to learn how to check the heat index and air quality index for their neighborhood.

However, this "proactive learning" was not found to be associated with 1) performance on true/false questions, 2) different types of learning, or 3) shifts in perceived knowledge of climate change, concern for local climate impacts, willingness to pay higher taxes for climate adaptation, or policy priorities in climate adaptation planning in Cambridge.

Citizen Input on Climate Adaptation Planning

Out of the 105 participants who completed the game and the after-survey, 77 people provided answers to the question: "What specific actions would you recommend the City of Cambridge take to manage the risks of climate change?" The participants provided a wide range of opinions on what Cambridge should do to adapt to climate change, but a few key themes emerged.

First, many players argued for the city to prioritize health in climate adaptation planning efforts. One player recommended that Cambridge foster "community wide networking and city policy which has health of people and earth as priority over development." Similarly, another player stated that Cambridge should "continue to improve the health and safety codes of buildings and public infrastructure to make getting around easier and safe for everyone."

Second, many highlighted the importance of further public engagement and education. The most frequent word in all of the input provided was "education." One participant asked of Cambridge: "Begin having community discussions hosted at City hall so people can express concerns, ask questions, and understand what to or collaborate on solutions." Another game player similarly said: "Provide ongoing education efforts and public forums for discussing and deciding on a range of approaches." In terms of the relevant stakeholder groups and venues, one player said, "Educate religious leaders and doctors so they can talk to their parishioners and patients about climate change, and what actions to take. Also make this game available through school, library, and adult education programs!" A couple of players emphasized the importance of having education efforts tailored for vulnerable populations as well.

Similarly, game players valued information provision, and called for more information on sources of vulnerability and existing resources in addressing vulnerability in Cambridge. Players were particularly intent on having more information about emergency response resources at hand, such as the locations of cooling centers for extreme heat events. In addition, one player asserted that Cambridge should "keep the issue visible to citizens and provide contact information for government and private groups working to prevent climate change." Another player said that Cambridge should "give residents a list of what they can do personally to reduce climate change." Finally, one participant stated the importance of not only having more information, but also making it more accessible: "Have more information available in languages other than English; make all information more visible so that more people are aware of the dangers to the specific groups shown here [in the game]."

Third, a significant number of participants emphasized the importance of renewable energy. Many people stated that Cambridge should shift to 100% renewable energy, by pursuing zero-emissions public transit and conversion of city fleets to electric vehicles. In the meantime, many players also emphasized the importance of energy efficiency and conservation. Again, similar to the role-play simulation participant group (in chapter 6), the digital game participants showed much more knowledge of and interest in climate mitigation activities than that of climate adaptation.

Interestingly, a couple of players argued that the City should do more for emergency preparedness planning. In particular, many concerns were voiced regarding the risks of coastal storms and flooding. For instance, one game player said, "I have nowhere to go in an extreme wind event and no basement. We need storm shelters. [We also need] events to make it easy to understand how to make emergency supplies (what to store them in and where in small spaces)." Another participant stated: "Organize evacuation routes and plan for people who don't drive, especially. Plan for evacuation." This was not surprising, when we consider the significant overlaps between emergency preparedness and public health-oriented climate adaptation planning. We can see similarities in how participants in both the digital game and face-to-face role-play simulation participants view increasing emergency preparedness as a key strategy in managing the health risks of climate change (see Chapter 6).

Out of local climate risks in Cambridge, flooding seemed to be the most salient risk in game players' minds, as there were several actions presented targeting flooding specifically, such as "I think restoring flood plains and planting more vegetation is crucial to mitigate the inevitable flooding that is coming." Another game player stated: "Organize an effort to install the other pump at Amelia Earhart Dam and raise the dam height 6-10 feet." Some Cambridge residents did mention extreme heat, among other extreme events. They advised the City to reduce the urban heat island effect, through building more parks and increasing trees on streets to provide shade and cooling.

Finally, one game participant concisely summarized what they thought the City should do in nine words: "Decide not to wait for bad things to happen."

In summary, the digital game participants presented a variety of suggestions to the city of Cambridge on how to respond to the health risks associated with climate change. Local governments, even at traditional public meetings, rarely get a chance to ask citizens about specific steps they can take to tackle abstract, large-scale policy issues like climate change (Susskind et al., 2015). We can see that digital games can be used, not only to facilitate digital learning about a policy issue, but also to elicit opinions or advice from game players on matters that affect residents' well-being and assets.

Feedback on Digital Game

Finally, many game players expressed their opinions about the digital game during and after the game play period. In addition to comments received via email and social media, post-game interviews conducted with two participants elucidated how the digital game helped them learn about the likely health impacts of climate change within their community.

Many participants remarked on how they identified with certain characters, empathized, and thought about the disproportionate impacts of climate change on more vulnerable members of the community. One participant remarked on the merits of having a range of characters to delve into: "I really liked having the different characters, with a mix of older people and younger people. I think it's important to feel connected to the character, and I readily feel connected to characters similar to me, so it's a good idea to present different characters so that lots of people can connect with at least one character." Another game player commented on one character that stood out in his email, saying, "I found the veteran who lost his legs in a wheelchair compelling without being overly shocking." Another game player remarked on how seeing a child getting sick on screen made her think more about climate change: "My favorite was Cora (child with respiratory issues). I found myself thinking, 'Oh no, her asthma will get worse!'" And lastly, one participant commented, "My heart went out to Sofia (the recent immigrant)." She went on to observe that this character made her more aware of certain groups in Cambridge, saying, "And I'm very glad you included the immigrant, or the person for whom English is not their first language, because it's something I hadn't really thought about."

In addition, the game induced players to think about issues they normally did not spend much time or effort on. One participant remarked on how until she had played the game, she had never thought about how climate change could affect her health: "I had mostly just thought about flooding, and weather conditions, and not much about health impacts [from climate change]." According to another player, the game made climate change more concrete. He said, "I think the game is effective because it makes climate change personally relevant. We're so used to bad news, that we're not bothered by it, but if it's personal, I think we pay a little more attention." Finally, one game player remarked on how the game made her reexamine heat as a potential threat to health: "I was surprised by the heat problems depicted in the game. I guess I didn't really consider that fact that a lot of people don't have air conditioners."

However, not everyone found the digital game experience to be technically smooth or engaging. Some participants pointed out that certain elements of the digital game felt less than real. One player commented that they found the game to be passive, as "you click on people and items and are fed text." Another participant also remarked that he found the game to be more like "an online brochure."

Many players had issues with starting the game, or selecting radio buttons to record their responses for the before- or after-survey questions. A number of players also reported confusion about next steps to take in the process of playing the digital game. Finally, about a dozen players encountered browser and mobile phone compatibility issues during the game play period. These instances point to the importance of providing optional instructions for playing the game, incorporating a troubleshooting element into the game to respond to participants with technical issues, and overall, further reducing technical barriers to playing the digital game.

Limitations and Future Research

This research effort has a number of limitations. First, the external validity of this study has limitations. The digital game was designed and implemented in Cambridge, MA, a particular city within the Northeast, known for its high educational attainment and progressive politics. While Cambridge, MA was picked partly for its early adapter status within climate adaptation in the United States, it is also important to note that the residents in Cambridge may or may not reflect how other members of the public learn and engage with climate adaptation planning in their communities. Future research should deploy this digital game on the likely public health impacts of climate change in different cities to study its effects in different cities and regions of the United States.

Second, the digital game participant sample does not represent Cambridge's overall population. In terms of demographics, compared with Cambridge's citywide statistics, the digital game participant sample skews to female, older, more politically liberal, and more educated residents. The digital game participant pool, in particular, was not significantly "broader" than the role-play simulation pool (see Chapter 6). In essence, the aim of designing the digital game of reaching a broader public was not realized.

However, more importantly, much work needs to be done to understand why this was the case, and ultimately, improve representation in future efforts. As of now, it is difficult to ascertain if it was a matter of recruiting strategies, or whether it speaks to a constraint in digital public engagement tools reaching broader or different publics, or both. While additional time and resources for recruitment would have enabled more robust sampling processes, recruitment for future efforts should also collect data within different recruitment mechanisms to enable richer analyses of the aforementioned processes.

Third, there were numerous public conversations on Facebook and Nextdoor among residents who played the game during the game play period, where people would share their game experiences and occasionally troubleshoot others' technical issues. Future versions of the digital game should incorporate an internal digital platform to facilitate public debriefing and discussion of the experience within the game setting.

Lastly, both the qualitative and quantitative analyses are restricted to a limited set of factors. While this enables a more detailed investigation of the observed variables and facilitates causal inferences and theory-building, this study does not account for other variables that could influence public learning and engagement in climate adaptation planning.

Conclusion

This study analyzed the results of designing and implementing a digital game focused on the health impacts of climate change in Cambridge, MA. The digital game provided personal accounts of characters representing four distinct sub-populations more vulnerable to the health impacts of climate change due to age, occupation, English proficiency, and/or existing health conditions. The game also highlighted actionable steps that players can take in daily life to alleviate these health risks, either personally or in a caretaker role.

Playing the digital game was associated with increases in perceived knowledge of climate change, concern for local climate impacts, and willingness to pay higher taxes for local climate adaptation planning. The study also probed perceived learning in the different dimensions of substantive learning of the health impacts of climate change, learning about various viewpoints regarding climate change, and reaching agreement in climate adaptation planning. Furthermore, the study analyzed differences in attitudinal shifts and perceived learning among participants by political viewpoint.

This study also examined the use and effectiveness of various digital in-game mechanics to measure learning in game participants. In addition, the importance of alleviating technical barriers to participating and engaging with the digital game and providing a platform to facilitate public deliberation about the game was discussed. Future research should further expand on comparing digital game-based participation and more conventional, such as face-to-face, forms of public engagement practices in climate adaptation planning.

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Chapter 7.5

Face-to-Face Role-Play Simulations versus Digital Games

This section juxtaposes the results of the face-to-face role-play simulation (Chapter 6) and the digital game (Chapter 7), and compares the two formats of game-based public engagement in climate adaptation planning.

Demographics

As seen in Table 1 below, the role-play simulation and digital game sample demographics are fairly similar. The role-play simulation sample has a more balanced gender breakdown and is slightly younger in age. However, the digital game reached a broader audience in terms of political viewpoint, with a bigger share of political conservatives and moderates. In addition, the digital game sample is more balanced in terms of household income. Both samples are similarly well-educated and work in similar industries.

Table 1. Role-Play Simulation versus Digital Game Demographics

Variables		**Role-Play Simulation (n=112)**	**Digital Game (n=105)**
Gender	Male	47.6%	28.6%
	Female	52.4%	70.5%
Age	19 or under	1.0%	7.7%
	20-29	13.5%	
	30-39	18.3%	14.3%
	40-49	15.4%	19.1%
	50-59	21.2%	19.1%
	60+	30.8%	40.0%
Political Viewpoint[42]	Conservative	11.5%	21.9%
	Moderate	7.7%	19.1%
	Liberal	80.8%	59.1%
Education	High school graduate (or equivalent)	2.9%	1.0%
	Some college or associate's degree (AA)	2.9%	2.9%

[42] Statewide (MA) statistics from Gallup State of the States 2015 used as proxy for city statistics

	Bachelor's degree (BA, BS, AB, etc.)	24.0%	26.0%
	Master's degree (MA, MSc) Professional or doctoral degree (MD, PhD, etc.)	70.2%	88.5%
Industry	Agriculture, forestry, fishing and hunting, mining	0%	1.0%
	Construction	3.1%	1.9%
	Manufacturing	1.0%	0.0%
	Wholesale trade	0%	0.0%
	Retail trade	0%	1.0%
	Transportation, warehousing, and utilities	2.1%	10.0%
	Management and administrative services	3.1%	9.7%
	Information, finance, insurance, real estate	13.5%	8.7%
	Educational services and healthcare	36.5%	33.0%
	Arts, entertainment, recreation, hospitality	3.1%	7.8%
	Public administration	5.2%	8.7%
	Other	32.3%	28.2%

Attitudinal changes

While both the face-to-face role-play simulation and the digital game were associated with increases in perceived knowledge of climate change and concern for local climate risks, we can see that the face-to-face role-play simulation effected larger shifts in its participants (knowledge of climate change: 0.073 vs. 0.049; concern for local climate risks: 0.259 vs. 0.175). The results are presented in Table 2 below.

Table 2. Main Effects of RPS versus Digital Game on Key Dependent Variables

Dependent variables	Role-Play Simulation Δ Post-Pre	Cohen's *d*	Digital Game Δ Post-Pre	Cohen's *d*
Perceived knowledge of climate change (1-3)	**0.073*** (0.031)	0.226	**0.049*** (0.023)	0.195
Perceived personal threat of climate change (1-5)	0.008 (0.051)	0.016	-0.115 (0.07)	0.149
Concern for local climate risks (1-5)	**0.259**** (0.099)	0.247	**0.175***** (0.081)	0.34
Willingness to pay higher taxes for climate adaptation (1-5)	-0.083 (0.076)	0.104	**0.058*** (0.032)	0.167

Note: Standard errors in parentheses. All mean comparisons significant at *p<0.5 (bold face), **p<0.1 (bold face), ***p<0.01 (bold face). Unequal variances assumed (t-test). Cohen's *d* is a standardized measure of effect size; values between 0.3 and 0.6 are considered "moderate" effect sizes in behavioral sciences (Cohen, 1988).

More importantly, when we compare the efficacy of the role-play simulation and digital game across the political spectrum, we discover profound differences in the two public engagement methods' outcomes. We saw that the face-to-face role-play simulation had the largest effects in bolstering one's perceived knowledge of climate change in political conservatives, compared to moderates or liberals. Similarly, the role-play simulation effected a bigger change in political conservatives in amplifying one's concern for local climate risks than moderates. The relevant numbers are presented below in Table 3 (numbers in red bold face). The significance of the face-to-face role-play simulation effecting shifts in the thoughts, feelings, and behavioral intentions of not only moderates and liberals, but also conservatives, cannot be overstated.

In contrast, the digital game had no effect in increasing perceived knowledge of climate change, concern for local climate risks, or willingness to pay higher taxes for climate adaptation in political conservatives. In political moderates, the digital game led to an increase in willingness to pay higher taxes. In other words, the shifts in these factors from playing the digital game primarily took place among liberal participants. The relevant numbers are presented in Table 4 below (numbers in red bold face). Therefore, we can see that while the face-to-face role-play simulation cultivated counter-attitudinal transformative learning, the digital game mostly fostered shifts in the cognition, affect, and behavior of political liberal residents already more likely to know more about, be more concerned about, and more likely to support climate policies in the first place.

Table 3. Main Effects of RPS on Key Dependent Variables by Political Viewpoint

Baseline pre-RPS means (average treatment effect)	**Average (n=112)**	**Conservative**	**Moderate**	**Liberal**
Perceived knowledge of climate change* (1-3)	2.624 (+0.073)	2.2 **(+0.2)**	2.57 **(+0.143)**	2.64 **(+0.07)**
Perceived personal threat of climate change (1-5)	4.446 (+0.009)	3.6 (+0.0)	4.14 (+0.143)	4.55 (+0.022)
Concern for local climate risks** (1-5)	3.901 (+0.259)	3.2 **(+0.2)**	3.43 **(+0.143)**	4.0 **(+0.281)**
Willingness to pay higher taxes for climate adaptation (1-5)	3.862 (-0.083)	3.2 (-0.4)	3.0 (-0.143)	3.99 (-0.081)

Note: Dependent variables with asterisks have mean increases significant at *p<0.5, **p<0.1, ***p<0.01.

Table 4. Main Effects of Digital Game on Key Dependent Variables by Political Viewpoint

Baseline pre-digital-game means (average treatment effect)	Average (n=129)	Conservative	Moderate	Liberal
Perceived knowledge of climate change*	2.612	2.333	2.2	2.618
(1-3)	(+0.039)	**(+0.0)**	**(+0.0)**	**(+0.045)**
Perceived personal threat of climate change	4.385	3.0	3.4	4.517
(1-5)	(-0.135)	(+0.0)	(+0.0)	(-0.124)
Concern for local climate risks***	3.942	3.0	3.2	4.045
(1-5)	(+0.144)	**(+0.0)**	**(+0.0)**	**(+0.18)**
Willingness to pay higher taxes for climate adaptation*	3.875	3.0	3.0	4.011
(1-5)	(+0.048)	**(+0.0)**	**(+0.2)**	**(+0.045)**

Note: Dependent variables with asterisks have mean increases significant at *p<0.5, **p<0.1, ***p<0.01.

What caused these differences in the games' efficacy in shifting participants' views? From the interviews conducted with the face-to-face role-play simulation participants, we know that applying what happened in the game to their actual communities in the debrief sessions contributed to participants shifting their views regarding climate adaptation planning. In contrast, the digital game had a solitary structure, where the game players learned about each of the four characters of the game on their mobile devices or through their personal computers, without a chance to process the results of the game in concert with other game players. Therefore, we can see that the design of the game experience, particularly in whether the game players experience a face-to-face debriefing session after playing the game, is likely to be linked to the extent of counter-attitudinal learning among game participants.

Different types of learning

In addition, the role-play simulation and digital game show different relative strengths in participants' perceived learning about local climate risks and adaptation planning. The digital game was more effective in substantive learning about the health impacts of climate change, while the role-play simulation was more effective in envisioning of possible future adaptation planning options and learning to reach agreement in climate adaptation planning.

We can see that in Tables 5 and 6 below, compared to the group of residents who participated in the face-to-face role-play simulation, the group of residents who played the digital game had higher scores in gauging how much the resident felt they learned about the health impacts of climate change. Counter to the original hypotheses of this study, the digital game players had higher levels of perceived learning about the views of other stakeholders in local climate adaptation planning processes. This could be from the design of the digital game, in which players learned about a wider range of sub-populations vulnerable to the health impacts of climate change through the four characters available to the participant, whereas in the face-to-face role-play simulation, the players assumed one role for the duration of the game session. On the other hand, we see that compared to the group of residents that played the digital game, the face-to-face role-play simulation participants, on average, had higher scores on the question gauging how much the public engagement tool helped them in imagining how their own city of Cambridge could proceed with climate adaptation in the future, through collaborating with other stakeholders in the city's climate planning and policymaking processes.

Therefore, we can see that the two games possess different strengths in the different dimensions of learning about climate adaptation planning: while the digital game helped participants gain a better understanding of the health implications of climate change within their own community, particularly in how certain groups of residents are more vulnerable to these likely impacts because of age, gender, mobility, pre-existing health conditions or English proficiency, the face-to-face role-play simulation helped participants imagine a way forward through multi-stakeholder collaboration in climate adaptation planning.

Table 5. Effects of RPS on Different Types of Learning by Political Viewpoint

Perceived learning in role-play simulation (1-5)	Average (n=112)	Conservative	Moderate	Liberal
Health impacts of climate change	2.79	2.33	2.75	2.83
Views of other stakeholders in climate adaptation planning	2.83	2.33	3.25	2.83
Reaching agreement in climate adaptation planning	2.8	2	3	2.83

Table 6. Effects of Digital Game on Different Types of Learning by Political Viewpoint

Perceived learning in digital game (1-5)	Average (n=105)	Conservative	Moderate	Liberal
Health impacts of climate change	2.86	2.33	3	2.92
Views of other stakeholders in climate adaptation planning	3.12	2.33	3.6	3.18
Reaching agreement in climate adaptation planning	2.65	2.33	2.8	2.7

Relative advantages and disadvantages of game format

As can be seen in the comparisons laid out above, the face-to-face role-play simulation and digital game are considerably different in the benefits and tradeoffs they offer to cities as public engagement and education tools around climate change. This goes hand in hand with research to date covering the wide variety of climate change games in different formats, and the relative strengths and weaknesses of each format (Wu & Lee, 2015).

The table below summarizes the comparisons drawn between the two game formats used in this dissertation project. A key takeaway in this research, gleaned from analyzing the outcomes of the two public engagement methods (face-to-face role-play simulation and digital game), is that both game formats have different comparative strengths, depending on intended learning outcomes. The face-to-face role-play simulation has a definite advantage in being flexible and adaptable to each group of participants attending, particularly in how each debrief session is tailored to target specific learning goals. In addition, through the debriefing sessions structured for participation reflection and peer learning, the face-to-face role-play simulation achieves cross-attitudinal transformative learning, leading to increases in perceived urgency of climate risks and support for local climate adaptation planning, potentially counter to one's own political viewpoints.

In contrast, the digital game offers a more consistent and scalable learning experience. Its relative strength is in the substantive learning about local climate risks and the health implications of climate change, particularly in how climate change most affects the health of already vulnerable populations in any given community. In addition, digital games allow for in-game assessment of learning, such as questions or points, that gauge players' learning regarding climate change. The digital game, with its true/false questions to check learning about climate change and resulting health impacts and proactive learning mechanisms about these phenomena in one's own neighborhood, resulted in game players saying they had learned more about substantive areas of climate change and public health after playing the digital version, when compared to the responses given by residents who had participated in the face-to-face role-play simulation.

Digital games also handle player data electronically, increasing the speed and data quality of assessments significantly (Bellotti et al., 2013; Wu & Lee, 2015). However, the research in this dissertation project suggests that the digital game-based learning may be confined to low-level learning (Argyris & Schon, 1978; Wu & Lee, 2015), as can be seen in the lesser magnitudes of the shifts in perceived knowledge of local climate risks and concern about climate change in one's community.

Table 7. Summary and comparison of face-to-face RPSs and digital games (adapted from Wu and Lee 2015, p. 416)

Game format	Key features of featured games	Pros	Cons	Goals and outcomes
Face-to-face role-play simulation	Role-playing mock decision-making process; facilitated post-game debrief	Flexible and adaptable experience; fosters counter-attitudinal transformative learning	Higher costs (game development & deployment) Facilitation requirement a potential barrier	Facilitated learning with debriefing; in-depth qualitative assessment
Digital game	Computer-based character game with actionable steps for each character	Consistent and scalable experience; fosters substantive learning about climate change	Lower costs (game development & deployment); Computer or mobile phone and some	In-game assessment

	technical literacy requirement a potential barrier

Cities should be cognizant of these relative strengths and weaknesses in employing these two public engagement methods (face-to-face RPS and digital game) in operationalizing the health framing of climate change, and furthering public engagement with climate change.

Chapter 8

Discussion and Policy Recommendations

Summary of Dissertation Findings

Urban climate change adaptation planning is most often framed as a necessary strategy for protecting a city's assets and reducing its vulnerability to hazards and disasters (Hughes, 2015). As a result, climate adaptation planning in coastal cities to date has focused on engineering protective structures to better withstand climate-related events. Consequently, as climate adaptation planning tends to be focused on protecting physical assets, critiques have pointed out that adaptation plans rarely incorporate equity or social vulnerability, and calls have emerged for climate adaptation planning to focus on human vulnerabilities instead (Hughes, 2015; IPCC, 2014).

In addition, cities have found that most publics in the U.S. do not find climate adaptation to be a political priority (Howe et al., 2015), highlighting the importance of communicating the need for climate adaptation to elected officials and the public (Carmin et al., 2012; Howe et al., 2015; Shi, Chu, & Debats, 2015). However, current public engagement practices in planning, centered around "death by PowerPoint (Winn, 2003)" in town hall meetings or information sessions, are woefully inadequate in fostering technical and political learning for climate-ready planning (Argyris & Schon, 1978; de Suarez et al., 2012; Susskind, 2001).

Therefore, cities should adopt a public health orientation to climate adaptation planning. The proposed normative benefits of a stronger focus on the public health impacts of climate change revolve around alleviating current climate adaptation planning efforts' lack of equity and social vulnerability components (Frumkin et al., 2008; Watts et al., 2015; WHO, 2013). On the pragmatic side of things, highlighting the health risks of climate change allows climate adaptation planning to transcend political schisms between climate advocates and dismissives or deniers (Maibach et al., 2010; Myers et al., 2012; Nisbet, 2009). Responding to calls for research on ways for cities to operationalize a public health focus on climate change (Akerlof et al., 2010; Hughes, 2015; Moser & Pike, 2015; Nisbet & Scheufele, 2009), this dissertation project developed and tested three public engagement methods to strengthen climate adaptation planning's capacity to involve citizens in responding to increasing threats to public health and well-being.

I. Issue Framing of Climate Change

In Chapter 5 of this dissertation, we saw that reframing climate change as a public health issue evokes a stronger sense of urgency regarding local climate risks and increases public commitment to climate adaptation planning. A public health frame is more powerful than an environment frame of climate change, or furthermore, no frame at all. This indicates that cities have much to gain from framing climate change as a public health issue, in terms of boosting public concern about the severity of the problem and building public support for policy action.

We also saw that the public health frame of climate change stresses climate change's potential to increase the prevalence of infectious diseases and other health problems that are already perceived as important, especially among the most vulnerable populations. More importantly, according to interview results, the public health frame also heightens the geographic, temporal, and social proximity of climate impacts, corroborating previous research on the efficacy of the public health frame of climate change as a public education and engagement tool for climate mitigation activities (Frumkin et al., 2008; Maibach et al., 2010). This study augments previous research findings by testing and clarifying the effectiveness of the public health frame in enhancing concern about local climate risks and furthermore, increasing public support for local climate adaptation efforts.

II. Face-to-Face Role-Play Simulations

The subsequent chapters delved into two different serious games that cities can use to operationalize the public health frame and engage the public with in climate adaptation planning. In Chapter 6, we found that role-play simulations, or serious games that engage participants in a face-to-face mock decision-making process, were effective tools for learning and mutual deliberation about how a city should deal with the local health effects of climate change. After participating in the role-play simulation, residents showed increases in perceived knowledge of climate change, concern about local climate risks, and confidence in effective local climate adaptation. These results expand on the New England Climate Adaptation and the Harboring Uncertainty projects, where role-play simulations were used as a public education and engagement tool to bolster awareness of local climate risks and build capacity to deal with uncertainty in infrastructure planning, respectively (Rumore et al., 2016), by using role-play simulations to involve citizens in public health-oriented climate adaptation planning.

In particular, it is important to note that with the role-play simulation used in this dissertation project, the conservative participants (versus moderate or liberal) showed the largest increases in perceived knowledge of climate change, concern about local climate impacts, and confidence in the city's effectiveness in local climate adaptation planning, demonstrating the efficacy of the face-to-face role play simulation in inducing counter-attitudinal transformative policy learning.

Furthermore, the role-play simulation also helped clarify the range of policy preferences among citizens in Cambridge, Massachusetts in the actions the city of Cambridge should take to adapt to climate change. After playing the role-play simulation, more Cambridge residents said they would prioritize the health risks of climate change in local climate adaptation planning. In addition, qualitative data collected during and after the role-play simulation point to the potential of role-play simulations in facilitating learning of process-based knowledge of how planning and policymaking works in a city like Cambridge, fostering perspective-taking of different stakeholders in climate adaptation planning, and strengthening the place identity and attachment of participants.

III. Digital Games

In Chapter 7, we found that playing a digital game providing personal accounts of characters representing sub-populations more vulnerable to the health impacts of climate change, with actionable steps that the player can take in daily life to alleviate these health risks, boosted perceived knowledge of climate change, concern about local climate impacts, and willingness to pay higher taxes for local climate adaptation planning. In addition, we also saw that more Cambridge residents chose the increased risks of hospitalization, disease, and death as the first priority for local climate adaptation planning efforts after playing the digital game. Lastly, we examined the use of various innovative in-game mechanics in the digital game to measure learning in game participants, such as true/false questions and proactive learning tools, substantiating the potential of digital games to generate nuanced assessments of learning outcomes (Wu & Lee, 2015).

In contrast to the face-to-face role-play simulation, we did not see any attitudinal changes in conservative residents that played the digital game. Instead, we witnessed a majority of the increases in knowledge of, concern about, and policy support for local climate adaptation planning from playing the digital game among liberal residents, who were already more likely to know about climate change, be concerned about, and be committed to climate adaptation planning action before playing the game.

We also saw that the digital game had comparative advantages in facilitating substantive learning of the health impacts of climate change and learning about different groups of residents particularly vulnerable to climate-related health risks in one's community, in comparison to learning about policymaking and planning processes or learning how to collectively plan for climate change.

Face-to-Face Role-Play Simulations versus Digital Games

As mentioned in the previous section (Chapter 7.5), a key takeaway in this research, gleaned from analyzing the outcomes of the two public engagement methods (face-to-face role-play simulation and digital game), is that both game formats have different strengths in different contexts.

The face-to-face role-play simulation has a definite advantage in being flexible and adaptable to each group of participants attending, particularly in how each debrief session is tailored to target specific learning goals. In addition, through the debriefing sessions structured for participation reflection and peer learning, the face-to-face role-play simulation achieves cross-attitudinal transformative learning, leading to increases in perceived urgency of climate risks and support for local climate adaptation planning, potentially counter to one's own political viewpoints.

In contrast, the digital game offers a more consistent and scalable learning experience. Its relative strength is in the substantive learning about local climate risks and the health implications of climate change, particularly in how climate change most affects the health of already vulnerable populations in any given community. In addition, digital games can assess players' learning regarding climate change through questions or other learning evaluation mechanisms within the game itself. The digital game used in this dissertation project, with its true/false questions to check learning about climate change and the resulting health impacts and proactive learning mechanisms about these phenomena in one's own neighborhood, resulted in game players saying they had learned more about the substantive areas of climate change and public health after playing the digital version, when compared to the responses given by residents who had participated in the face-to-face role-play simulation. However, the research in this dissertation project suggests that digital games may only induce low-level learning (Argyris & Schon, 1978; Wu & Lee, 2015), as can be seen in the lesser magnitudes of the shifts in perceived knowledge of local climate risks and concern about climate change in one's community.

The table below (Table 8.1) summarizes the comparisons drawn between the two game formats used in this dissertation project.

Table 8.1. Comparison of face-to-face RPS and digital game (adapted from Wu and Lee 2015, p. 416)

Game format	Key features of featured games	Pros	Cons	Goals and outcomes	Costs
Face-to-face role-play simulation	Role-playing mock decision-making process; facilitated post-game debrief	Flexible and adaptable experience; fosters counter-attitudinal transformative learning	Higher costs (game development & deployment) Facilitation requirement a potential barrier	Facilitated learning with debriefing; in-depth qualitative assessment	
Digital game	Computer-based character game with actionable steps for	Consistent and scalable experience; fosters substantive learning about	Lower costs (game development & deployment) Computer or mobile phone	In-game assessment	

	each character	climate change	and some technical literacy requirement a potential barrier	

Policy Recommendations

This section examines the implications of the research findings from this dissertation project and provides recommendations for enhancing public engagement and adopting a public health orientation to climate adaptation planning in cities across the United States.

First, cities should actively frame climate change as an issue impacting citizens' health and well-being today. As mentioned above, this dissertation project showed through a set of survey experiments that framing climate change as a public health issue, in comparison to framing it as an environmental issue, but particularly when compared to not framing climate change at all, results in increased perceived knowledge, concern about local climate risks, and confidence in the city's ability to tackle climate change through its climate adaptation planning and policymaking processes.

Furthermore, the framing of climate adaptation not only affects how adaptation planning is perceived relative to other municipal goals (Shaw et al., 2014), but it also has implications for if and how adaptation plans are implemented (Dupuis and Knoepfel, 2013). While assessing climate risks and vulnerabilities and identifying adaptation options are generally thought of in discrete steps, how a city defines the problem impacts the solution space (Rittel & Webber, 1973). Accordingly, problem identification impacts how the city will go about enhancing the awareness of individuals, organizations, and institutions about climate change as well (IPCC 2014, Chapter 16).

Therefore, local governments and advocacy organizations should leverage the public health frame of climate change as a conversation starter, and subsequently shift their city's climate adaptation planning to have more of a public health orientation. As one environmental activist working with vulnerable populations in Cambridge described this process, "When you go to communities and start talking about the things that concern them, issues like asthma resonate. That affects people very tangibly. It affects more low-income, people of color, poor housing conditions, etc. By starting with what concerns people, and helping to address it immediately, you can also broaden into other areas." Time and time again in the interviews conducted for this dissertation project, competing policy priorities came up as a barrier to climate adaptation planning gaining more traction in the Cambridge area. Acknowledging that climate change is often not the leading policy priority of most people, instead, cities should connect climate change to issues such as health or safety first, and explain how climate change will affect these other priorities or issues that are more important to the public.

In doing so, here is a short summary (Table 8.2) of the public health risks of climate change that cities can focus on.

Table 8.2. Human Health Effects of Climate Change

Climate Impacts	Health Impacts	Populations Most Affected
Extreme Heat	- Premature death - Cardiovascular stress and/or failure - Heat-related illnesses, such as heat stroke, heat exhaustion, and kidney stones	- Children - Elderly - Diabetics - People with respiratory conditions - People with cardiovascular conditions - Outdoor workers - Low-income populations
Poor Air Quality/Pollution	- Increased asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular and respiratory	- Children - Elderly - People with

	diseases	respiratory conditions - People with cardiovascular conditions - Outdoor workers - Low-income populations
Wildfires	- Injuries and death from burns and smoke inhalation - Eye and respiratory illnesses from air pollution - Exacerbation of asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular and respiratory diseases - Population displacement, loss of home and livelihood	- People with respiratory conditions
Extreme Weather Events	- Injuries or death from drowning - Lack of access to drinking water, water-, and food-borne disease from damage to potable water, wastewater, and irrigation systems - Population displacement, loss of home and livelihood	- Children - Elderly - Low-income populations
Increased Average Temperatures	- Cardiovascular stress and/or failure Increased number and range of: - Vector-borne diseases, such as West Nile virus, malaria - Water-borne diseases, such as cholera, E.coli - Food-borne diseases, such as salmonella poisoning - Allergies from pollen	- Children - Elderly - Diabetics - People with respiratory conditions - People with allergies - Outdoor workers
All Impacts	Mental health effects, such as depression, anxiety, Post-Traumatic Stress Disorder (PTSD)	

(Adapted from CDPH, 2012; WHO, 2013; Watts et al., 2015; USGCRP, 2016)

Second, cities should deploy face-to-face role-play simulations to enhance the readiness of communities to engage in climate adaptation planning, specifically by boosting collective recognition of location-specific climate and climate-related health risks. While best practices in designing and implementing role-play simulations within a community are documented extensively (see Susskind et al., 2015), some generalizable recommendations based on designing and implementing a public health-oriented climate adaptation role-play simulation include the following:

- **Secure collaborations with relevant municipal agencies responsible for environment, adaptation, or resilience and community health and well-being early on in the process of designing and implementing the role-play simulation.**

  In Cambridge, this project benefitted tremendously from the resources and support provided by the Community Development Department, and the Director of Environmental Planning, John Bolduc, along with the Public Health Department, and the Director of Environmental Health, Sam Lipson. Both municipal agencies and the heads of these divisions provided the local vulnerability assessment results and other relevant vulnerability information to base the role-play simulations on. They also provided support in connecting the issues of climate change and public health to other planning and public health initiatives in the city to broaden the reach of the face-to-face role-play simulation workshops. These collaborations can further catalyze the "mainstreaming" of climate preparedness into the activities of other city agencies as well.

- **Base the role-play simulation on localized information on climate risks, and emphasize this fact throughout events to further disseminate this information to the community.**

  The (perceived) lack of localized information on relevant climate risks to a community is a significant barrier to furthering climate adaptation planning. During the face-to-face role-play simulation events, we had many participants asking questions about the technical information provided in the general instructions of the role-play simulation. Some even asked if they could take the materials with them after the event. The face-to-face role-play simulation events provide a valuable opportunity for technical learning and deliberation about the local climate and climate-related health risks residents face in their communities. Therefore, cities should design their role-play simulations and the events featuring role-play simulations accordingly. For instance, having staff members or facilitators prepared to answer questions about and further explain the technical information presented in the role-play simulation is crucial.

- **Structure the role-play simulation, and especially the post-simulation debriefing session, to elicit residents' preferences in terms of climate adaptation planning.**

  In the post-simulation interviews, many participants voiced frustration at the lack of outlets in which to express their views regarding climate change to decision-makers in their communities. The debriefing session, where people discussing their game experiences and step back into their daily lives as citizens of a certain locality, should be structured to ask people for their input. Furthermore, the input should be aggregated and sent to the relevant municipal agencies after the game-based public engagement process is over.

Third, cities should deploy digital games to enable substantive learning of the likely public health impacts of climate change, and particularly, how already vulnerable populations will suffer the most in the face of climate change, to boost collective recognition of location-specific climate and climate-related health risks. Some recommendations based on designing and implementing a public health-oriented climate adaptation digital game include the following:

- **Focus the digital game on climate adaptation, with the recognition that most people currently emphasize climate mitigation, and individual climate mitigation activities, i.e. reducing greenhouse gas emissions by flying less, eating less meat, etc.**

  Post-game interviews highlighted how game participants had not thought of how to adapt to climate change, or preparing for and managing climate risks, when compared to how often they thought of climate mitigation actions they could incorporate into their daily lives. Similarly, game players focused primarily on energy efficiency measures when asked to advise which climate planning actions the city of Cambridge should take. Therefore, the game should emphasize the necessity for climate adaptation, and the need for climate adaptation planning to address the climate risks facing cities.

In addition, climate communication research shows that people sustain knowledge of climate risks better when information is coupled with steps they can take to reduce vulnerabilities and prepare for climate-related emergencies (Pidgeon & Fischhoff, 2011). Therefore, the digital game should provide actions residents can take to increase community resilience to climate risks, after learning about likely local climate risks.

- **Design the game with the aim of reaching the broadest audience possible, by alleviating barriers of computer and/or other digital media proficiency.**

Even after adaptive programming and extensive pilot-testing, we received numerous inquiries and complaints regarding the functioning of the digital game. Ensuring browser and mobile phone compatibility is crucial. In order to further alleviate the barriers of computer literacy and other technical skills, future efforts should not only provide optional instructions for playing the game, but also budget the resources and capacities for technical support during the game play period.

- **Clarify the aim of in-game assessments before incorporating them into the digital game.**

Digital games offer a plethora of opportunities to collect data during the game experience on a variety of factors. For instance, for the digital game in this dissertation project, data were collected on factors such as browser used for the game, game duration, order of characters played, etc. However, after collecting the data, many factors proved to be of minimal use in explaining learning, or differences in learning among the game players. While the exact use of different data collected during a game play period is hard to delineate before the design and implementation of the digital game, future deployments of the digital game should be carried out with a clear idea of what each data point is meant to measure, and for what purpose.

- **The possibility of a digital public engagement tool engaging a broader audience does not mean it always does.**

  Although digital forms of public engagement have been touted for their potential to alleviate the "usual suspect" problem in public engagement, we saw in this dissertation project that the digital game players (in comparison to the face-to-face role-play simulation participants) were not more representative of Cambridge's overall population as expected. We saw that the digital game participant sample skewed to female, older, more politically liberal, and more educated residents, but in addition, the digital game participant sample was also more skewed in gender and age than the role-play simulation sample (see demographics section in Chapter 7.5 for more details). While the digital game sample was more balanced in political views, the findings of the dissertation project reinforce the importance of not relying on a medium or technology itself to reach a more representative audience.

  However, it is clear from the study that the digital game players logged on to play the game from more dispersed zip codes and at various times throughout the day. In other words, while digital games may not reach a more representative audience or foster the deliberation and the mutual learning seen at face-to-face events, they provide more opportunities to engage residents in less proximate places and at more convenient times. Therefore, digital games, and other forms of digital engagement should be viewed as a supplement to, rather than replacement for, face-to-face role-play simulations and public engagement events.

Fourth, cities should deploy the two serious games used in this dissertation project, face-to-face role-play simulations and digital games, but in a specific order to maximize complementarities.

- **The digital game should be used first as a substantive primer introducing the relevant health impacts of climate change likely to arise in the community.** The digital game is cheaper and easier to scale up than the face-to-face role-play simulation. In addition, digital game outreach efforts can also be utilized toward publicizing upcoming face-to-face events. However, as we saw, the digital game has limitations on the scope of learning it can facilitate. As its relative strengths lie in the substantive learning about local climate risks and the health implications of climate change, the digital game should be used to set the stage first.

- **Subsequently, cities should deploy face-to-face role-play simulations to better engage the public and increase readiness to prepare for climate change.** We saw that the face-to-face role-play simulation's relative strengths are in allowing participants to better envision possible future adaptation planning options and to reach agreement in climate adaptation planning. In particular, the facilitated debriefing session is critical; it is likely to foster cross-attitudinal transformative shifts in perceived knowledge of climate change, concern about local climate risks, and confidence in the local government to effectively plan for and respond to climate change. Therefore, the debriefing sessions should be structured to catalyze deliberations of climate change and its ramifications for the community across the political spectrum. In addition, the face-to-face role-play simulation seems to also cultivate the place identity and attachment of the resident population that participates, building upon an important source of strength that future climate adaptation planning and policymaking efforts can marshal.

All things considered, the findings of this dissertation indicate that cities should implement multi-modal game-based engagement in climate adaptation planning. This goes hand in hand with research showing that public engagement is most effective with a variety of participatory tools (Kelly, Ferranto, Lei, Ueda, & Huntsinger, 2012). Different publics will need different ways to receive and give information, and furthermore, engage with planning for climate change.

Contributions

This dissertation engages with and contributes to three areas of theory and practice.

First, the dissertation project aims to explain why and how the health impacts of climate change should be given a more prominent role in climate adaptation efforts. To date, climate adaptation planning has mostly focused on protecting physical assets from potentially catastrophic climate change. While the lack of human vulnerability and equity components in adaptation planning have been critiqued by many (Hughes 2015; IPCC, 2014; Watts et al., 2015), this has not yet led to a more productive reframing and operationalization of climate adaptation planning that situates citizens' health and well-being front and center. In response, this dissertation project tests how a public health orientation to climate adaptation planning affects public perceptions of local climate risks and policy preferences for adaptation efforts. The results point to how cities can initiate public conversations about preparing for and managing the likely health impacts of climate change.

Second, the dissertation presents new tools for cities to enhance public awareness of and facilitate engagement around climate risk management choices. While the importance of public engagement in climate adaptation planning is widely acknowledged (Hughes, 2015; Moser & Pike, 2015), there is a relative lack of empirical research testing the efficacy of various engagement methods with specific testable hypotheses. Therefore, this dissertation project designed and implemented three public health-oriented climate engagement methods, and tested the methods with a set of common dependent variables, facilitating comparisons of the relative strengths and weaknesses of each. The findings indicate how cities can use a variety of public engagement methods to create pathways for envisioning local preferences in climate adaptation planning.

Finally, the dissertation project examines planners' roles in science-intensive planning and policymaking processes, in particular, through addressing the unique challenges to enhancing public engagement around climate change. This dissertation project presents ways for planners to bridge expert and public views regarding scientific or technical matters. Furthermore, it examines how planners can foster collective decision-making capacities among different publics, and ultimately, enable technically sound and politically feasible responses by individuals and communities to adapt to climate change.

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Appendix A. Issue Framing Vignettes[43]

Environment Frame

According to Dr. Thomas Lovejoy, a research biologist and former Assistant Secretary for Environmental Affairs at the Smithsonian Institution in Washington, D.C, climate change is putting new stresses on important species, which can destabilize ecosystems. “It is now clear that over the next few decades climate change is likely to become a major threat to many of America’s plant and animal species,” says Lovejoy. Rising temperatures and changes in weather have already contributed to disruptions in ecosystems and species declines in many areas of the country and around the world, according to several new studies.

Health Frame

According to Dr. Howard Frumkin, a medical doctor and former director of the National Center for Environmental Health at the U.S. Centers for Disease Control & Prevention (CDC), climate change is increasing the rates of some diseases, and is making extreme weather conditions such as heat waves and severe storms more deadly. “It is now clear that over the next few decades, climate change is likely to become a major threat to the health of Americans,” says Frumkin. Increasingly, severe heat waves, other extreme weather events, and the spread of infectious diseases have already contributed to illness and deaths in all regions of the country and around the world, according to several new studies.

[43] abridged versions of vignettes used in Myers et al. (2012)

2: Not very concerned

3: Somewhat concerned

4: Very concerned

5: Extremely concerned

Q1.6 How confident are you that your city or town will be able to effectively respond to climate-related risks, despite uncertainty about what the future climate will be like?

1: Not at all confident

2: Not very confident

3: Somewhat confident

4: Very confident

5: Extremely confident

Q1.7 How do you feel about your city or town incorporating projections of what the climate might be like in 50 years in everyday planning and infrastructure decisions?

1: It is a very bad idea.

2: It is a somewhat bad idea.

3: It is neither a good nor bad idea.

4: It is a somewhat good idea.

5: It is a very good idea.

Q1.8 How willing would you be to pay higher taxes so that your city or town can reduce climate change risks?

1: Not at all willing

2: Not very willing

Appendix B. Issue Framing Survey Questions

Q1.1 Please answer the following questions. All responses will be kept confidential and compiled in total. Survey results will only be used for academic research purposes.

[Environment/Health Frame Groups: insert vignettes here]

Q1.2 Please enter your zip code. ____________

Page Break

Q1.3 How much do you know about global warming or climate change?

I have never heard of it.

I know something about it.

I know a great deal about it.

Not sure.

Q1.4 How serious of a threat is climate change to you?

1: Not at all serious

2: Not very serious

3: Somewhat serious

4: Very serious

5: Extremely serious

Q1.5 How concerned are you about the possible impacts a changing climate might have on your city or town?

1: Not at all concerned

3: Somewhat willing

4: Very willing

5: Extremely willing

Q1.9 Your city or town is looking to reduce its climate risks. Which climate change impact do you think your city or town should prioritize in its policies?

Individual property damage

Local business disruption

Increased risks of disease, hospitalization, and death

Disproportionate impacts to people less able to prepare for climate impacts

Water, energy, and transportation infrastructure damage

Watershed, forest, and ecosystem degradation

Page Break

Q1.10 What is your gender?

Male

Female

Other: ____

Q1.11 What is your age?

19 or under

20-29

30-39

40-49

50-59

60+

Q1.12 How would your describe your political viewpoint?

Extremely conservative

Conservative

Slightly conservative

Moderate, middle of the road

Slightly liberal

Liberal

Extremely liberal

Other: ____

Q1.13 Do you belong to any non-profit groups that regularly advocate on behalf of environmental conservation and/or protection? (Please select all that apply.)

No

Yes, a national group (like The Nature Conservatory or National Aubudon Society, etc.)

Yes, a local group (like a watershed alliance or local conservation committee, etc.)

Yes, other: ____

Q1.14 What industry most accurately describes your primary field?

Agriculture, forestry, fishing and hunting, mining

Construction

Manufacturing

Wholesale trade

Retail trade

Transportation, warehousing, and utilities

Finance, insurance

Real estate

Management and administrative services

Education

Healthcare and social assistance

Arts, entertainment, recreation, hospitality

Public administration

Other: ____

Q1.15 What is the highest level of education you have completed?

No formal schooling completed

High school graduate (or equivalent)

Some college or associate's degree (AA, etc)

Bachelor's degree (BA, BS, AB, etc.)

Master's degree (MA, MSc)

Professional or doctoral degree (MD, JD, PhD, etc.)

Other: ____

Q1.16 Could you estimate your household's total income for the calendar year of 2016? (Optional)

Less than $14,999

$15,000 to $24,999

$25,000 to $34,999

$35,000 to $49,999

$50,000 to $74,999

$75,000 to $99,999

$100,000 to $149,999

$150,000 or more

Appendix C. Role-Play Simulation General Instructions

How to Handle the Public Health Impacts of Climate Change: A Community Role-Play Simulation

Prepared by the MIT Science Impact Collaborative MIT Department of Urban Studies and Planning

General Instructions

Climate change is likely to bring hotter temperatures, increased storm frequency and intensity, and sea level rise to New England. The threats, particularly the human health impacts, posed by shifting climatic conditions are daunting, but they are difficult to quantify precisely. Despite uncertainty about what the future holds, it is important that municipalities take whatever actions they can to minimize their vulnerability. There has been much discussion about possible strategies cities can take to minimize the impacts of climate change. So far, though, there are very few examples of cities that have taken all the steps they can to reduce the public health risks likely to be caused by climate change.

Role-Play Background

Mapleton is a high-density, progressive city in New England with a population of about 100,000 residents. Climate change is on the minds of many residents. Hotter summers, harsh winter storms, and increased flooding continue to wreak havoc on the city's infrastructure. Wanting to better understand the climate change threats facing the city, the City Council has initiated a multi-year climate change adaptation effort. Consultants hired by the city recently completed a climate vulnerability assessment that shows that Mapleton ***is particularly vulnerable to increasing temperatures and more intense storms with increased precipitation***.

The climate vulnerability assessment shows that by 2030, in a high emissions scenario, Mapleton could experience as many as 20 more days a year with temperatures above 90 degrees. Over the next 50 years, under a high emissions scenario, storms that bring heavy rain will become more common. What is considered a 100-year storm today (1 in 100 chance it will occur) will become a 25-year storm (1 in 25 chance). This translates to a 10% increase in flood-prone areas that will repeatedly experience over three feet of flooding during storms. These statistics have sparked increasing concern among residents and public health officials.

The vulnerability assessment has highlighted extreme heat and flooding as the primary focus of Mapleton's climate adaptation efforts. However, these impacts have not been, nor will they be equally distributed across the city. This variation is due to proximity to rivers, poor storm water infrastructure, and green space. Armed with this new data, the City is now asking, "What should we do?"

Public Health Impacts of Climate Change

The Mapleton Department of Public Health is especially concerned that the city is unprepared to manage the health effects that a string of extreme heat events and flooding will have on the most vulnerable residents, especially the young, homeless, elderly, and people with pre-existing health conditions. Extreme heat triggers respiratory illnesses, like asthma, and causes cardiovascular illnesses, including heat stroke. Flooding and intense precipitation can cause toxic mold growth, contaminate water supplies, increase the spread of vector-borne illnesses, and restrict access to roads i the event of an emergency. In addition, both extreme heat and flooding can cause power outages that can leave people who depend on electric medical equipment at risk, as well as cut off power to refrigerators, increasing the risk of food-borne illnesses.

City officials have been on high alert ever since the summer two years ago, when a nearby large city experienced a massive heat wave. The heat wave lasted for five consecutive days, the temperature was over 95 degrees Fahrenheit with a heat index of 115 degree Fahrenheit. Approximately 10,000 residents were hospitalized for a mixture of heat stroke, renal failure, asthma, severe dehydration, and mental distress that experts say peaked because of the extreme heat. As a result of the heat wave in that city, 500 residents lost their lives. Most of the people who passed away lived alone or had weak social support networks, pre-existing health conditions, limited access to transportation, and no air conditioning.

Although Mapleton fared better during that heat wave, the region experienced a record high precipitation year with several flash floods. These floods closed many tunnels, bridges, and transit stations, and knocked out power for three days in some parts of the metropolitan area.. Hospitals were able to stay online with generators, but access to medical care was cut off to many residents. Flooding also caused sewage overflow in combined sewers, which contaminated waterways. The region has experienced an 80% increase in precipitation since the 1950s and may be at risk of $200 million worth of damage due to serious citywide flooding.

The State Public Health authorities have cautioned, "We need to be prepared for more climate-related emergencies. These events show us that the threat is not years away, but it is happening right now." In light of this tragedy and warnings from the State Health Department, officials in Mapleton want to be prepared for climate-related emergencies. They want to take steps to reduce the health risks associated with extreme heat events.

The Decision at Hand

The City Council has made climate adaptation a priority. It has an extensive stakeholder engagement effort underway, seeking community input into ways of managing climate-related health risks.

The City Council has assembled a representative Advisory Group to help formulate a strategy to deal with climate-related health risks. While the Advisory Group will not have the final say, the City Council has indicated it will pay close attention to whatever the group recommends—if it can achieve agreement. The Council hopes the group will get everybody on board, but it will take seriously any recommendation that is supported by five of the six members of the Advisory Group. In the end, the Council will make the final decision, but there is substantial political pressure to generate a recommendation supported by as many stakeholders as possible.

The City Council and the Director of Public Health have compiled a list of possible action strategies the City can take to reduce its vulnerability to climate change. They have also hired a trained facilitator to help run the Advisory Group meeting (that you are about to attend!). The pre-made list of possible strategies will be discussed at today's meeting. Of course, the City is also interested in creative solutions that might emerge from the Group's discussions. The City has limited resources and will probably be able to implement just two of the strategies listed. So, that is what the Advisory Group will focus on.

You will be assigned to play the role of one of the six members of the Advisory Group. You will have a chance to prepare. Then, with the help of a facilitator, the Group's discussion will run for 60 minutes. After that, everyone in attendance will talk about what happened in the simulation and what the results might mean.

The City Council has put together a table listing the various approaches, a description of the activities associated with each strategy, and the public health benefits of each strategy:

	Option	Description	Public Health Benefits
A	**Information-Based Strategy** *Low Expense*	Aimed at sharing information about how the public can remain safe during a climate emergency. Potential activities include: public awareness campaigns about the link between climate change and health, and a mobile alert system that will be activated during emergencies.	• Discourages community members from engaging in hazardous activities, thereby preventing unnecessary injuries • Notifies community members with chronic illnesses of health advisories during extreme climate events • Provides information on how to avoid health threats during extreme heat and flooding
B	**Emergency Preparedness** *Medium Expense*	Focused on improving response time and organizing services to help people in need during climate-related emergencies. Activities include: evacuation drills, clarifying emergency medical response team responsibilities, and adding emergency responder trainings for current public health staff, first responders, and neighborhood activists.	• Reduces emergency response time, reduces the number of deaths • Helps first responders identify climate-related health risks and respond effectively • Trains residents to assist their neighbors and communicate urgent medical needs to first responders, insuring that those in the greatest need are helped first
C	**Resource Allocation** *High Expense*	Ensures that city officials have additional funds and capacity to address short-term emergencies and long-term public health impacts of climate change. Activities include: hiring additional public health professionals, adding more program coordinators, and investing in necessary equipment and supplies. Supporting climate adaptation programs.	• Funds ongoing research into viable policy solutions for climate-related illnesses • Facilitates coordination between various city agencies to implement policies that prevent climate-related illness, providing wide-scale health benefits. • Creates long-term strategy for city to manage public health issues of climate change.
D	**Rules and Regulations** *Low Expense*	Enforces and adds legislation and regulations to ensure the safety of city infrastructure and core services during extreme weather events. Includes: changes to building codes and zoning laws; changes in operating procedures Places requirements on private property owners.	• Cool design and green infrastructure reduce heat levels within and around buildings, limiting heat stroke and dehydration. • Reduces risk of water damage to buildings and improves indoor air quality, reducing risk of worsening respiratory illnesses • Reduces risk of personal injury within the home, workplace, and other private property during flooding.
E	**Prevention** *High Expense*	This involves actions to promote long-term improvements in sustainability and limit greenhouse gas emissions. This focuses on long-term reduction of climate risks. Actions include: supporting the construction of "green infrastructure" (like rooftop gardens on all public buildings and adopting cool design improvements) to city-owned buildings; encouraging green infrastructure on private property.	• Cool design and green infrastructure reduces heat levels within and around buildings, limiting heat stroke and dehydration. • Reduces risk of water damage to buildings and improves indoor air quality, reducing risk of worsening respiratory illnesses • Cool design and green infrastructure will be placed on publicly owned land, providing greater access to vulnerable populations and improving their health outcomes

The Stakeholders (Members of the Advisory Group appointed by the City Council)

City Manager - The City Manager is supportive of the innovative culture of Mapleton and wants to be responsive to the environmental concerns of residents. S/he wants to see more collaboration among the government, public, and the private sector.

Director of Public Housing - The Director has been a tireless advocate for the marginalized residents of Mapleton. S/he is worried that climate change will adversely affect low-income and homeless residents. The Director believes that any city-funded efforts should focus on the most vulnerable.

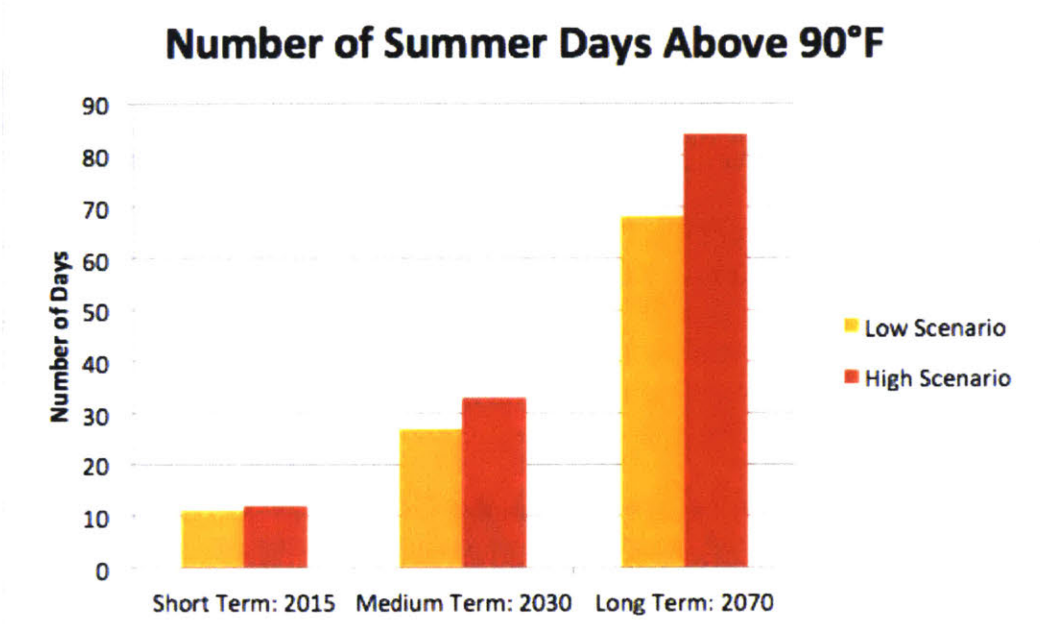
Director of Public Health - The Director is very concerned about the threat of more frequent heat waves and intense storms. S/he knows first hand the devastating toll these events have had throughout history, and is worried that too little attention has been given to the public health effects of climate change in recent public conversations. The Director is also concerned that heat waves will impact senior citizens and people with limited mobility most of all, especially those living in older housing or with inadequate transportation options.

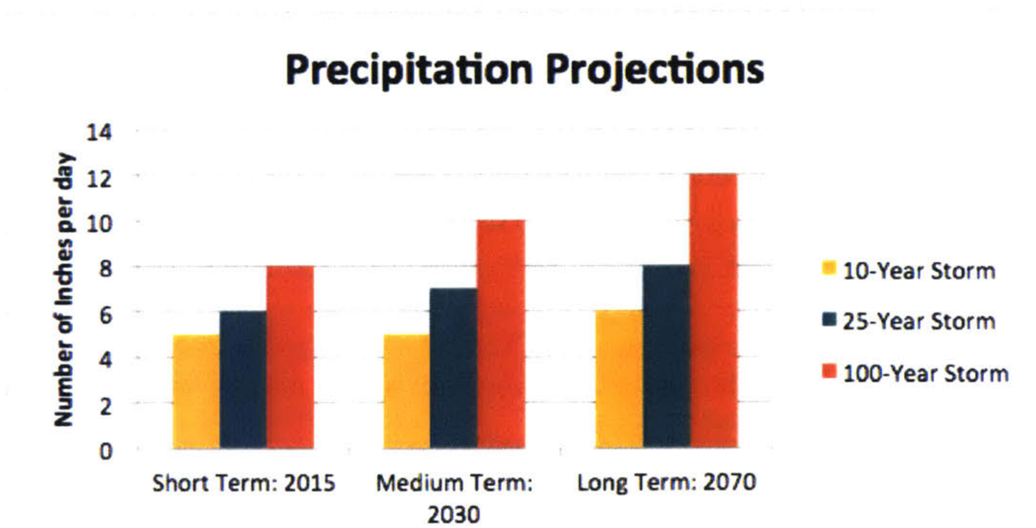
Executive Director, Neighbors for a Green Mapleton (NGM) - This environmental group wants to ensure that the city does not inadvertently worsen greenhouse gas emissions in its efforts to adapt to the impacts of climate change (like adding more air conditioning to protect people from heat waves and in the process adding to the overall level of CO_2 emissions). NGM wants to find a balance between short-term needs and long-term considerations in addressing Mapleton's heat and flooding vulnerabilities.

Long-Range Planner for Mapleton University - Mapleton University is striving to be "a good neighbor." The university's long-range planner is primarily concerned about the health and safety of university students, faculty and staff, but also wants to be a leader in addressing climate change more generally. Mapleton University is a major landowner in the city.

President, Mapleton Chamber of Commerce - The Chamber of Commerce wants to maintain the economic vitality of the city, and represents the interests of business owners in Mapleton. The Chamber facilitates conversations among business owners, residents, and consumers and is well versed in the concerns of all these groups. The Chamber wants to ensure that long-term climate adaptation decisions do not undercut the city economy or conflict with the immediate needs of businesses and real estate owners.

Climate Projections for Mapleton





Glossary of Terms

Cool Roof - A roof with high solar reflectance that reduces heat absorption in the building, reducing temperatures inside.

Green Infrastructure - The use of vegetation, soils, and natural elements to manage water, provide habitat, cooling and shade, and reduce pollution. Examples include extensive tree planting, "green roofs" (i.e. planted with grass, shrubs and trees), rain gardens, and permeable pavement.

Green Roof - A vegetative layer on a rooftop which helps provide shade, reduce heat, manage water, and reduce pollution by mimicking natural processes.

Heat Stroke - A very serious and sudden heat-related illness that can cause nausea, disorientation, seizure, damage to the brain or other internal organs, and even death. Older Americans are two-and-a-half times more likely to be hospitalized for heat stroke during a heat wave.

Heat Wave - An extended period of excessively hot weather; causes temporary lifestyle changes and has adverse health effects.

Morbidity – The proportion of illness or sickness in an area.

Mortality – The frequency of deaths in an area.

Public Cooling Center - Air-conditioned, indoor spaces that are temporarily open to the public to offer residents relief from unbearable heat.

Renal Failure - Also known as kidney failure, prevents kidneys from properly filtering blood, resulting in the buildup of harmful wastes in the body. Older Americans are at a 14% greater risk of hospitalization for renal failure during heat events

Respiratory Disease- Asthma and other respiratory diseases can be exacerbated during extreme heat and from mold growth during flooding, requiring medical care.

Urban Heat Island - A localized temperature increase of up to 10 degrees Fahrenheit in cities and towns relative to nearby rural areas due to the replacement of natural plants and trees with buildings, pavement and infrastructure that eliminates natural cooling functions.

Vector-borne Disease- Illnesses that are spread by insects, such as mosquitoes and ticks, which are expected to increase with temperature and precipitation increases.

Zoning Code - Local regulations that control the development and allowable uses of property.

Appendix D. Role-Play Simulation Before-Survey Questions

Q1.1 Thank you for your interest in the upcoming workshop. Please provide the following information to reserve your spot. We will also email you with more details and information as the workshop approaches. We will not use your contact information for any other purposes.

Q1.2 Please write your name.

First Name ______________
Last Name ______________

Q1.3 What is your preferred email address? We will be sending you workshop details to this address.

____

Q1.4 Do you live and/or work in Cambridge?

I live in Cambridge.

I work in Cambridge.

I both live and work in Cambridge.

I neither live nor work in Cambridge.

Please answer the following questions. All responses will be kept confidential and compiled in total. Survey results will only be used for academic research purposes.

Q2.2 How much do you know about global warming or climate change?

I have never heard of it.

I know something about it.

I know a great deal about it.

Not sure.

Q2.3 How serious of a threat is climate change to you?

1: Not at all serious

2: Not very serious

3: Somewhat serious

4: Very serious

5: Extremely serious

Q2.4 How concerned are you about the possible impacts a changing climate might have on the city of Cambridge?

1: Not at all concerned

2: Not very concerned

3: Somewhat concerned

4: Very concerned

5: Extremely concerned

Q2.5 How confident are you that Cambridge will be able to effectively respond to climate-related risks, despite uncertainty about what the future climate will be like?

1: Not at all confident

2: Not very confident

3: Somewhat confident

4: Very confident

5: Extremely confident

Q2.6 How do you feel about the city of Cambridge incorporating projections of what the climate might be like in 50 years in everyday planning and infrastructure decisions?

1: It is a very bad idea.

2: It is a somewhat bad idea.

3: It is neither a good nor bad idea.

4: It is a somewhat good idea.

5: It is a very good idea.

Q2.7 How willing would you be to pay higher taxes so that Cambridge can reduce climate change risks?

1: Not at all willing

2: Not very willing

3: Somewhat willing

4: Very willing

5: Extremely willing

Q2.8 The city of Cambridge is looking to reduce its climate risks. Which climate change impact do you think Cambridge should prioritize in its policies?

Individual property damage

Local business disruption

Increased risks of disease, hospitalization, and death

Disproportionate impacts to people less able to prepare for climate impacts

Water, energy, and transportation infrastructure damage

Watershed, forest, and ecosystem degradation

Q2.9 Which policy option should the city of Cambridge prioritize to reduce climate-related risks?

Information provision

Emergency preparedness

Resource allocation

Rules and regulations

Prevention

Q2.10 What industry most accurately describes your primary field?

Agriculture, forestry, fishing and hunting, mining

Construction

Manufacturing

Wholesale trade

Retail trade

Transportation, warehousing, and utilities

Finance, insurance

Real estate

Management and administrative services

Education

Healthcare and social assistance

Arts, entertainment, recreation, hospitality

Public administration

Other: ____________________

Appendix E. Role-Play Simulation After-Survey Questions

Please fill out this survey after the debriefing of the role-play simulation, as yourself, rather than in the role you just played. Feel free to take as much time as you need to thoroughly read and respond to the questions. Your responses will remain confidential.

1. Please write your name. ________________________

2. Are you a resident of Cambridge? Yes / No
   a. If you are a resident of Cambridge, how long have you lived in the community? ____ years

3. How much do you know about global warming or climate change?
   a. I have never heard of it.
   b. I know something about it.
   c. I know a great deal about it.
   d. Not sure.

4. How serious of a threat is climate change to you?

1	2	3	4	5
Not at all serious	*Not very serious*	*Somewhat serious*	*Very serious*	*Extremely serious*

5. How concerned are you about the possible impacts a changing climate might have on the city of Cambridge?

1	2	3	4	5
Not at all concerned	*Not very concerned*	*Somewhat concerned*	*Very concerned*	*Extremely concerned*

6. How confident are you that the city of Cambridge will be able to effectively respond to climate-related risks, despite uncertainty about what the future climate will be like?

1	2	3	4	5
Not at all confident	*Not very confident*	*Somewhat confident*	*Very confident*	*Extremely confident*

7. How do you feel about the city of Cambridge incorporating projections of what the climate might be like in 50 years in everyday planning and infrastructure decisions?

1	2	3	4	5
Very bad idea	*Somewhat bad idea*	*Neither a good nor bad idea*	*Somewhat good idea*	*Very good idea*

8. How willing would you be to pay higher taxes so that Cambridge can reduce climate change risks?

1	2	3	4	5
Not at all willing	*Not very willing*	*Somewhat willing*	*Very willing*	*Extremely willing*

9. The city of Cambridge is looking to reduce its climate risks. Which climate change impact do you think the city of Cambridge should prioritize in its policies?

   a. Individual property damage
   b. Local business disruption
   c. Increased risks of disease, hospitalization, and death
   d. Disproportionate impacts to vulnerable populations
   e. Water, energy, and transportation infrastructure damage
   f. Watershed, forest, and ecosystem degradation

10. Which policy option should the city of Cambridge prioritize to reduce climate-related risks?

   a. Information provision
   b. Emergency preparedness
   c. Resource allocation
   d. Rules and regulations
   e. Prevention

Please answer the following questions about the workshop in general.

11. How much did you learn about the health impacts of climate change?

1	-	2	-	3	-	4	-	5
A great deal		*A lot*		*A moderate amount*		*A little*		*None at all*

12. How much did the role-play simulation help you better understand the viewpoints of different stakeholders in dealing with climate change in Cambridge?

1	-	2	-	3	-	4	-	5
A great deal		*A lot*		*A moderate amount*		*A little*		*None at all*

13. How much did the role-play simulation improve your ability to imagine how stakeholders in Cambridge could reach agreement on how to proceed with climate adaptation?

1	-	2	-	3	-	4	-	5
A great deal		*A lot*		*A moderate amount*		*A little*		*None at all*

14. What is your gender?
    a. Male
    b. Female
    c. Other: _______________

15. What is your age group?
    a. 19 or under
    b. 20-29
    c. 30-39
    d. 40-49
    e. 50-59
    f. 60+

16. How would you describe your political viewpoint?
    a. Extremely conservative
    b. Conservative
    c. Slightly conservative
    d. Moderate, middle of the road
    e. Slightly liberal
    f. Liberal
    g. Extremely liberal
    h. Other: _______________

17. Do you belong to any non-profit groups that regularly advocate on behalf of environmental conservation and/or protection? (Can select multiple options)
    a. No
    b. Yes, a national group (like The Nature Conservancy or National Audubon Society, etc.)
    c. Yes, a local group (like a watershed alliance or local conservation committee, etc.)
    d. Yes, other: _______________

18. What is the highest level of education you have completed?
    a. No formal schooling completed
    b. High school graduate (or equivalent)
    c. Some college or associate's degree (AA, etc.)
    d. Bachelor's degree (BA, BS, AB, etc.)
    e. Master's degree (MA, MSc)
    f. Professional or doctoral degree (MD, JD, PhD, etc.)
    g. Other: _______________

19. Could you estimate your household's total income for 2016? (Optional)
    a. Less than $14,999
    b. $15,000 to $34,999
    c. $25,000 to $34,999
    d. $35,000 to $49,999
    e. $50,000 to $74,999
    f. $75,000 to $99,999
    g. $100,000 to $149,999
    h. $150,000 or more

Appendix F. Role-Play Simulation Facilitator Questionnaire

Name ________________________ **Date** __________ **Table Number** _________

1. Did your table get agreement? (YES / NO)

- If there was an agreement, was it unanimous? (YES / NO)
  - If not, which stakeholder did not take part in the agreement?
  - Which strategies were included or emphasized in the final agreement?
- If there wasn't an agreement, what (or who) was the obstacle to getting agreement?

2. Can you briefly describe what carried weight in terms of <u>process</u> or <u>substance</u> at the table you facilitated in reaching the final outcome?

Process explanation examples:
The people at my table were very cooperative.
They listened to each other and respected each other's views.
One of the parties offered a very persuasive argument and the rest of us went along.
There was only one person who didn't agree with rest of us.
The people who spoke seemed very sure of what they were saying.

Substantive explanation examples:
It wasn't hard to narrow down the list to the two most important strategies.
By tweaking one (or two) of the strategies, we were able to get everyone on board.
Most of us were clear on which strategies offered the greatest benefits to the whole city (or which were too costly relative to the benefits).
To get political agreement we had to include one of the strategies, even those one of the others might actually produce a better result.
The technical material made clear which would be the best strategies to include.

3. Did anything else occur at your table that you found interesting?

Thank you so much for your time! Please return this questionnaire.

Appendix G. Role-Play Simulation Debriefing Script

1. Before the game, had you thought about the public health impacts of climate change? Has your thinking changed? How?

2. Given the discussion during the game, which climate-related health impacts are you most worried about affecting you, your family, or your community? Why?

3. Most people haven't been thinking about climate change in terms of the increased risks to human health that flooding and heat waves might cause. Do you think talking about the city's vulnerability to climate change in terms of public health risks is a good idea? Why?

4. In the game, we were all talking about which strategies would be the best for the city of Mapleton to choose and why. Which of the five strategies do you think Cambridge should prioritize? Why?

5. It will not be easy to reduce the city's vulnerability to climate risks or enhance the city's resilience. There are things that might best be handled by the public sector (government) and other risk management efforts that should be the responsibility of citizens and property owners. What, in your view, are the government's responsibilities for trying to reduce the risks of climate change and what are the responsibilities of citizens and private property owners? Why?

Appendix H. Role-Play Simulation Post-Game Interview Questions

Permission

1. Do you give permission to for me to record this conversation? Yes / No
(if they say yes, start recording, and ask question again)
2. Do you give permission for your title, name or direct quotes to be used in our research report? Yes / No

1. Tell me a little bit about who you are and why you attended the [date and location] workshop.

a. What is your name, title, and organization
b. What were you hoping to get from workshop?

2. What do you remember from playing the role-play simulation?

a. Please tell us everything you remember from the game and workshop.
b. Did you find the role-play simulation enjoyable? Interesting? What were the most striking elements?
(optional) c. What role did you play? Was the role you played and related interests similar or quite different from your real-life role and interests?

[REFRESHER] date of game, outcome of game, table results

3. Prior to the workshop, what thoughts did you have about how climate change might affect Cambridge?

a. How would you describe your thinking/concern about climate change impacts on Cambridge before the workshop?
b. Before the game, had you thought about the public health impacts of climate change?
c. How would you describe your policy support for climate adaptation in Cambridge before the workshop?

i) What climate risks should Cambridge prioritize? [If needed, examples: property damage; business disruption; increased health risks; infrastructure damage; ecosystem degradation; disproportionate impacts to vulnerable populations] Why?

ii) What policy approaches should Cambridge take? [If needed, examples: information provision; emergency preparedness; resource allocation; rules and regulations; prevention] Why?

[Get them to elaborate on this]

4. Did the role-play simulation make you think or feel differently in any way on what you would recommend that Cambridge do to plan for climate change? Why?

a. concern about climate impacts
b. concern about public health
c. policy recommendations for adaptation in Cambridge

5. Most people have not considered climate change in terms of public health risks from increased flooding and extreme heat. Do you think talking about Cambridge's vulnerability to climate change in terms of public health risks is a good idea? Why?

6. Is there anything else that you took away from participating in the simulation? [Can ask about climate risks, engaging diverse stakeholders in planning for adaptation, health impacts of climate change, etc]

a. Please explain how the role-play simulation affected you in this way.
b. Do you think that these lessons could easily be learned in other ways?

7. Do you have any other recommendations on how to best engage diverse populations in climate adaptation planning?

a. What resonates with people?

Extra Potential Questions

Since participating in the workshop, have you talked with anyone (family, friends, colleagues) about the experience?

a. What did you tell them?

Was the role you played and related interests similar or quite different from your real-life role and interests?

a. How did it feel to "step into someone else's shoes" for a while?

Did the simulation make you think or feel differently in any way about the local climate risks that Cambridge is trying to prepare for?

Given the discussion during the game, which climate-related health impacts are you most worried will affect you, your family, or your community? Why?

Appendix I. Digital Game Role Descriptions

1. Child with asthma/other respiratory issues: vulnerability to air quality issues

Name: Cora
Age: 7
Family: parents + one older sister and one younger brother
Neighborhood: Cambridgeport

Cora is a second-grader at Morse Elementary School in Cambridge, MA. Cora has lived in Cambridge all her life. Cora loves dinosaurs and climbing trees. Lately, Cora has had coughing spells that seem to be come and go after she plays during recess, when she laughs watching TV with her brother, and in the evenings. She sometimes gets a weird tight feeling in her chest as well.

After visiting her pediatrician with her mother, Cora was told that she has asthma. Further tests revealed that Cora is susceptible to a number of asthma triggers, including irritants in the air, such as smoke or strong odors, and allergens like pollen, pet dander and dust mites. Cora is worried because she doesn't understand how she can avoid encountering these things when she's home, at school, or playing outside with her friends. She also now has to carry an inhaler to school, and she worries about what to tell her friends if they ask.

Climate Risk!
Children's growth and development from infancy to adolescence makes them more sensitive to environmental hazards related to climate. For example, because children's lungs develop through adolescence, they are more sensitive to respiratory hazards. Climate change worsens air quality because warming temperatures make it easier for ground-level ozone to form. Changing weather patterns and more intense and frequent wildfires also raise the amount of pollution, dust, and smoke in the air. For children, this change in air quality may increase the number and worsen the severity of asthma episodes. Climate change is also expected to lead to longer and more severe pollen seasons, triggering asthma and allergies in children.

Caretaker Actions to Alleviate Risk
How Caregivers Can Protect Children's Health
Air Quality & Respiratory Illnesses
Check the Air Quality Index and pollen counts on your local weather reports and consider limiting outdoor time if levels are high. www.airnow.gov
Extreme Weather Events

If children are exposed to storms or floods, watch for diarrhea symptoms and mental health impacts. Also, watch for signs of mold indoors after a flood, and be sure to clean and dry affected areas. During a power outage, never use a generator indoors or in a garage. http://emergency.cdc.gov/disasters

2. Disabled Afghan veteran in wheelchair: limited mobility in climate events, such as coastal storms and flooding

Name: Jake
Age: 32
Family: parents + one older sister
Neighborhood: Inman Square

Jake is a graduate of the Naval Academy and proud veteran that served two duties in Afghanistan. When Jake was on his second deployment with the Marines in Afghanistan, he lost both his legs. Another squad had been hit by two improvised explosive devices (IEDs), and he was helping to clear the landing zone so a helicopter could pick up the casualties, when his patrol also triggered an IED. At 27, Jake became a double-leg amputee.

Jake went to get his MBA from the Sloan School of Management at MIT, and now works in sales for a biotech company in Kendall Square. While his home and workplace are wheelchair-accessible, Jake still encounters mobility issues from time to time. He finds it difficult to maneuver the aisles in certain buses and trains, and going to the bathroom while on a plane is almost unthinkable.
Jake can't help but wonder about what would happen if either building were to lose power in an emergency. Jake lives on the 8th floor of an apartment building in Inman Square, and his office is on the 17th floor of a building in Kendall Square.

Climate Risk!
People with disabilities may also face additional physical challenges associated with evacuations, which can make health impacts worse, especially if local emergency response plans do not adequately anticipate and address the special needs of these populations. Examples from Hurricane Katrina include the inability to meet demand for wheelchair-accessible transportation, challenges associated with maintaining adequate supplies of prescription medication or access to necessary medical equipment like oxygen, and a lack of evacuation shelters with appropriate facilities, equipment, and trained staff to meet the various needs of people with disabilities. Extreme events can also cause power outages that can affect electrically-powered medical equipment and elevators, leaving some people with disabilities without treatment or the ability to evacuate.

Caretaker Actions to Alleviate Risk

Install wheelchair ramps
Advocate for wheelchair accessible transportation in emergency preparedness
Formulate evacuation plans for emergencies; practice at home

3. Senior citizen with history of heart problems: susceptibility to extreme heat

Name: Martin
Age: 74
Family: Wife + three daughters
Neighborhood: Huron Village

Martin is a retired architect. After an illustrious career of three national award-winning books, numerous gallery exhibitions, and teaching at universities in cities in the US and Sweden, he and his wife are now settled in Inman Square. Martin and his wife have three adult daughters: Aria, a clinical psychologist, Jessica, a graphic artist, and Hannah, a mother of two toddler sons. Their daughters visit them often in Cambridge, but are increasingly worried about their father's health.

After smoking about a pack of cigarettes a day for over 20 years, Martin has had two heart attacks, his first at the age of 42. Since then, Martin has been on a steady mix of heart disease medications.

Climate Risk!
A recent University of Chicago Medical Center study found that 40% of heat-related fatalities in the U.S. were among people over 65. There are several reasons for elderly heat vulnerability. People's ability to notice changes in their body temperature decreases with age. Many seniors also have underlying health conditions that make them less able to adapt to heat. Furthermore, many medicines that seniors take can contribute to dehydration.
In particular, drugs used to treat heart diseases, such as diuretics and beta-blockers, can make people with heart disease more sensitive to heat stress.

Caretaker Actions to Alleviate Risk

1. Offer Plenty of Liquids
   Dehydration is the root of many heat-related health problems.
2. Make sure they're wearing appropriate clothes
   Know that older people also are less perceptive about temperature shifts than younger people. There are instances of old people wearing fur coats in heat waves.
3. Stay Indoors During Mid-day Hours
   During periods of extreme heat, the best time to run errands or be outdoors is before 10am or after 6pm, when the temperature tends to be cooler.

4. Take it Easy
   Avoid exercise and strenuous activity, particularly outdoors, when it's very hot out.
5. Watch the Heat Index
   When there's a lot of moisture in the air (high humidity), the body's ability to cool itself through sweating is impaired. The heat index factors humidity and temperature to approximate how the weather really feels. The current heat index can be found on all popular weather websites, and is also usually announced on local TV and radio weather reports during periods of warm weather.
6. Seek Air-conditioned Environments
   Seniors whose houses aren't air-conditioned should consider finding an air-conditioned place to spend time during extreme heat.The mall, library or movie theater are all popular options. During heat waves, many cities also set up "cooling centers," air-conditioned public places, for seniors and other vulnerable populations. Seniors without convenient access to any air-conditioned place might consider a cool bath or shower.
7. Know the Warning Signs of Heat-related Illness
   Dizziness, nausea, headache, rapid heartbeat, chest pain, fainting and breathing problems are all warning signs that help should be sought immediately.

4. Recent immigrant with limited English proficiency: lack of access to public health information in first language

Name: Sofia
Age: 45
Family: husband + two sons
Neighborhood: East Cambridge

Sofia is a recent immigrant in the East Cambridge area. Her two sons are acclimating nicely in the public schools in Cambridge. East Cambridge also has a bank with complete services in Portuguese to its clientele, and a local church that offers Mass in both English and Portuguese. In addition, Sofia has found a community of other Portuguese-speaking mothers within East Cambridge, making her transition easier.

However, Sofia finds it difficult to communicate with people at her son's schools and hospitals. Her sons translate school documents for her, so she trusts and signs certain forms when her sons say they need parental permission for certain events or activities. When she or her sons need to see a doctor though, as her sons are not able to translate everything the doctor says for her, she finds it frustrating.

While Sofia has no difficulties maneuvering day-to-day life, hospital and school visits are stressful. After visiting the doctor, in particular, she worries that her lack of English proficiency is preventing her from accessing crucial information in maintaining her own health and the health of all her family members.

Climate Risk!

Research studies illustrate the importance of language services for Lack of English Proficiency patients. The lack of language services has been shown to affect access to health care services and preventive care. A Canadian study found that women who did not speak English were less likely to receive breast exams, mammograms or pap smears. Spanish-speaking patients with English-speaking only physicians were found to be more likely to make at least one additional visit to the emergency room as compared to Spanish-speaking patients with Spanish-speaking doctors.

The lack of language services also results in poor communication of important information between the provider and patient, with significant negative outcomes on patient health and treatment. One study found that patients with language barriers were unable to comprehend diagnoses, resulting in them not being able to ask questions and having to guess what was being told to them. Other studies show that patients who did not speak the same language as their physician were more likely to miss an appointment, to not comply with follow-up instructions including taking medications, and to not be as satisfied with their healthcare experience. These types of incidents can significantly increase the likelihood of medical errors and distrust between providers and their patients.

In addition, access to emergency public health information in climate-related emergencies is key.

Caretaker Actions to Alleviate Risk

Increased language interpretation and cultural competency training at healthcare facilities
Translation of emergency public health information into multiple languages in a timely manner

Appendix J. Digital Game Role Screens

I. Cora (child w/ asthma/other respiratory issues: vulnerability to air quality issues)

1. Intro to Character

a. Cora at home

- Cora growing up in Cambridge - baby growing up into a 7 year old, along with older sister and younger brother in Cambridgeport (just a typical residential neighborhood)

b. Cora at school

- Cora enjoying dinosaurs and climbing trees
- Cora playing during recess

2. Existing Health Conditions

a. Cora's health - child asthma

- Cora w/ coughing spells 1) during recess 2) when she laughs watching TV at home, and 3) evenings, accompanied with tight feeling in her chest

- Pediatrician telling Cora + her mother Cora has asthma
- Cora undergoing further tests
- Results showing susceptibility to certain asthma triggers: smoke, strong odors, allergens like pollen, pet dander, and dust mites
- Cora worried: impossible to avoid triggers at home, at school, outside
- Cora carrying inhaler to school now discreetly, worried about what her friends will think

3. How Will CC Impact Character? (Click on relevant weather/crisis icon to learn about increased risks)

a. Click on different climate buttons to learn how risks will get worse

- Warmer temperature button (heat): increased ground-level ozone; longer and more severe pollen seasons
- Changing weather patterns (cloud)/more intense and frequent wildfires (fire): increases pollution, dust, and smoke in air

-> decreased air quality increases the number and severity of asthma episodes

b. Vulnerable population - children

- Children's ongoing growth and development makes them more vulnerable to climate hazards

cf) children's lungs are still developing; more sensitive to respiratory threats

- Check learning with true/false question - children are more vulnerable to air quality issues than adults

4. Actions to Alleviate Risk

(drag and drop each of the 3 "tools" from room into preparedness toolkit; tool will be highlighted and ready to be picked; each tool dragged will lead into subsequent screen on tool itself)

a. Check Air Quality Index (tool: air quality measurement tool)

- Link to airnow.gov
- Player has to check current AQI for Cora's zip code (02138?) to proceed
- Check learning by asking what the AQI threshold is for Cora (sensitive population)

b. Limit outdoor time and duration of exertion (tool: hourglass)

c. Wear mask outside (tool: mask)

II. Jake (vet w/ wheelchair: limited mobility in climate events)

5. Intro to Character

a. Jake in war

- Jake graduating Naval Academy
- Jake in combat
- Jake waking up in hospital after double amputation

b. Jake post-war

- Jake getting his MBA from MIT Sloan
- Jake working in new job in biotech sales in Kendall Square
- Jake maneuvering wheelchair both at home and at work (both places are wheelchair-friendly with ramps and bars, elevators)

6. Existing Health Conditions

- Mobility issues - difficult to maneuver the aisles in certain buses and trains
    1. going to the bathroom on plane is almost impossible
- Jake worries about either home or office building losing power in an emergency
    1. Lives on 8th floor of apartment building
    2. Works on 17th floor of building in Kendall Square

7. How will CC impact character?(Click on relevant weather/crisis icon to learn about increased risks)

. Click on different climate buttons to learn how risks will get worse

- Increase in severity and frequency of climate and weather-related emergencies (hurricane or other crisis icon) - physical challenges with evacuations, finding wheelchair accessible transportation options in emergencies, lack of emergency shelters with appropriate facilities

a. Vulnerable population - disabled

- Limited mobility in evacuations may worsen the health impacts of extreme events
- Extreme events can also cause power outages affecting electrically powered medical equipment and elevators

- Possible loss of water pressure and the risk of foodborne illness that goes with power outage (loss of refrigeration) in the home -> limited access to a fresh and safe food supply

8. Actions to Alleviate Risk

. Create a personal support network. (tool: friend/spare key)

- Family, friends, and others who would be able to offer you assistance if needed during an emergency, including one out of town person; if they are not affected by the emergency they may be more capable to assist you. Be sure to talk to these people in advance of an actual emergency. Let them know your emergency communications plan, where you intend to go during an emergency, how you intend to evacuate, where you keep your emergency supplies, and make sure someone in your network has a spare key to your home.

a. If you need to evacuate and require handicap accessible transportation be sure you have alternative modes of transportation planned and that they are also accessible. (tool: van)

- Start to make the arrangements now.

b. If you are dependent on medication, oxygen, batteries for a wheelchair or hearing aid keep a supply in your Household Emergency Kit. (tool: batteries in emergency kit)

- Know the expiration dates and rotate the medications as needed
- Storage of emergency food and water

III. Martin (retired architect w/ heart issues: susceptibility to extreme heat)

9. Intro to Character (screens are more about describing than doing, more brochure-y narratives)

a. Martin at work

- Martin's successful career - show him as writer, gallery exhibition curator, and professor
- Retirement - show retirement ceremony

b. Martin at home now

- Lives with wife in downsized apartment in Huron Village (nicer residential neighborhood)
- Has 3 daughters - show adult daughters visiting Martin with their children (a couple will do)

10. Existing Health Conditions

. Martin's health - history of heart issues

- Martin as heavy smoker - pack a day for over 20 years
- Martin's two heart attacks, first at 42 (maybe show him hospitalized)
- Martin's daily medication - show a cocktail of differently colored pills with days of the week labeled

11. How Will CC Impact Character? (Click on relevant weather/crisis icon to learn about increased risks)

. Warmer temperatures (heat) - increased risk of extreme heat - both in terms of absolute temperatures, but also frequency of heat wave occurrences (hotter more often)

a. Vulnerable population - elderly people
  - 40% of heat-related fatalities in the US among people over 65
  - Ability to notice changes in body temperature declines; underlying health conditions make it difficult to adapt to heat; heart disease medications make people more sensitive to heat stress
  - Check learning with true/false question - senior citizens are more vulnerable to heat stress than younger adults

12. Actions to Alleviate Risk

(drag and drop each of the 3 “tools” from room into preparedness toolkit; tool will be highlighted and ready to be picked; each tool dragged will lead into subsequent screen on tool itself)

a. Check Heat Index (tool: thermometer)
  - Link to https://weather.com/maps/current-heat-index; also on all popular weather websites
  - The heat index is the "feels-like" temperature, or how hot it really feels when the relative humidity is factored in with the actual air temperature
  - When there is a lot of moisture in the air, the body can’t cool itself through sweating
  - Check learning by asking if high humidity in the air makes it seem warmer or cooler than the actual temperature

b. Drink lots of liquids (tool: water bottle)
  - Dehydration is the root of many heat-related health problems

c. Stay cool indoors (tool: mirror/air conditioner)
  - Make sure you’re wearing appropriate clothing - older people are less perceptive about temperature shifts than younger people
  - Stay indoors during 10am-6pm; avoid exercise and strenuous activity outdoors when it’s hot out; seek air-conditioned environments

cf) Many cities set up cooling centers during heat waves; mall, library, movie theaters are also good options

IV. Sofia (recent immigrant w/ limited English proficiency)

13. Intro to Character (screens are more about describing than doing, more brochure-y narratives)

a. Sofia at home
  - Sofia’s recent move from Portugal to US - show Sofia+husband+2 sons moving, maybe on world map

- Sons transitioning in schools in Cambridge - bringing home flyers in English for Sofia to sign
- Family settling into house in East Cambridge (like Cambridgeport, a little more run down)

b. Sofia in the community

- Going to East Cambridge Savings Bank with Portuguese-speaking teller, and St. Anthony's Church for Portuguese Mass
- Sofia finding group of Portuguese speaking mothers in East Cambridge

14. Existing Health Conditions

. Sofia frustrated at communicating directly with teachers at schools and doctors and hospitals - show sons translating by her side

a. Sofia worried about her lack of English proficiency preventing her from accessing information crucial to maintaining her own and rest of family's health - show Sofia struggling to make sense of medicine labels and doctor's notes

15. How Will CC Impact Character? (Click on relevant weather/crisis icon to learn about increased risks)

. Increase in severity and frequency of climate and weather-related emergencies (hurricane or other crisis icon) - can't access emergency public health information!

a. Air quality index and heat index information (smoke and heat icons) - can't access information to gauge other health-related information in daily life either

b. Vulnerable population - limited English proficiency

- Poor communication btw healthcare providers and patients; unable to understand diagnoses
- Patients with limited English proficiency more likely to miss appts, not comply with instructions for treatment, to be dissatisfied with health care experiences
- Check learning with true/false question - people with limited English proficiency are more vulnerable to climate hazards than native English speakers

16. Actions to Alleviate Risk

(drag and drop each of the 3 "tools" from room into preparedness toolkit; tool will be highlighted and ready to be picked; each tool dragged will lead into subsequent screen on tool itself)

a. Create a household emergency plan (tool: paper plan, can resemble a map, or a checklist)

- Identify an out-of-town contact
- Designate two meeting places: near home and outside your neighborhood
- Map evacuation routes
- Locate Neighborhood Emergency Centers

b. Making a household emergency kit and Go-Bag (tool: emergency bag); build two types of kits:

- Shelter-in-Place Kit
  A Shelter-in-Place Kit should include items that you need if you cannot leave your house for up to 1 week, including food, water, batteries, flashlights, and more.
- Go Kit
  A Go Kit should be created for events that require you to quickly evacuate your home for as long as 12-72 hours, such as a home fire or flooding. A Go Kit should include clothing, personal documents (ex: copies of passports, birth certificates), and more.

c. Increased language interpretation and cultural competency training at healthcare facilities (tool: interpreter)

- Offer language assistance to individuals who have limited English proficiency and/or other communication needs, at no cost to them, to facilitate timely access to all health care and services
- Inform all individuals of the availability of language assistance services clearly and in their preferred language, verbally and in writing.
- Ensure the competence of individuals providing language assistance, recognizing that the use of untrained individuals and/or minors as interpreters should be avoided.
- Provide easy-to-understand print and multimedia materials and signage in the languages commonly used by the populations in the service area.

Appendix K. Digital Game Before-Survey Questions

Q1. How much do you know about global warming or climate change?

I have never heard of it.

I know something about it.

I know a great deal about it.

Not sure.

Q2. How serious of a threat is climate change to you?

1: Not at all serious

2: Not very serious

3: Somewhat serious

4: Very serious

5: Extremely serious

Q3. How concerned are you about the possible impacts a changing climate might have on the city of Cambridge?

1: Not at all concerned

2: Not very concerned

3: Somewhat concerned

4: Very concerned

5: Extremely concerned

Q4. How willing would you be to pay higher taxes so that Cambridge can reduce climate change risks?

1: Not at all willing

2: Not very willing

3: Somewhat willing

4: Very willing

5: Extremely willing

Q5. The city of Cambridge is looking to reduce its climate risks. Which climate change impact do you think Cambridge should prioritize in its policies?

Individual property damage

Local business disruption

Increased risks of disease, hospitalization, and death

Disproportionate impacts to people less able to prepare for climate impacts

Water, energy, and transportation infrastructure damage

Watershed, forest, and ecosystem degradation

Appendix L. Digital Game After-Survey Questions

Q1. How much do you know about global warming or climate change?

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I know something about it.

I know a great deal about it.

Not sure.

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Individual property damage

Local business disruption

Increased risks of disease, hospitalization, and death

Disproportionate impacts to people less able to prepare for climate impacts

Water, energy, and transportation infrastructure damage

Watershed, forest, and ecosystem degradation

Q6. How much did the digital game help you learn about the health impacts of climate change?

None at all

A little

A moderate amount

A lot

A great deal

Q7. How much did the digital game help you better understand the viewpoints of different stakeholders in dealing with climate change in Cambridge?

None at all

A little

A moderate amount

A lot

A great deal

Q8. How much did the digital game improve your ability to imagine how stakeholders in Cambridge could reach agreement on how to proceed with climate adaptation?

None at all

A little

A moderate amount

A lot

A great deal

Q9. What is your gender?

Male

Female

Other: ____

Q10. What is your age?

19 or under

20-29

30-39

40-49

50-59

60+

Q11. How would your describe your political viewpoint?

Extremely conservative

Conservative

Slightly conservative

Moderate, middle of the road

Slightly liberal

Liberal

Extremely liberal

Other: ____

Q12. Do you belong to any non-profit groups that regularly advocate on behalf of environmental conservation and/or protection? (Please select all that apply.)

No

Yes, a national group (like The Nature Conservatory or National Aubudon Society, etc.)

Yes, a local group (like a watershed alliance or local conservation committee, etc.)

Yes, other: ____

Q13. What industry most accurately describes your primary field?

Agriculture, forestry, fishing and hunting, mining

Construction

Manufacturing

Wholesale trade

Retail trade

Transportation, warehousing, and utilities

Finance, insurance

Real estate

Management and administrative services

Education

Healthcare and social assistance

Arts, entertainment, recreation, hospitality

Public administration

Other: ____

Q14. What is the highest level of education you have completed?

No formal schooling completed

High school graduate (or equivalent)

Some college or associate's degree (AA, etc)

Bachelor's degree (BA, BS, AB, etc.)

Master's degree (MA, MSc)

Professional or doctoral degree (MD, JD, PhD, etc.)

Other: ____

Appendix K. Digital Game Post-Game Interview Questions

Permission

1. Do you give permission to for me to record this conversation? Yes / No
(if they say yes, start recording, and ask question again)
2. Do you give permission for your title, name or direct quotes to be used in our research report? Yes / No

1. Tell me a little bit about who you are and why you played the digital game.

a. What is your name, title, and organization
b. What were you hoping to get from the digital game?

2. What do you remember from playing the digital game?

a. Please tell us everything you remember from the digital game.
b. Did you find the digital game enjoyable? Interesting? What were the most striking elements?

3. Prior to playing the digital game, what thoughts did you have about how climate change might affect Cambridge?

a. How would you describe your thinking/concern about climate change impacts on Cambridge before the digital game?
b. Before the game, had you thought about the public health impacts of climate change?
c. How would you describe your policy support for climate adaptation in Cambridge before the workshop?

i) What climate risks should Cambridge prioritize? [If needed, examples: property damage; business disruption; increased health risks; infrastructure damage; ecosystem degradation; disproportionate impacts to vulnerable populations] Why?

ii) What policy approaches should Cambridge take? [If needed, examples: information provision; emergency preparedness; resource allocation; rules and regulations; prevention] Why?

[Get them to elaborate on this]

4. Did the digital game make you think or feel differently in any way on what you would recommend that Cambridge do to plan for climate change? Why?

d. concern about climate impacts
e. concern about public health

f. policy recommendations for adaptation in Cambridge

5. Most people have not considered climate change in terms of public health risks from increased flooding and extreme heat. Do you think talking about Cambridge's vulnerability to climate change in terms of public health risks is a good idea? Why?

6. Is there anything else that you took away from playing the digital game? [Can ask about climate risks, engaging diverse stakeholders in planning for adaptation, health impacts of climate change, etc]

a. Please explain how the digital game affected you in this way.
b. Do you think that these lessons could easily be learned in other ways?

7. Do you have any other recommendations on how to best engage diverse populations in climate adaptation planning?

b. What resonates with people?

Extra Potential Questions

Since playing the digital game, have you talked with anyone (family, friends, colleagues) about the experience?

a. What did you tell them?

Did the digital game make you think or feel differently in any way about the local climate risks that Cambridge is trying to prepare for?

Given what you saw in the digital game, which climate-related health impacts are you most worried will affect you, your family, or your community? Why?