Climate Smart Communities Scenarios

Health Impact Assessment

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Executive Summary

Health impact assessment (HIA) provides decision-makers with information about how a proposed policy, program or project may affect the health of people, with a specific focus on equity. HIA differs from traditional public health assessment in an important way - the health impacts of a proposal are assessed before a final decision is made, allowing the results of the HIA to be considered in the decision-making process. HIA provides objective information that can be used to increase the positive health impacts of a project or policy and mitigate negative impacts.

The Oregon Health Authority (OHA) conducts HIAs on projects or policies with statewide impact and on local or regional issues when there is sufficient interest from community members or other agencies. OHA supports statewide HIA practice by facilitating the Oregon HIA Network, providing trainings, and awarding mini-grants to local health departments.

The Climate Smart Communities Scenarios (CSCS) project underway in the Portland, Oregon metropolitan (PDX metro) region is the focus of this HIA. The CSCS project is Metro Regional Government's (Metro) response to a legislative requirement to meet Oregon greenhouse gas (GHG) emissions reduction goals for small trucks and cars. While the law was passed in an effort to mitigate climate change and reduce air pollution, Metro is also considering impacts on public health, the economy, the environment and equity as part of the planning effort.

The HIA will help to support Metro in their consideration of public health and health equity in the selection and implementation of transportation and land use decisions related to GHG reduction policy in the Portland metropolitan region. Our recommendations in this report apply to the selection of the three Phase Two GHG-reduction scenarios to be further tested in 2013, as well as the development and adoption of a preferred scenario in 2014.

Changes to our climate have the potential to impact health in many ways [1]. For example, more summer heat waves with higher temperatures or longer durations would increase heat-related illness and death. Increased frequency and severity of winter storms could lead to impacts such as increased respiratory illness from mold exposure, and increased drowning [2, 3]. Plans and policies intended to help communities mitigate or adapt to climate change also have health implications.

Creating walkable and bikeable communities may increase the proportion of Portland metropolitan region residents who meet physical activity benchmarks and reduce the burden of chronic diseases that are associated with inactivity, while reducing vehicle travel and carbon emissions [4, 5]. In addition, advancements in fuel technology and policies related to fleet mix and turnover also may reduce GHG emissions in the region. Reducing greenhouse gas emissions will have inevitable health benefits for Oregonians by slowing down climate change and improving air quality.

Summary of Findings

OHA found that almost all of the policies under consideration could improve health, and that certain policy combinations were more beneficial than others. The majority of the health benefits result from increased physical activity, followed by reductions in road traffic crashes and lower exposure to particulate air pollution. Strategies that meet GHG reduction goals by decreasing vehicle miles traveled (VMT) will have the most positive impact on human health by increasing physical activity through active transportation and reducing injuries and fatalities from collisions.

The most health-promoting scenarios have similar elements: most ambitious levels of community design policies, intermediate and ambitious levels of pricing and incentives, highest levels of active transportation (including transit), lowest levels of single occupancy vehicle driving, and lowest levels of particulate air pollution. The majority of the health benefits come from increases in physical activity, followed by decreases in injuries and fatalities from collisions, and finally from decreased exposure to air pollution.

Some of the policies under consideration, or the way they are implemented, may also negatively affect health. For example, some communities in the Portland metropolitan region have poor access to active transportation infrastructure (sidewalks, bike routes, transit service). If these areas are not prioritized, implementation could worsen existing inequities, leading to increased health disparities for some of the region's residents.

The modeling tool used in this assessment shows positive health impacts due to reductions in motor vehicle crashes, but also revealed potential negative impacts from increased bike injuries. Understanding the range of potential impacts will help policy makers decide which strategies to prioritize and how to implement the strategies to maximize health and reduce health-related costs for local communities.

CSCS HIA Key Recommendations

- Develop and implement a preferred scenario that meets or surpasses the greenhouse gas emissions reduction target set for the region.
- To maximize public health benefits and meet the state target, emphasize strategies that best increase active transportation and physical activity: community design, pricing and incentives.
- Include strategies, such as community design, that can lead to decreases in road traffic injuries and fatalities for all populations in the region, in particular for children.
- Carry out additional quantitative health impact assessment of the three scenarios that are identified for further evaluation in spring 2013 to further inform development and adoption of a final preferred scenario. OHA recommends the use of ITHIM or a similar health impacts model for this future assessment.

Introduction

Health impact assessment (HIA) provides decision-makers with information about how a proposed policy, program or project may affect the health of people. HIA differs from traditional public health assessment in an important way - the health impacts of a proposal are assessed before a final decision is made, allowing the results of the HIA to be considered in the decision-making process. HIA provides objective information that can be used to increase the positive health impacts of a project or policy and mitigate negative impacts.

OHA conducts HIAs on projects or policies with statewide impact and on local or regional issues when there is sufficient interest from community members or other agencies. OHA supports statewide HIA practice by facilitating the Oregon HIA Network and providing trainings, and awarding small grants to local health departments.

Purpose

The Climate Smart Communities Scenarios (CSCS) [6] project underway in the Portland, Oregon metropolitan (PDX metro) region is the focus of this HIA. The CSCS project is a response by Portland metropolitan regional government (Metro) to a legislative requirement to meet Oregon greenhouse gas (GHG) emissions reduction goals for cars and small trucks. While the law was passed in an effort to mitigate climate change and reduce air pollution, Metro is also considering impacts on public health, the economy, the environment and equity as part of the planning effort. All of the findings and recommendations in this report focus on public heath.

The report provides a community profile, including information about current health conditions; results of a literature review on the links between proposed policies and health outcomes; quantitative assessment of land use and transportation policies tested in Phase One of the CSCS project; and recommendations for future work to expand the reach of positive impacts and mitigate negative health impacts.

The HIA will support Metro in their consideration of public health and health equity in the selection and implementation of transportation and land use decisions related to GHG reduction policy in the Portland metropolitan region. Metro's CSCS technical work group, the Metro Council, and other committees and stakeholders will use the report as they develop additional policy options to be tested in 2013, and in the creation of a final scenario to be adopted in 2014.

Climate Policy Background

Oregon passed a bill in 2007 that set goals for reducing GHG emissions in the state. House Bill 3543 states that Oregon will reduce emissions to 10 percent below 1990 levels by 2020, and to

75 percent below 1990 levels by 2050. In 2009, Oregon enacted House Bill 2001, which requires Metro to develop a preferred scenario that accommodates planned population and job growth and reduces GHG emissions from light vehicles. House Bill 2001 was a broad-based transportation bill that focused on sustainable transportation systems and funding, with the goal of ensuring that Oregon begins to address climate change. The law requires Metro to adopt the preferred scenario after public review and consultation with local governments. It also requires that local governments implement the preferred scenario through scheduled updates to transportation and land use plans.

The Oregon Land Conservation and Development Commission (LCDC) subsequently set light duty vehicle GHG emissions reduction targets for each of Oregon's six largest metropolitan areas in June 2011. In November 2012, the LCDC established administrative rules directing Metro to complete the scenario planning and adopt a preferred scenario by December 31, 2014. In the future, Oregon's other metropolitan planning organizations may also conduct similar scenario planning.

Metro's CSCS planning process will adopt a recommended transportation and land use scenario for the Portland metropolitan region that includes policies and strategies for reducing GHG emissions to meet the LCDC target. The adopted scenario will update regional policies and describe a general course of action for achieving the GHG emissions reduction target through policies, investments and actions at the state, regional and local levels.

The Oregon Health Authority (OHA) developed the CSCS HIA to support Metro's consideration of health impacts early in the scenario planning process and in future planning and implementation efforts.

Climate Policy and Health

Changes to our climate have the potential to impact health in many ways [1]. For example, more summer heat waves with higher temperatures or longer durations would increase heat-related illness and death. Increased frequency and severity of winter storms could lead to impacts such as increased respiratory illness from mold exposure, and increased drowning [2, 3]. Plans and policies intended to help communities mitigate or adapt to climate change also have health implications.

Creating walkable and bikeable communities may increase the proportion of Portland metropolitan region residents who meet physical activity benchmarks and reduce the burden of chronic diseases that are associated with inactivity, while reducing vehicle travel and carbon emissions [4, 5]. In addition, advancements in fuel technology and policies related to fleet mix and turnover also may reduce GHG emissions in the region. Reductions in air pollution may have positive impacts on health, including reductions in chronic diseases such as asthma or cancer, and acute conditions such as heart attack or stroke.

However, these policies or the way they are implemented may also negatively affect health. For example, some communities in the Portland metropolitan region have poor access to active transportation infrastructure (sidewalks, bike routes, transit service). If these areas are not prioritized, implementation could worsen existing inequities, leading to negative health effects for some of the region's residents. Understanding the range of potential impacts will help policy makers decide which strategies to prioritize and how to implement the strategies to maximize health and reduce health-related costs for local communities.

Climate Smart Communities Scenarios HIA

The CSCS HIA is intended to inform Phase Two of Metro's CSCS planning effort, which will include the development and evaluation of three alternative scenarios. Although the Phase Two scenario alternatives will draw from the 144 tested in the first phase of the CSCS project, the three scenarios will not necessarily match any of the 144 scenarios tested in Phase One. The three alternatives considered are framed around varying levels of community investment; each is designed to maximize public health, equity, economic, and environmental benefits.

In spring 2013, the Metro Council will direct staff to move forward to test the three alternatives developed in Phase Two, after gathering input from other community and business leaders at a regional summit. These alternatives will be assessed prior to the creation of a final scenario in Phase Three of the CSCS planning process. Results of the Phase Two assessment will be released in fall 2013 for discussion and to gather input to identify which policies, investments and actions should be included in a preferred scenario.

A final preferred scenario will be selected by the end of 2014 and will be implemented through policies, investments and actions at the regional and local levels, including Metro's Regional Transportation Plan and the Portland metropolitan region's growth management strategy and local plans.

The CSCS HIA will help to ensure that public health and health equity are considered in the selection and implementation of transportation and land use options related to GHG reduction policy in the Portland metropolitan region and potentially in Oregon's other metropolitan areas. The goals of the CSCS HIA are:

1. Provide evidence-based recommendations to aid decision-makers in understanding potential health impacts and tradeoffs of the CSCS policy options
2. Build and strengthen relationships between OHA and governing and planning bodies in the Portland metropolitan region
3. Promote consideration of health impacts in transportation planning and climate change mitigation efforts throughout the state
4. Promote HIA practice in Oregon

OHA followed the guidelines recommended in the North American HIA Practice Standards in developing each stage of the HIA. These stages include: screening, scoping, assessment, reporting and evaluation [7].

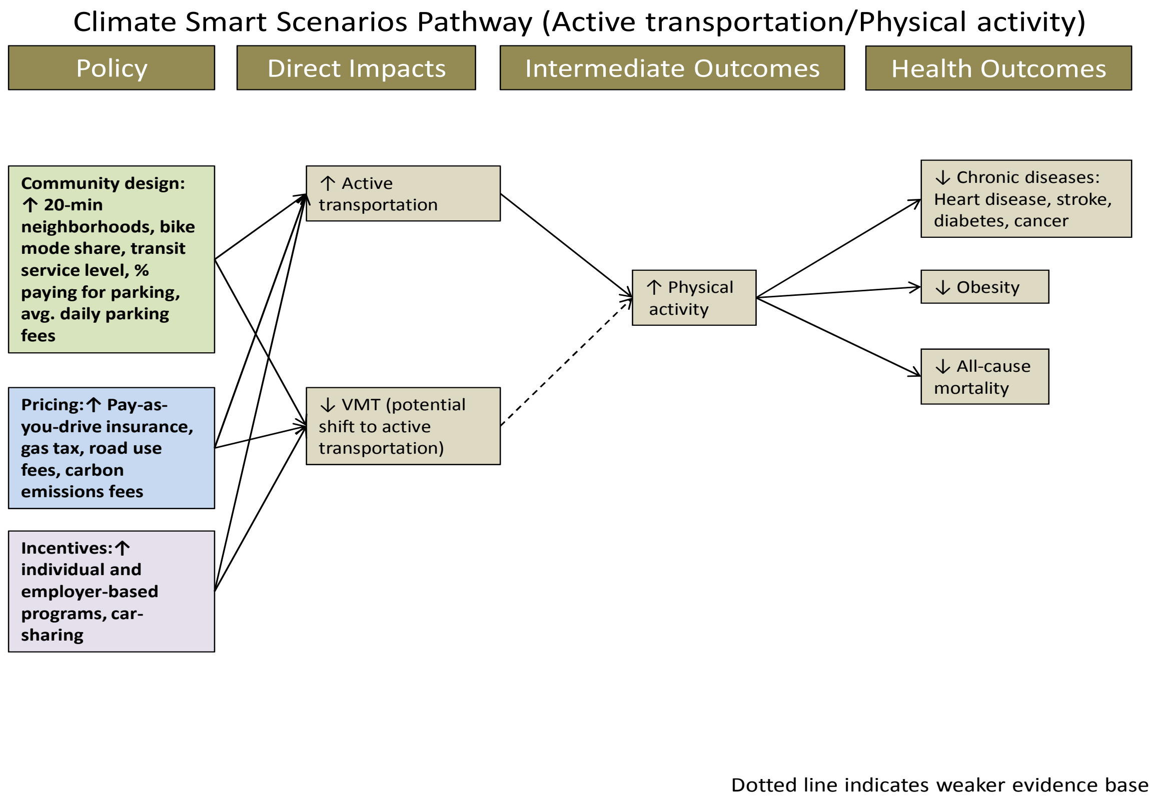
Screening and Scoping

In September 2011, OHA screened the CSCS HIA with partners at Metro and determined that an HIA could bring important health considerations to the CSCS decision-making process. In March 2012, OHA convened a group of 37 stakeholders representing planning, transportation and public health experts from around the Portland metropolitan region for a one-day workshop. Many of these stakeholders also represented local communities and vulnerable populations who will be potentially impacted by Metro's adoption of a preferred scenario. In the meeting, OHA provided an overview of Metro's CSCS planning project, gave an introduction to health impact assessment methodology, and presented the above CSCS HIA goals.

With the input and support of the advisory group, OHA determined priority health impacts, obtained necessary data, and found essential sources for the literature review. A list of advisory group members can be found in Appendix A.

Below is a sample pathway diagram that demonstrates the potential links between GHG reduction policy and program options and health impacts in the Portland metropolitan region. The pathways were drafted by OHA during the scoping phase of the assessment and revised with input from the advisory committee and information learned during the assessment. Additional pathways demonstrating potential links between policies and programs related to particulate air pollution exposure and roadway-related injuries and fatalities and health impacts are in the findings section of the report.

Pathway Diagrams 1 - Active transportation and physical activity



Assessment Methodology

OHA conducted a literature review about the proposed GHG reduction policies and the priority health determinants or impacts within our scope, which included physical activity, air pollution and road traffic injuries and fatalities. OHA identified the most relevant publications in each category for inclusion in the report's evidence base and rated their quality according to guidelines from the Agency for Healthcare Research and Quality [8]. A summary table is available on page 27.

In addition to the literature review, OHA used the Integrated Transport and Health Impact Modeling (ITHIM) tool in order to quantitatively determine which types of policy combinations had the most positive impact on health [9]. ITHIM is a comparative risk assessment model developed by Dr. James Woodcock at Cambridge University. ITHIM estimates changes to life expectancy and quality of life for scenarios based on known relationships between physical activity and chronic illnesses such as cardiovascular disease and diabetes; serious injuries and fatalities from motor vehicle related crashes; and illness and death from particulate air pollution exposure [9, 10].

Reporting and Evaluation

This report presents information about potential health benefits and impacts of the proposed GHG reduction policies evaluated in Phase One of the CSCS project. It also provides recommendations for expanding the reach of positive impacts and mitigating negative health impacts. Subject matter experts from OHA, the CSCS HIA Advisory Committee and Metro reviewed the report. The report will be disseminated to policymakers and community stakeholders in the Portland metropolitan region and to state and national partners. An evaluation will be completed in the summer of 2013 and will include an evaluation of the CSCS HIA process and its effectiveness in influencing the decision-making process.

Community Profile

The decision-makers and planners at Metro and the region's local governments have done significant work to understand the existing conditions related to health status and local health determinants, as shown in the region's planning documents, travel surveys and reports [11, 12]. The local health context is an essential consideration when choosing policies for inclusion in the 2014 preferred Climate Smart Communities Scenario and when implementing these policies. This existing conditions summary explores population and travel characteristics for the region's counties and presents information about the underlying health status of residents, with a particular focus on vulnerable populations who may experience worse health outcomes. County health measures are compared to the state or to national targets to provide context, as is customary in health assessments. The measures of health status and health determinants for Portland metropolitan region communities presented below relate to the CSCS policies that OHA assessed.

Population and Travel Characteristics/Infrastructure

The Portland metropolitan region has a population of nearly 1.5 million distributed across three counties (Clackamas, Multnomah, and Washington) and 25 cities. It is the most populous region in Oregon and the 24th largest metropolitan area in the country. Portland itself is the sixth largest city on the West Coast. Population in the Portland metropolitan region is forecasted to grow to nearly 2 million by 2035 [13].

Vehicle Miles Traveled

In the Portland metropolitan region in 2010, there were 5,074 vehicle miles traveled (VMT) per capita [14]. This was the lowest level of VMT per capita for the region since 1985 [14]. Nevertheless, due to population growth, average daily VMT has continued to grow steadily. Between 1982 and 2010, average daily VMT for the Portland metropolitan region has risen from 15 million miles to over 26 million miles [14].

In addition to population growth, long commute times and above average dependence upon automobiles for drive-alone commuters have contributed to the increase in VMT in the Portland metropolitan region. The average commute time for every county in the region is above the state average (Appendix B, Table 1). Additionally, Clackamas and Washington counties have higher percentages of single passenger auto commuters. Multnomah County is significantly below the state average of single passenger auto commuters; however, when examined at a smaller scale (Appendix B, Table 2) only the City of Portland is below average while more than one-third of Multnomah County's other cities are above average.

Public Transit Travel

Substantial growth in public transit ridership within the Portland Metro region occurred in the late 1990s. From 1997 to 2007, ridership on bus and rail lines increased 45%, nearly twice the growth rate in population [15]. The rate of ridership slowed to 15% between 2002 and 2012, but it is still well over the 10% population growth rate the region experienced in the same decade [16, 17]. Additionally, with a 52-mile MAX light rail system, 79 bus lines, and a 14.7-mile WES Commuter Rail serving 570 square miles, nearly 90% of the region's residents live within one-half mile of a bus stop or a rail platform [15]. In 2004, transit ridership in the Portland metropolitan region was ranked 7th in the U.S. at 70 passenger trips per capita [18]. Since this time, TriMet, the agency overseeing transit services in the Portland metropolitan region, has expanded its transit network. Consequently, in 2009 transit ridership has increased to 73 passenger trips per capita [19]. TriMet currently operates 225 lift vehicles and provides 958,000 annual rides to seniors and people with disabilities. Weekly ridership on buses and MAX rail lines has increased for all but one year in the past 23 years due to recession-related service cuts [16, 17].

Active Transportation Travel

Significant investments to expand bicycle infrastructure throughout the Portland metropolitan region have also occurred over the past two decades. For example, the City of Portland invested more than $12 million between 1991 and 2004 to develop its regional bicycle network which contains more than 300 bikeway miles [15, 20]. In addition, Metro's Regional Flexible Fund Allocation (RFFA) program provided funding for 46 miles of bicycle boulevards, bike lanes, trails and other bicycle projects between 2006 and 2015 [21]. These investments build on RFFA investments that have been made since 1995. Although bicycle data is limited, regional reports and a recently completed travel behavior survey have documented increased bicycle ridership throughout the region [15].

The regional pedestrian network has not seen the same level of expansion as public transit and bicycle facilities. In addition to locally funded pedestrian projects, Metro's RFFA program provided funding for nearly 9 miles of sidewalks in mixed-use centers throughout the Portland metropolitan region. Although nearly 90% of the region's residents live within one-half mile of a bus stop or a rail platform, only 69% of those stops are accessible by sidewalk [15]. Additionally, it was found that the region has 1,230 miles of potential pedestrian facilities located within transit/mixed use corridors and pedestrian districts [15]. In the regional network of corridors and districts, 19% of all streets have no sidewalks, 19% have sidewalks on at least one side of the street and 62 % of all streets had sidewalks on both sides of the street [15, 22].

One in six trips in the Portland metropolitan region are now made using active travel. Comparison of the 1994 and 2011 Oregon Household Activity Survey shows that between 1994-95 and 2011, all trips made by walking, biking and transit increased by 36% (from 13.1% to

17.8% of all trips) while trips made by auto declined by 5.7%. Walking trips increased by 14%, trips by biking increased over 190%, and trips by transit increased by 50% [23].

Lower income, disabled, and people of color make more of their trips using active travel, especially walking and transit, than higher-income, white and non-disabled persons [24]. People with disabilities particularly rely on access to transit for travel. Nearly 7% of the population reports having a disability that affects their ability to travel. People with disabilities drive and bike less and walk and take transit more often than people that reported having no disability that affects their ability to travel [25].

Safety

Making streets safer for people walking and riding bicycles and reducing bicycle and pedestrian crashes is important to protecting the public's health. Feeling and being safe while walking and bicycling is an important factor in the travel choices people make and therefore is a critical part of a complete transportation system. Transportation safety is also an equity issue. Research and data show that people with low incomes and people of color are more likely to live near wide, high-traffic streets and are thus much more likely to be injured by an automobile [26].

Serious pedestrian and bicycle crashes account for 20% of all serious crashes in the region [27]. Serious crashes are those that result in a fatality or an incapacitating injury. While 3.2% of all trips (not counting trips to access transit) take place by bicycle, 8% of all serious crashes involve bicyclists. Pedestrians make 10% of all trips in the Portland metropolitan region (not including trips to access transit); however 12% of all serious and fatal crashes involve a pedestrian.

There were a total of 1,297 pedestrian crashes resulting in injury in the Portland metropolitan region between 2007 and 2010. Of those crashes, 252 resulted in a death or an incapacitating injury. The majority of pedestrian crashes occur while pedestrians are crossing the roadway, either at an intersection or mid-block. Nearly 80% of all serious and fatal pedestrian crashes occur when people are crossing the roadway.

There were a total of 1,503 bicycle crashes resulting in injury in the Portland metropolitan region between 2007 and 2010. Of those crashes, 140 resulted in a death or an incapacitating injury. Most serious and fatal bicycle crashes (73%) occur at intersections.

Major factors contributing to serious crashes include high-traffic streets, streets with multiple lanes, excessive speed, driver impairment due to alcohol or drugs, lack of adequate street lighting and congestion [27].

Air Quality

Overall, air pollution in the Portland metropolitan region has decreased dramatically over the last 30 years [28]. However, air quality remains an environmental justice and equity issue. The Portland Air Toxics Solutions Committee Report mapped census block groups with minority populations above 25% overlaid with total times above benchmarks for all pollutants observed in the study, including emissions from cars and trucks [29]. Visual inspection of the overlay suggests that there is an overlap between high minority and high impact areas in some areas of the study boundary, including Forest Grove, Hillsboro, Aloha, Beaverton, North Portland, East Portland and Gresham.

Vulnerable Populations

Transportation is essential to the health of all the region's residents. Transportation connects people to jobs, schools, parks and recreation facilities, shopping, friends, and essential services like health care. Transportation-related air pollution and a lack of access to affordable, high-quality transportation options negatively impacts health. Certain groups within the region are more likely to be affected by air pollution and lack transit access, such as youth, seniors, low-income residents and communities of color [30, 31]. These groups are also at higher risk for health conditions linked to limited transportation options and transportation-related air pollution, such as asthma, heart disease, and obesity [32, 33].

Age

Older adults make up a smaller portion of the Portland metropolitan region's population compared to Oregon as a whole (Table 1). Comparatively, children and teens comprise a greater share of Clackamas and Washington County's population than Oregon as a whole. Multnomah County has a lower percentage of youth than the state.

Table 1. Portland Metropolitan Region Comparison, County and State - Age

Age Category	Clackamas County	Multnomah County	Washington County	State of Oregon
Under 18 Years Old	23.7%	20.5%	25.6%	22.6%
65 Years or Older	13.6%	10.5%	10%	13.9%
Source: Profile of General Population and Housing Characteristics: 2010 prepared by the U.S. Census Bureau, 2011.				

Race and Ethnicity

When examining race and ethnicity within the Portland Metro region, Multnomah and Washington County are similar (Table 2). While white residents make up a large share of both counties' population (approximately 81%), Multnomah and Washington still have higher percentages of residents of color (in all race/ethnicity categories) than Oregon as a whole [34]. Washington County in particular has one of the greatest Hispanic/Latino population in the state [34]. In contrast, Clackamas County's population is primarily white and has smaller populations of communities of color (in all race/ethnicity categories) compared to Oregon as a whole [34].

Table 2. Portland Metropolitan Region Comparison, County and State – Race/Ethnicity

Race/Ethnicity	Clackamas County	Multnomah County	Washington County	State of Oregon
White	91.1%	80.5%	80.4%	87.1%
Black or African American	1.4%	7.1%	2.7%	2.6%
American Indian and Alaska Native	1.9%	2.5%	1.7%	2.9%
Asian	4.8%	8.2%	10.6%	4.9%
Native Hawaiian and Other Pacific Islander	0.5%	0.9%	0.9%	0.7%
Some Other Race	3.7%	5.9%	8.4%	6%
Hispanic or Latino	7.7%	10.9%	15.7%	11.7%

Source: Profile of General Population and Housing Characteristics: 2010 prepared by the U.S. Census Bureau, 2011.

In the Portland metropolitan region, both white and non-white heads of households make the majority of trips by auto. However, non-white householders make a greater percentage of their trips by walking, bicycling and transit than white householders. Non-white householders make 20.5% of all their trips by walking and bicycling and transit, while white householders make 15% of all their trips by walking and bicycling and transit [12].

Income and Poverty

Within Clackamas and Washington counties, the median household income is approximately $62,000, which is higher than the median Oregon household income ($49,260) [35]. Within both counties, fewer than 10% of people had an income in the past 12 months lower than the poverty rate (Table 3) [35]. This was roughly 5% lower than the state as a whole. In comparison, Multnomah County has a median household income that is similar to the median Oregon household income [35]. Also, 16% of Multnomah County residents had an income in the past 12 months lower than the poverty rate [35], a slightly higher percentage than the state as a whole.

Table 3. Metropolitan Region Comparison, County and State – Other Demographics

Category	Clackamas County	Multnomah County	Washington County	State of Oregon
Median Household Income	$62,007	$49,618	$62,574	$49,260
Income in the past 12 months below the poverty level	9%	16%	9.5%	14%
Source: 2006-2010 American Community Survey [Oregon] prepared by the U.S. Census Bureau, 2011.				

Households in the four-county Portland metropolitan region (including Clark County) with lower income levels make more of their trips using active travel modes, especially walking and taking transit. As income rises, more trips are made by auto. For example, for households with income under $15,000, 26% of all trips are made by active modes and 74% of trips are made by auto. This is compared to households with the highest level of income, $150,000 or more, where 11% of trips are made by active modes and 89% of trips are made by auto [12].

For walking trips, 32.8% of all walking trips are made by households with income under $35,000, 32.3% are made by households with income between $35,000 and $75,000, and 35% are made by households with income greater than $75,000. For trips by bicycle, 21.2% of all trips by bicycle are made by households with income under $35,000, 37.1% are made by households with income between $35,000 and $75,000, and 41.8% are made by households with income greater than $75,000 [12].

For transit trips, 44.6% are made by households with income under $35,000, 30% are made by households with income between $35,000 and $75,000 and 24.6% are made by households with income greater than $75,000 [12].

Health Conditions

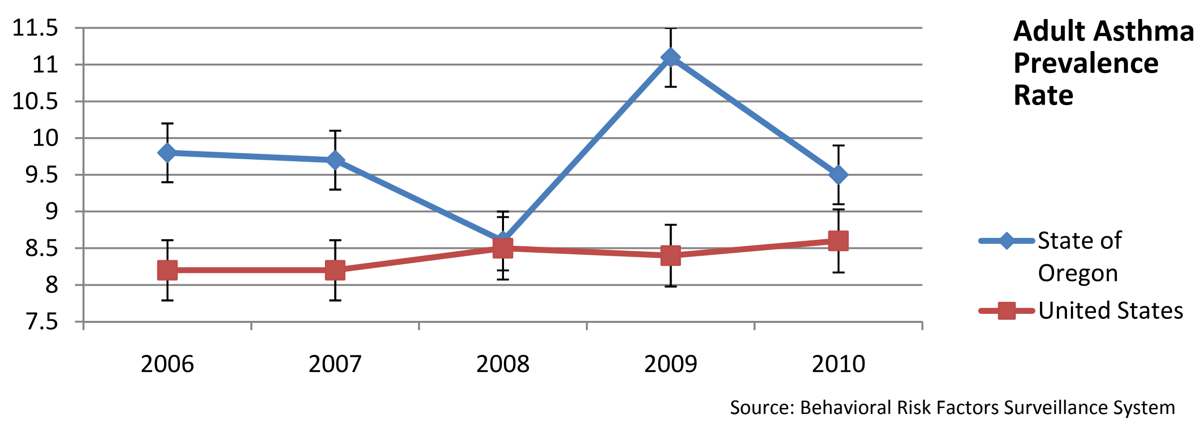
Chronic health diseases such as asthma, diabetes, stroke, heart disease, and cancer, along with factors such as obesity, are significant contributors to illness and death for all Oregon and Portland metropolitan region residents and many of the proposed policies designed to reduce GHG emissions would impact these chronic health conditions. For a tabular comparison of the burden of these illnesses, see Appendix B, Table 3.

Asthma

Asthma is a chronic lung disease that inflames and narrows the airways to cause shortness of breath, coughing, and wheezing [36, 37]. Asthma affects people of all ages, but it is one of the most common long-term chronic diseases of children [38]. Exposure to air pollution increases the risk of developing asthma and can cause those with asthma to experience worsening of symptoms.

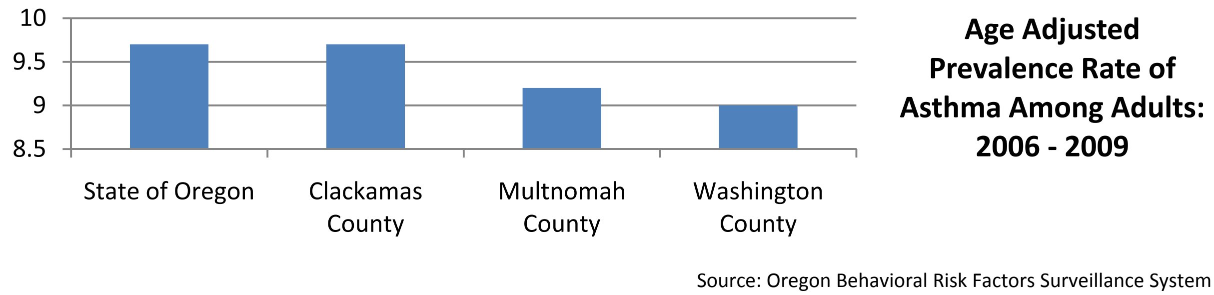
In 2009, approximately 10.2 % (≈300,000) of Oregon adults and 9.5% (≈ 83,000) of children had asthma [36] . As a result, Oregon ranked among the top five states in the nation with the highest percent of adults with asthma (Figure 1) [36, 39]. The most current county-level prevalence data (Figure 2) shows that from 2006 – 2009 the counties of Clackamas (9.7%), Multnomah (9.2%), and Washington (9.0%) fared the same or better than the state average prevalence (9.7%) of adult asthma [40].

Figure 1. Percent of adult population with asthma, Oregon and U.S.



Source for above image: http://www.cdc.gov/asthma/brfss/default.htm#08

Figure 2. Percent of adults with asthma, Oregon and Portland metropolitan region counties



Source for above image: http://public.health.oregon.gov/DiseasesConditions/ChronicDisease/Documents/TableI.pdf

Studies have shown that asthma is distributed unevenly throughout the population. Non-white children and children living in poverty have a significantly higher risk of asthma than do white children [41]. The local patterns of asthma were highlighted in 2002 by a study which showed lower income, more racially and ethnically diverse areas of inner Northeast Portland had higher rates of asthma than the county average and other higher income, less diverse areas within the region (such as Orenco Station in Hillsboro and inner Southeast neighborhoods in Portland) [42, 43].

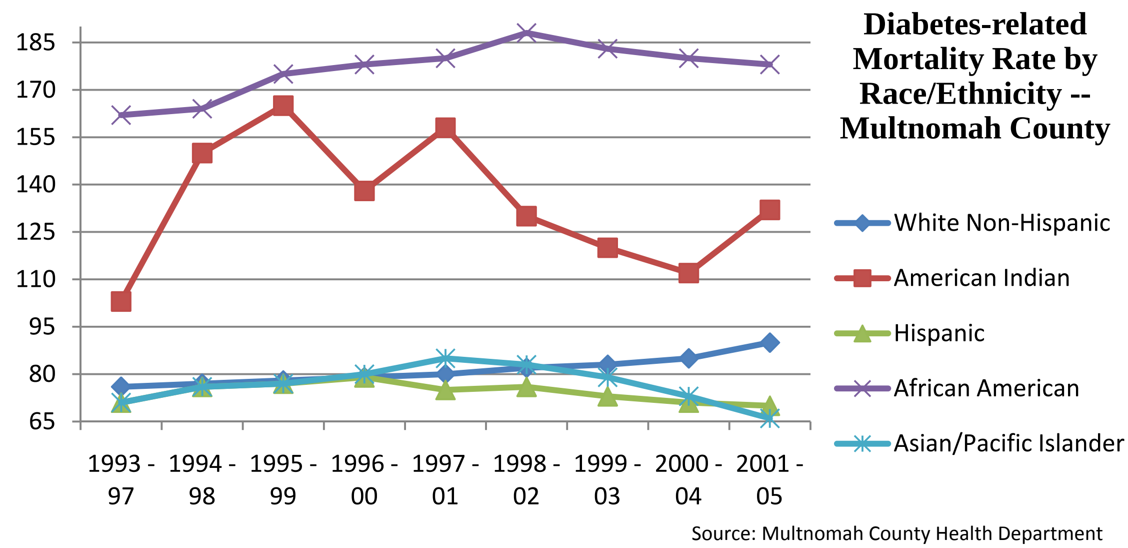
Diabetes

Diabetes is a chronic disease in which blood sugar levels are high and not regulated well, which can lead to serious health complications and premature death [44]. It is the seventh leading cause of death in the United States[45]. Regular physical activity lowers the risk of diabetes.

In 2010, Oregon's diabetes prevalence rate for adults was 7.2%, leading to Oregon's rank among the 10 states with the lowest diabetes rates in the nation [46]. The most current county-level prevalence data shows that from 2006 – 2009 the counties of Clackamas (6.6%), Multnomah (6.2%), and Washington (5.9%) were similar to or slightly better than the state average (6.8%) for adult diabetes [40]. Although the Portland metropolitan region has slightly better diabetes rates than the state average, the rates are still much higher than the 20 per 1,000 population Healthy People 2010 target [47]. Moreover, the most recent data shows that Multnomah County has a higher diabetes mortality rate than the national average [48].

Diabetes predominately affects lower income groups, communities of color, and individuals over the age of 65 [42, 49]. In 2010, diabetes contributed 6.5% of the total deaths for non-white Oregonians, compared to only 3% for white non-Hispanic Oregonians [50]. Figure 3 shows the differences between different races/ethnicities in diabetes-related mortality rates.

Figure 3. Diabetes-related mortality rate, Multnomah County



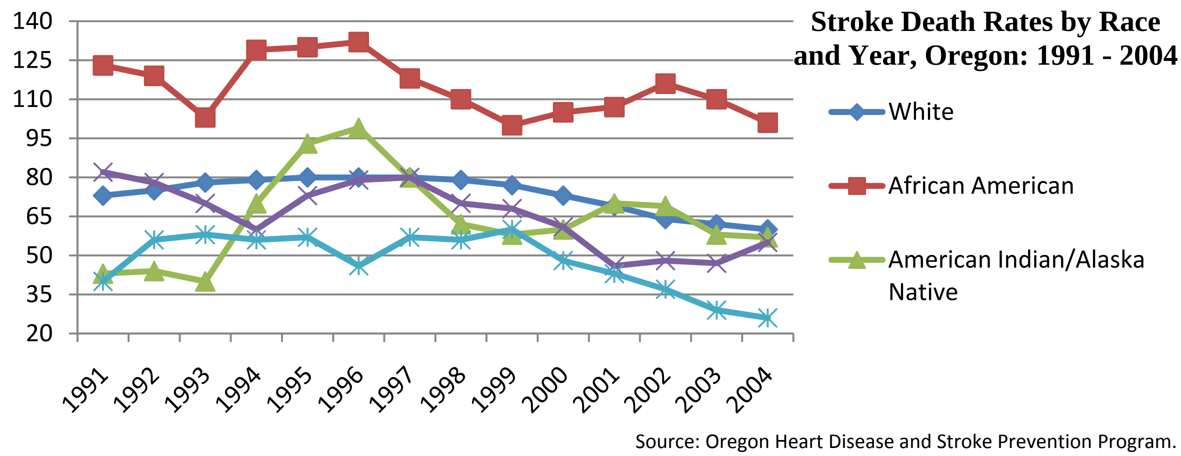
Source for above image: http://web.multco.us/sites/default/files/health/documents/winter2009_diabetes.pdf

Stroke

Stroke is the third leading cause of death in Oregon [51]. In 2010, Oregon's stroke prevalence was 2.2% (1.9 – 2.6) and it ranked among the fifteen states in the nation with the lowest prevalence rate [52]. However, since 1990, Oregon's stroke death rate has been higher than the national average. With a death rate of 49 per 100,000 individuals, Oregon ranks among the top 10 states with the highest stroke death rate in the nation [53, 54]. The most current county-level prevalence data shows that from 2006 – 2009 the counties of Clackamas (2.6%), Multnomah (1.8%), and Washington (1.9%) were similar to the state average (2.3%) of stroke prevalence [53]. Regular physical activity lowers the risk of stroke.

Various studies have shown that in the United States, African-American communities are disproportionately affected by stroke [55]. This disparity also exists in Oregon. Since 1991, the stroke death rates for African Americans living in Oregon have been significantly higher than all other resident races and ethnicities (Figure 4). For example, the African-American death rate from stroke in 2005 was 90.4 per 100,000 [51]. The second closest was the death rate for American Indians/Alaskan Natives which was 69.0 per 100,000 [51]. Figure 4 below shows the differences between different races/ethnicities in stroke-related mortality rates.

Figure 4. Stroke mortality rates by race and year, Oregon



Source for above image:
http://public.health.oregon.gov/DiseasesConditions/ChronicDisease/HeartDiseaseStroke/Documents/2007BurdenReport.pdf

Heart Disease

Heart disease refers to several heart conditions, the most common being coronary artery disease, which results when the flow of blood and oxygen to the heart is restricted or cut off [56]. This disease can cause heart attacks and angina. In 2009, more than 168,000 Oregonians (approximately 5.3%) had heart attack, angina, or coronary artery disease [53]. Approximately, 20% of all deaths in Oregon in 2010 were attributed to heart disease [50]. Nevertheless, the most recent Centers for Disease Control and Prevention data highlights that Oregon ranks among the top five states with the lowest heart disease prevalence in the nation [57]. Regular physical activity lowers the risk of heart disease, while exposure to airborne particulate matter increases the risk. The more a scenario promotes physical activity and decreases air pollution, the greater the expected reduction in this disease.

The most current county-level data shows that from 2006 – 2009 the prevalence of angina or heart attack in Clackamas (4.3%), Multnomah (4.6%), and Washington (4.2%) counties was below the state average (5.0%) [53]. Moreover, similar to the State of Oregon, heart disease mortality rates have dropped within the Portland metropolitan region. Nevertheless, heart disease is the second leading cause of death within Clackamas, Multnomah, and Washington counties [42, 58, 59]. While rates of heart disease mortality have dropped within the Portland metropolitan region, there are still populations that experience higher rates of heart disease. In Multnomah County, for example, the rate of coronary heart disease is higher for African-Americans than for other population groups [42]. Over the past 20 years in Oregon, heart disease mortality rates have been statistically higher in rural areas than in urban areas [53].

Cancer

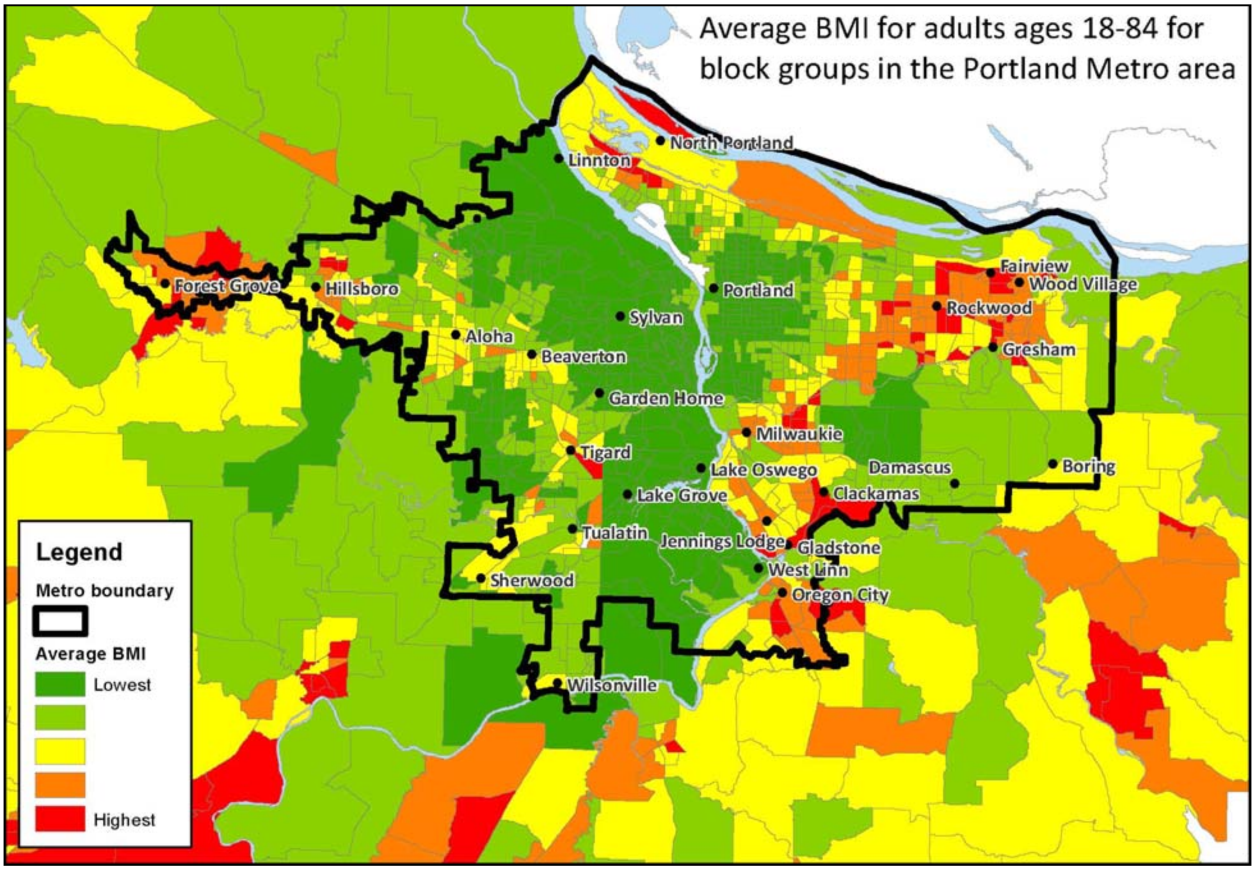
Cancer is the leading cause of death in Oregon and in the Portland metropolitan region [42, 58-60]. With a 2009 death rate of nearly 179 per 100,000 individuals, Oregon ranks in the top quarter of states with the highest cancer death rate in the nation [60, 61]. Additionally, except for lung and colorectal cancer, Oregon has higher incidence rates for all cancer types compared to the national average [62]. Regular physical activity lowers the risk of cancer. Reducing certain transportation-related air pollutants, such as benzene, can also lower cancer risk [29, 63].

Within the Portland metropolitan region, the most current county-level data shows that from 2005 – 2009 the cancer incidence rate for Multnomah County (477 per 100,000) was above the state average (465 per 100,000) while rates in Clackamas (457 per 100,000) and Washington (435) counties were below [64]. Cancer is also the leading cause of years of potential life lost in the region [58].

Obesity

Obesity is increasingly a concern in Oregon and in the Portland metropolitan region [65]. Obesity contributes to the deaths of about 1,400 Oregonians each year, making it second only to tobacco as the state's leading cause of preventable death. More than 60% of Portland metropolitan region residents are overweight or obese, and more than half do not meet physical activity recommendations. Even more worrisome, since those overweight in childhood are more likely to remain so as adults, around one-quarter of Metro region adolescents are overweight or obese. Obesity varies significantly by neighborhood and may be correlated with measures of socio-economic status as well as aspects of the built environment (Figure 5).

Figure 5. Age-adjusted mean Body Mass Index (BMI*) by census block group, Portland metropolitan region, from Department of Motor Vehicles records, 2010



Source: Oregon Health Authority, Environmental Public Health Tracking report: DMV records are valuable for obesity surveillance in Oregon, September 2012

This map shows average body mass index (BMI) for adults ages 18-84, based on self-reported height and weight information on driver licenses and ID cards issued by the State of Oregon from 2003-2010. BMI is expressed in units of kg/m2, is the standard measure used for population-based obesity surveillance. Higher mean values indicate heavier populations. Data are aggregated by block groups based on 2010 Census definitions and age-adjusted to the 2000 U.S. Census standard population. Block groups are classified into quantiles based on all block groups in Oregon.

Literature Review

Methodology

OHA conducted a literature review about the proposed GHG reduction policies and the priority health determinants or impacts within our scope (physical activity, particulate air pollution exposure and road traffic injuries and fatalities).

The CSCS HIA literature review is summarized in Table 4. On the left side there is a list of the policy options that make up the scenarios assessed in Phase One of Metro's scenario planning effort. Metro's scenarios are combinations of the strategies in Table 4 at various levels of proposed change, from a base year representing current conditions (2010) to new policies or more ambitious implementation of current plans (level 3). For example, for the bicycle mode share strategy, the baseline is 10% of the region's single-occupant vehicle tours less than 20 miles round-trip by bike and the most ambitious policy change would increase that to 30%. Detailed descriptions of each strategy and the levels of potential change considered can be found in Metro's Phase One Findings report [66].

To search for available evidence to understand the links between the strategies on the left side and health outcomes on the right (see Table 4), OHA queried multiple online databases using standardized search terms, and included results from PubMed, Google Scholar, Oregon State University library, Human Impact Partners evidence base, and previously published HIAs, in particular the two completed by Upstream Public Health on climate change policy [67, 68]. OHA identified the most relevant publications in each category for inclusion in our evidence base, read and abstracted each article, and rated its quality according to guidelines from the Agency for Healthcare Research and Quality, and summarized the entire evidence base [8] in Table 4 below.

The literature review is represented graphically through pathway diagrams in findings sections of the report below. These diagrams show the connection between the policies and strategies and health outcomes through direct impacts and intermediate outcomes.

Table 4. Climate Smart Communities Scenarios HIA Literature Review - Summary of the Quality of Evidence

Policies (existing conditions - most ambitious scenario)	Physical activity	Air pollution	Crash Injury/ Fatality
Community design			
Mixed use/complete neighborhoods	****	*	**
Bicycle mode share (2% - 30%)	****	**	**
Transit service level (2010 level - 4x RTP level)	***	**	**
Workers/non-work trips pay for parking (13%/8% - 30%/30%)	*	**	*
Average daily parking fee ($5 - $7.25)	*	**	*
Pricing			
Pay as you drive insurance (0% - 100%)	**	**	**
Gas tax ($0.42 - $0.18/cost per gallon^)	**	**	**
Road use fee ($0 - $0.03/cost per mile)	*	*	*
Carbon emissions fee ($0 - $50/cost per ton)	*	**	**
Incentives			
Households participating in eco-driving (0% - 40%)	N	*	*
Households participating in marketing programs (9% - 65%)	*	*	*
Workers in employer-based commuter programs (20% - 40%)	*	*	*
Car-sharing in high density areas (1 - 2 members/100 people)	*	*	*
Car-sharing in medium density areas (1 - 2 members/200 people)	*	*	*
Fleet			
Fleet Mix and turnover rate (light duty vehicles)	N	**	*
Technology			
Fuel economy, Carbon intensity of fuels, electric tech., etc.	N	**	N

^Combined with road use fee - see page 28 of Metro's Phase 1 Findings report for details

Legend
**** 10+ strong studies
*** 5-9 strong studies
** 5 or more studies of weak or moderate quality, or studies have mixed results
* <5 studies and policy-impact link consistent with public health principles
N = No evidence found
For a full explanation of these proposed policies, please see the Metro Climate Smart Communities Phase 1 Findings Report [66].

Integrated Transport and Health Impacts Modeling (ITHIM)

The Integrated Transport and Health Modeling (ITHIM) tool was developed by public health researchers in the UK to assess the potential health impacts of GHG reduction scenarios for London, UK and Delhi, India [9]. The model was later adapted for use in the San Francisco Bay Area and applied to transportation scenarios created to comply with California's GHG reduction goals. OHA further adapted the tool for use in the Portland metropolitan region, including the use of census data for the geography that makes up the Portland metropolitan region governed by Metro.

The purpose of the CSCS Project's Phase One analysis was to understand what level of policies and investments might be needed (beyond current adopted plans and policies) to meet the region's GHG reduction goals. In collaboration with ODOT, Metro staff tested 144 scenarios and found more than 90 scenarios met or exceeded the GHG emissions reduction goals, some by a significant margin. For more detailed information on the CSCS project and methodology please see the CSCS Phase One Report, an essential companion document to this report.

OHA did not assess the health impacts of each of the 144 Phase One scenarios. Instead, OHA used ITHIM to assess 6 sample scenarios in order to provide information about the health impacts of the types of policies and investments decision-makers will consider including as they develop the final three Phase Two scenarios.

Methodology

For the purposes of this HIA, ODOT and Metro staff identified 6 sample scenarios of the 144 scenarios tested in Phase One. OHA also evaluated the current set of policies and investments, named 2010 Base Year, to provide a base year comparison.

The sample scenarios vary primarily with respect to the community design and pricing policy areas tested in Phase One of the CSCS project; differences between each primarily reflect progressively higher levels of transit, bicycle mode share, and pricing strategies as noted by the level 1, level 2 and level 3 labels for each policy area (e.g., community design, pricing).

- Sample scenarios 1 through 3 correspond to community design levels 1 to 3 and pricing level 1.
- Sample 4 through 6 correspond to community design levels 1 through 3 and pricing levels 2 and 3.

More information about the selection of the sample scenarios is available in Appendix D.

The inputs to ITHIM include:

- Information on household vehicle miles traveled (VMT) from the GreenSTEP model [69] developed by the Oregon Department of Transportation (ODOT)
- Monitored particulate matter ($PM_{2.5}$) from DEQ

- 2000 and 2010 census data [13], adjusted for the Portland metropolitan region; household travel data from Metro's Household Activity Survey [70]
- Crash data from ODOT [71]
- Information about the global burden of disease [72]

The outputs to ITHIM include: modeled data on changes in disease, injuries, and deaths. More information about ITHIM is available in Appendix D and in Woodcock et al [73].

Limitations to ITHIM

ITHIM is a unique and reliable tool for modeling and comparing the health impacts of planning scenarios. This is especially true when ITHIM's outputs are considered alongside local health data, such as those described in the existing conditions summary above.

However, ITHIM was developed using global burden of disease data, and OHA did not adapt the tool to use Oregon or Portland metropolitan region health data. Additionally, ITHIM uses particulate air pollution, specifically $PM_{2.5}$, as a proxy for total transportation-related air pollution. Although such assessment is outside of the scope of this HIA, additional analyses on the reduction of toxic air pollutants and ozone precursors from transportation and transportation-specific policies (such as fleet turnover and advances in fuel technology) would likely show additional health benefits [9, 10].

ITHIM detailed results

The CSCS HIA results indicate that all of the GHG reduction scenarios that Metro has evaluated to date could result in net health benefits from increases in active travel and decreases in both air pollution exposure and motor vehicle-related injuries and fatalities (Table 5). There are sample scenarios that are more beneficial to the health of Portland metropolitan region residents than others, and these are discussed in detail below. Additional summary tables are available in appendix C.

A summary of ITHIM's health impact results for sample scenarios 1 through 6 are reported in Table 5, which shows reductions in premature deaths, years of life lost (YLL), years living with disability (YLD), and disability-adjusted life years (DALY) for changes in physical activity, particulate air pollution exposure, and road traffic crashes. DALYs are calculated by adding YLL and YLD across a population. One DALY can be thought of as representing one lost year of healthy life. The sum of DALYs across a population represents the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability [72].

Table 5. ITHIM Results: Annual health co-benefits compared to base year scenario (2010) for sample scenario 1-6 (2035), Portland Metro region

	Counts						Rate per Million Population					
	Sample scenario1	Sample scenario2	Sample scenario3	Sample scenario4	Sample scenario5	Sample scenario6	Sample scenario1	Sample scenario2	Sample scenario3	Sample scenario4	Sample scenario5	Sample scenario6
Physical activity												
Premature deaths	-49	-112	-139	-66	-131	-157	-39	-89	-111	-52	-105	-125
YLL	-492	-1,230	-1,623	-647	-1,403	-1,789	-391	-979	-1,291	-515	-1,116	-1,423
YLD	-201	-528	-710	-216	-526	-703	-160	-420	-565	-172	-419	-560
DALYs	-693	-1,758	-2,333	-863	-1,929	-2,492	-551	-1,398	-1,856	-686	-1,535	-1,983
Particulate air pollution												
Premature deaths	-3	-11	-19	-8	-15	-22	-3	-9	-15	-7	-12	-17
YLL	-42	-140	-236	-105	-189	-271	-34	-111	-188	-83	-151	-215
YLD	0	-1	-1	-1	-1	-1	0	-1	-1	0	-1	-1
DALYs	-42	-141	-237	-105	-190	-272	-34	-112	-189	-84	-151	-216
Road traffic crashes												
Premature deaths	0	-11	-24	-9	-19	-29	0	-7	-16	-6	-13	-20
YLL	-5	-443	-945	-373	-756	-1,181	-3	-299	-637	-252	-510	-796
YLD	-21	-117	-222	-93	-177	-267	-14	-79	-150	-63	-119	-180
DALYs	-25	-560	-1,168	-466	-933	-1,447	-17	-378	-787	-314	-629	-976
Total												
Premature deaths	-53	-134	-182	-83	-165	-208	-42	-106	-142	-65	-129	-162
YLL	-539	-1,813	-2,804	-1,125	-2,348	-3,240	-428	-1,389	-2,116	-850	-1,777	-2,435
YLD	-222	-645	-933	-310	-704	-971	-174	-499	-716	-235	-539	-740
DALYs	-761	-2,458	-3,738	-1,434	-3,052	-4,212	-602	-1,888	-2,832	-1,085	-2,315	-3,175

*YLL, years of life lost; YLD, years living with disability; DALY, disability-adjusted life years (sum of YLL and YLD)

The sample scenarios that represent higher levels of active transportation modes (bicycling, walking and transit), show corresponding reductions in car and light truck travel. The Portland metropolitan area-adapted ITHIM found that with high levels of active transportation compared to the 2010 baseline, as in sample scenarios 3 and 6, the model predicts:

- 5% fewer premature deaths;
- 6% fewer years of life lost for cardiovascular disease, heart attack and stroke; and
- a 4% reduction in diabetes.

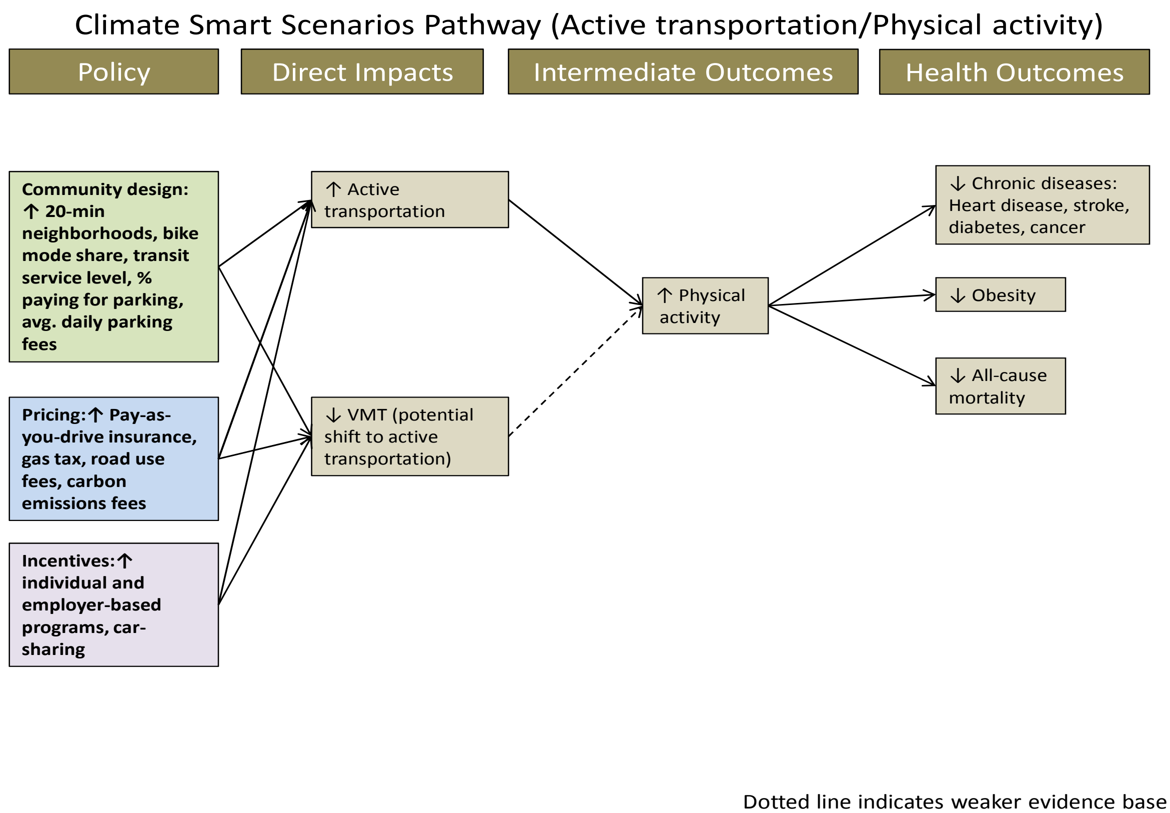
When considering the main health outcome measure (DALYs) between baseline and Scenario 6, the majority (59%) of the health benefit can be accounted for by increased levels of physical activity, followed by decreased road traffic crashes (34%) and decreases in particulate air pollution exposure (7%).

To walk through a specific example from Table 5, under sample scenario 3 the Portland metropolitan region would experience 182 fewer premature deaths in 2035 compared to 2010. In addition 2,804 years of life lost and 933 years living with disability would also be averted. The majority of the health benefits result from increased physical activity, followed by reductions in road traffic crashes and lower exposure to particulate air pollution. Appendix C, Table 2 shows predicted changes in the health of the region's residents due to changes in physical activity under each sample scenario for specific conditions such as heart disease and diabetes.

After accounting for a small increase in the disease burden from fatal and serious traffic injuries to bicyclists (see Appendix C, Table 4), the Portland metropolitan region would still experience 208 fewer premature deaths and 3,240 years of life gained. Strategies for mitigating this increase are discussed in the road traffic injury recommendations below.

Active Transportation and Physical Activity Results

Pathway diagram 1 – Active transportation and physical activity



Pathway 1 was drafted by OHA and refined with information from the advisory committee.

ITHIM findings

Results from the ITHIM model indicate that sample scenarios 3 and 6 have the largest increases in active transportation (Table 5). Averages from these sample scenarios show the largest positive impact on health with reductions of 182-208 premature deaths per year and large reductions in DALYs (scenario 3: 3,738; scenario 6: 4,212). Approximately 60% of the health benefit in these two sample scenarios comes from increased physical activity.

Health equity findings

Decisions about strategies and their implementation can have different impacts on different populations in the Portland metropolitan region. For example, pricing policies that increase costs, including time costs, associated with transportation may disproportionately impact low-income residents. Increased cost burden may lead to increased stress, which negatively affects health [74-76].

Individuals with physical or mental disabilities may experience worse health status than the non-disabled population. In addition they may have more difficulty accessing improvements to active transportation infrastructure or have different needs related to transportation [77-79].

Prioritizing investments and thoughtful implementation of active transportation policies and programs in vulnerable communities could improve inequitable health outcomes for vulnerable populations of the Portland metropolitan region. For example, since African-Americans experience disproportionately higher rates of heart disease, diabetes, and stroke, active transportation investments in predominantly African-American communities may have greater health impacts.

Literature review findings

Policies and investments supporting complete neighborhoods and active modes of travel (walking and biking) best promote physical activity. Public transportation service levels and use also effectively promote physical activity. There is some evidence that pricing policies, such as pay-as-you-drive insurance or a direct tax on gasoline, may reduce VMT and shift trips to active modes of travel. However, these policies may simply reduce the number of driving trips without increasing active transportation, and therefore would not be associated with health benefits associated with physical activity. Policies that lead to reductions in VMT in addition to increases in active transportation will likewise impact the prevalence of chronic disease and mortality.

OHA found the least evidence supporting a positive association between policies in the incentives category and increases in physical activity. There is a need for additional studies about this proposed link. The fleet mix and technology policies as well as the percent of households participating in eco-driving programs are not expected to have an effect on physical activity levels.

It is also worth noting that improvements to active transportation infrastructure may increase leisure time physical activity, along with the accompanying health gains.

Context

When local decision-makers understand the characteristics of their communities that encourage or discourage active transportation, policies and plans can be customized accordingly. For example, a recent HIA in Washington County found a strong preference among residents for bicycle and pedestrian pathways that are separated from traffic, and identified specific barriers to increasing bicycle and pedestrian travel that should be accommodated in local plans and projects [80].

People who commute by walking, bicycling or public transit are more likely to meet physical activity recommendations by engaging in twice as much physical activity (transportation and recreation combined) as those who commute by car [81-88].

Regular, moderate physical activity (at least 30 minutes a day, 5 days a week) provides substantial health benefits, including lower risk of mortality, cardiovascular disease, stroke, cancer, depression, high blood pressure, diabetes, and obesity [89, 90]. Table 6 shows the prevalence of weight-related risk factors and physical activity among adults living in the three counties contributing to the Portland metropolitan region.

Table 6. Age-adjusted prevalence of selected modifiable risk factors among adults by county, 2006-09

Risk factors	Clackamas %	Multnomah %	Washington %	Oregon %
Overweight	35.7	33.8*	36.9	36.1
Obese	23.6	21.8*	23.2	24.5
Met physical activity recommendations	55.6	55.1	53.8	55.8

*Statistically significant difference compared to Oregon

Source: Behavioral Risk Factor Surveillance System, 2006-2009

While obesity is traditionally understood to result from an imbalance between calorie consumption and energy expenditure, it is clear from recent studies that the built environment, transportation infrastructure, access to healthy and nutritious food, and other environmental factors strongly influence physical activity and healthy eating [91-100].

These factors also influence children and adolescents, through commutes to school and other destinations important to youth, like community centers and work locations. Table 7 shows the prevalence of weight-related risk factors and physical activity among 8th and 11th graders living in the three counties contributing to the Portland metropolitan region. Children who walk or bike to school are more likely to meet physical activity recommendations and attain healthier body composition and cardiorespiratory fitness [85, 101-106]. However, just 48% of Oregon children who live within one mile of school walk to school at least 3 days per week, and only 8% bike to school at least 3 days per week.

Table 7. Prevalence of selected modifiable risk factors among 8th and 11th graders by county, 2007-08

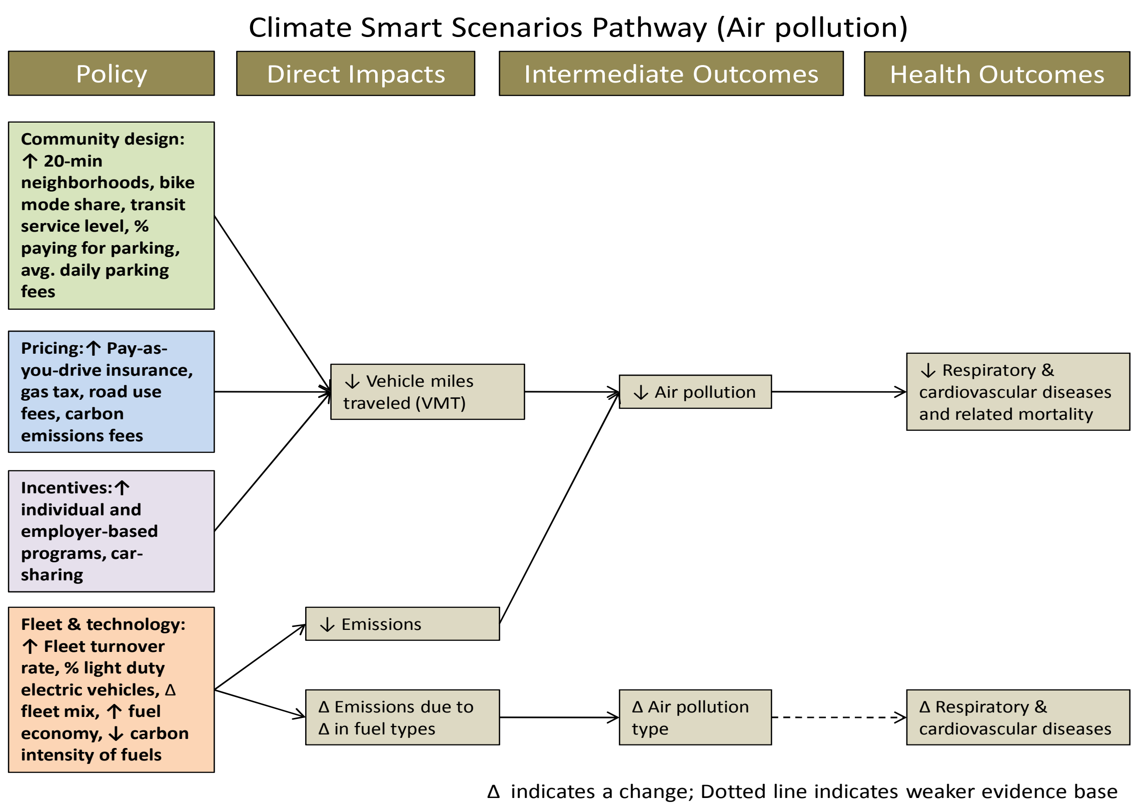
Grade	Risk Factor	Clackamas %	Multnomah %	Washington %	Oregon %
8th	Overweight	14.3	15.4	13.8	15.2
	Obese	9	10.9	10.2	10.7
	Met PA recommendations	53.9*	52.7*	50.8*	57.1
11th	Overweight	13.3	12.8	12.2	14.2
	Obese	9.8	11	10	11.3
	Met PA recommendations	49.8	38.4*	46.2	49.2

*Statistically significant difference compared to Oregon

Source: Oregon Healthy Teens, 2007-2008

Particulate Air Pollution Results

Pathway Diagrams 2 - Particulate air pollution



Pathway 2 was drafted by OHA and refined with information from the advisory committee.

ITHIM findings

Results from the ITHIM model indicate that sample scenarios 3 and 6 have the largest decreases in VMT (Table 5). These scenarios show the largest positive impact on health due to reduced air pollution exposure, with reductions of 19-22 premature deaths per year and reductions in disability adjusted life years (scenario 3: 237; scenario 6: 272). Approximately 6% of the health benefit in these two sample scenarios comes from decreased exposure to $PM_{2.5}$.

Health equity findings

The Oregon Department of Environmental Quality (DEQ) has extensively studied the distribution of air toxics in the Portland metropolitan region. DEQ found that low-income and minority communities are disproportionately impacted by higher concentrations of air toxics compared to mid- to high- income, white communities [29].

Low-income communities and communities of color are more likely to live in close proximity to high-traffic roads, and thus have higher exposures to harmful air pollution. These groups may also live in lower quality housing with poor indoor air quality. Their cumulative exposure to indoor and outdoor air pollution may be significantly higher than other groups.

There is evidence that children, older adults, people with pre-existing cardiopulmonary diseases and people with low incomes are more susceptible to negative health effects from exposure to $PM_{2.5}$ [107].

Children living next to (within 100 meters of) high-traffic roads (>= 10,000 vehicles per day) have worse lung function measures and more respiratory disease symptoms, asthma hospitalizations and doctor visits than children who live further away from high traffic areas [108-110].

Literature review findings

Policies supporting active modes of travel, including public transportation, would reduce levels of air pollution on and near roadways. There is some evidence that the individuals using active modes could increase their air pollution exposure if they are walking or biking next to busy roads.

There is also some evidence that pricing policies, such as a carbon emissions fee or direct tax on gasoline use, may reduce VMT and related air pollution. OHA found more published evidence linking pricing, fleet and technology policies to air pollution levels than incentive policies.

Shifts to lower carbon-intensity fuels and electric vehicles may change the type of emissions from motor vehicle traffic, and consequently affect changes in health conditions, such as asthma and cancer, that result from exposure. Specifically, nitrogen oxides and aldehydes may increase and benzene and 1,3 butadiene may decrease [111]. However, these changes would require large-scale shifts in the types of fuels and vehicles used in the region. While the link between improved air quality and policies related to fleet turnover and fuel technology has been demonstrated [112-114], the link between different types of emissions and changes in health outcomes has not been adequately described.

The CSCS HIA Advisory Committee asked whether an increase in 20-minute neighborhoods might lead to increased congestion and to increased exposure to air pollutants. OHA did not find any evidence to support this link, and in fact found evidence that 20-minute neighborhoods and similar community design policies decrease congestion and are likely to positively influence health [100, 115-117].

There is evidence that drivers and passengers of cars and buses are exposed to air pollution at levels similar to or exceeding those of pedestrians and cyclists [118-120]. There is also evidence that air pollution exposure is higher for pedestrians and bicyclists along busy roadways than next to roads with less traffic. A study underway in Portland has demonstrated that pedestrian exposure on a high-volume roadway is greater than driving exposure, but less than bus exposure. Travel along lower-volume roadways significantly reduced pedestrian exposure [121]. In addition, several studies have demonstrated that the health benefits from physical activity outweigh the negative health impacts of air pollution exposures to pedestrians and cyclists [9, 122, 123].

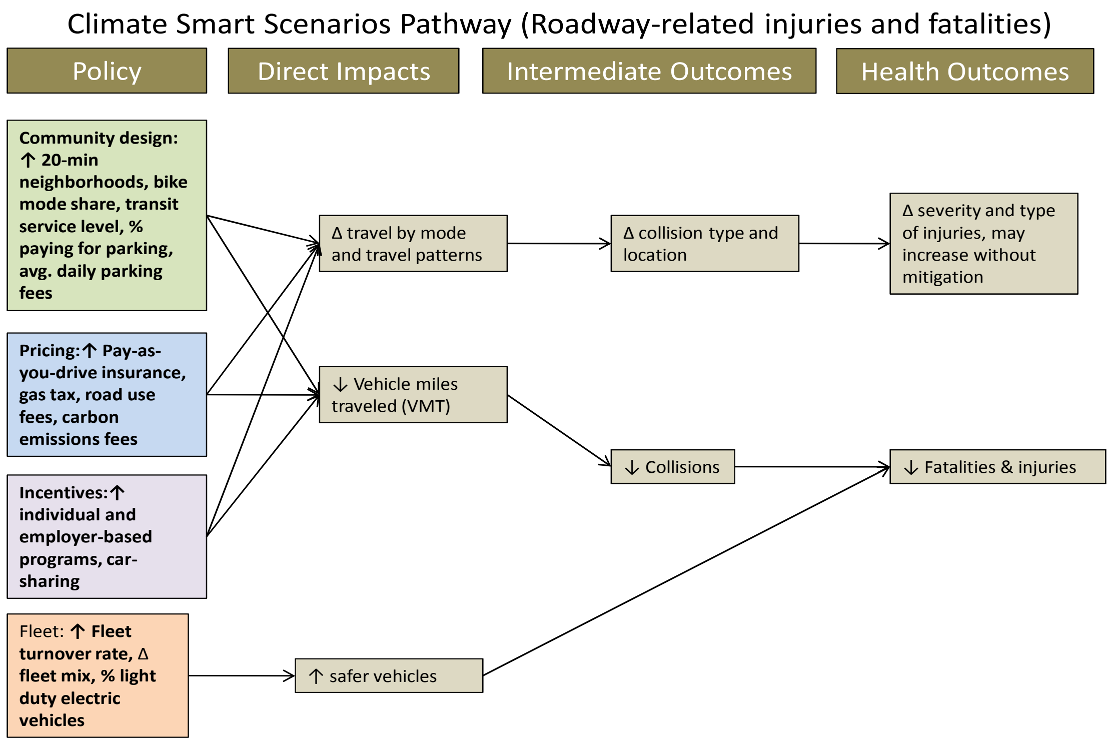
Context

Vehicle emissions contain a mix of particulate matter, nitrogen oxide, diesel exhaust, benzene, and other air toxics. These toxics are harmful to respiratory and cardiovascular health and are associated with increases in mortality and cancer incidence and mortality [32, 124, 125]. There is evidence of a causal relationship between exposure to emissions from motor vehicle traffic and a number of adverse health outcomes, including lung function impairment, asthma incidence, cardiovascular disease, and cardiovascular and overall mortality [125-130]. These adverse health effects may impact drivers and passengers of vehicles, an impact that increases as length of commute time increases. Those outside of cars may also be impacted, including residents of housing less than 300 meters (~1,000 feet) from a major road (more than 10,000 motor vehicles per day), and bicycle and pedestrian commuters along major roads [32, 125, 131].

The literature review and modeling assessment focused on fine particulate matter that is 2.5 micrometers and smaller in diameter ($PM_{2.5}$). The World Health Organization estimates that $PM_{2.5}$ exposure contributes to as many as 800,000 premature deaths each year, making it the 13th leading cause of mortality worldwide [132]. In the U.S., the Environmental Protection Agency estimates that beginning in 2020 approximately 230,000 premature deaths related to $PM_{2.5}$and ozone exposure could be avoided due to implementation of Clean Air Act Amendments [133].

Road Traffic Injuries and Fatalities Results

Pathway Diagrams 3 - Roadway-related injuries and fatalities



Pathway 3 was drafted by OHA and refined with information from the advisory committee.

ITHIM findings

Results from the ITHIM model indicate that sample scenarios 3 and 6 have the largest decreases in VMT (Table 5). These scenarios are associated with the largest positive impact on health due to decreased road traffic crashes, with reductions of 24-29 premature deaths per year and reductions in disability adjusted life years (scenario 3: 1,168; scenario 6: 1,447). Approximately 1/3 of the health benefits from these two sample scenarios come from reductions in motor vehicle crashes. With increased rates of biking, negative health impacts from increased bike injuries and deaths may arise.

Health equity findings

Children between 5 and 9 years have the highest pedestrian-motor vehicle injury rates [134]. Older adult pedestrians are more likely to die as a result of a motor-vehicle pedestrian crash than younger pedestrians [135].

There is a correlation between lower socioeconomic status and the risk of road traffic injury death for child pedestrians [136]. These socioeconomic differences may result from environmental factors or behavioral differences, or a combination of the two.

Literature review findings

Policies and investments supporting complete neighborhoods with safer infrastructure, active modes of travel, including public transportation, as well as pricing policies that reduce VMT would best reduce roadway-related injuries and fatalities. There is the least amount of evidence to support a link between incentives and fleet policies and road-related injuries and fatalities. However, fleet policies could have an impact if fleet turnover increases the number of newer and safer vehicles being driven in the region. Technology policies were not found to have an impact on crash injuries and fatalities. While crash-avoidance technologies such as sensory systems that stop a car before a collision, may reduce crash events, currently this technology is still fairly new and has yet to be directly linked to population-level impacts [112-114, 137, 138].

Risks of traffic injury and death vary by age, with higher injury rates for children and youth and higher fatality rates for older adults. Features of the built environment and transportation infrastructure contribute to the risk of motor vehicle, pedestrian and bicycle crashes. One study found that crosswalk markings without signals or stop signs are associated with increased risk of pedestrian-motor vehicle crashes for older pedestrians [135]. There is evidence of a significant positive relationship between traffic volume and the rate of vehicle collisions involving pedestrians [139-141]. One review and analysis found that the highest risk of severe or fatal crashes occurs in areas with low street network density, and that safety outcomes improve as intersection density increases [140].

One researcher has found that for bike and pedestrian crashes, there is safety in numbers; as the number of bicyclists and pedestrians increases, severe and fatal crashes decrease [142]. However, other studies have shown that higher pedestrian and bike activity does not result in increased safety. These studies suggest that other factors such as vehicle volume, speed, and roadway design are the most important contributors to bicycle and pedestrian motor vehicle crashes [139, 143].

Pedestrian and bicycle injuries are typically underestimated. Non-fatal crashes with motor vehicles and bicycle-only injuries are less likely to result in a police report, and therefore end up in official crash statistics. A Portland study found that 20% of bicycle commuters surveyed had experienced a traumatic event and 5% required medical attention during one year of commuting [144]. A San Francisco study found that over 50% of bicycle injuries treated at one hospital were not associated with a police report [137].

Context

Motor vehicle crashes are the leading cause of injury death in the United States and the second leading cause in Oregon [145, 146]. Motor vehicle crashes are the leading cause of death for individuals between the ages of 5 and 24 [147]. In 2010, the State of Oregon's rate of traffic fatalities per 100 million VMT was .94 [148]. In 2010, the State of Oregon's rate of 1.2 [149]. This was below the national rate of 1.10 and the highest injury rate of 1.2 [148, 149]. Oregon's rate of traffic injuries per 100 million VMT in 2010 was higher than the national MSA average of 8.2 [149, 150].

In 2009, the Portland metropolitan region ranked in the top 15 metropolitan statistical areas (MSA) nationally for lowest annual rate of traffic fatalities per 100,000, with a rate of 6.2 compared to the national MSA average of 8.2 [150]. When injury and fatality data are combined, both Clackamas County (5.2) and Washington County (5.25) had better rates than the statewide (5.51) fatal and injury crash rate per 1,000 [151, 152]. Conversely, Multnomah County was significantly worse (8.03) [153, 154]. Nevertheless, all three counties fared better than the state rate of crash-related deaths for individuals between the ages of 15 and 24 [155]. OHA has set a goal to decrease statewide motor vehicle fatalities by 17% below the 2007 rate of 12.1 per 100,000.

In the Portland metropolitan region, streets with more lanes and higher speeds (arterials such as SE 82nd Ave, SE McLoughlin Boulevard, and SW Beaverton-Hillsdale Highway) have higher serious crash rates, especially for pedestrians. About 40% of all vehicle travel in the Portland metropolitan region between 2007 and 2009 was on arterials. Arterials were the location of 57% of the serious auto crashes, 67% of the serious pedestrian crashes, and 52% of the serious bike crashes [11]. Serious pedestrian and bicycle crashes disproportionately occurred after dark on unlit streets. Travel by transit is relatively safe in the region, with a rate of 0.23 deaths involving a transit vehicle per 100 million transit-passenger-miles, compared to the rate of 0.42 for all traffic [11].

Conclusion and Recommendations

Significant shifts in the climate are already happening and as the climate continues to warm the impacts to public health will become more apparent. We can expect exposure to more frequent heat waves, an increase in asthma, changes in disease patterns and diminishing water quality and quantity. Curbing climate change is a pressing public health issue, and the Public Health Division strongly supports efforts across the state to reduce greenhouse gas emissions. Reducing greenhouse gas emissions will have In addition to the inevitable health benefits for Oregonians by slowing down climate change and improving air quality.

The changes required to reduce GHG emissions represent a significant investment of resources, many of which have the potential to impact health. To maximize the health benefits of these investments and minimize any potential health risks, OHA makes the following recommendations.

Findings and Recommendations

Air quality

Findings:
All scenarios that meet GHG reduction goals have potential positive impacts on human health. The most health-promoting scenarios evaluated in this assessment had similar elements:

- The most ambitious levels of community design policies,
- Intermediate and ambitious levels of pricing and incentives,
- Highest levels of active transportation (including transit),
- Lowest levels of single occupancy vehicle driving, and
- Lowest levels of particulate air pollution.

In addition, air pollution has several health equity impacts of concern, such as:

- Children, older adults, people with pre-existing cardiopulmonary diseases and people with low incomes are more susceptible to negative health effects from exposure to $PM_{2.5}$.
- Low-income communities and communities of color are more likely to live in close proximity to high-traffic roads, and thus have higher exposures to harmful air pollution. These groups may also live in lower quality housing with poor indoor air quality. Their cumulative exposure to indoor and outdoor air pollution may be significantly higher than other groups.

Recommendation:
Develop and implement a preferred scenario that meets or surpasses the greenhouse gas emissions reduction target set for the region. Further:

- Prioritize strategies that lead to decreases in air pollution exposure for all populations in the region; in particular for low income communities, children, seniors, people with low incomes, and people with chronic health conditions or disabilities. An example strategy may be creating and promoting walking and biking routes adjacent to low-traffic roads specifically in lower income neighborhoods).
- Follow through with implementation of the recommendations identified in the Portland Air Toxics Solutions Report**.** The report identifies a number of recommendations that will reduce air pollution from light vehicles and have also been linked to reducing GHG emissions.

Physical activity

Findings:

Scenarios that meet GHG reduction goals by decreasing vehicle miles traveled (VMT) will have the most positive impacts on health. In the most health-promoting scenarios assessed, the majority of the health benefits result from increased physical activity (60%), followed by reductions in road traffic crashes (approximately 33%) and lower exposure to particulate matter in the air (6%).

Recommendation:

To maximize public health benefits and meet the state target, emphasize the types of strategies that best increase active transportation and physical activity: community design, pricing and incentives. Further:

- Implement active transportation strategies with an understanding of existing local health conditions and inequities.
    a. Increasing the number of people biking and walking could cause a small increase in injuries and deaths from collisions. Therefore Metro and partners should implement strategies in ways that do not worsen these health conditions and inequities, such as planning for necessary safety infrastructure.
    b. Portland metropolitan region residents do not all have equal access to active transportation opportunities. An effort should be made to improve access for all communities.
- Prioritize strategies that lead to increases in active travel for all populations in the region, in particular for children, seniors, people with low incomes, communities of color, and people with chronic health conditions or disabilities. Example strategies include marketing and incentive programs targeted to these populations, improved active travel infrastructure on routes to schools, and improved public transportation service in areas where these populations live.

Collisions

Findings:

The modeling tool used in this assessment shows positive health impacts due to reductions in motor vehicle crashes and potential negative impacts from increased bike injuries.

- Children are more likely to experience pedestrian-motor vehicle injuries and older adult pedestrians are more likely to die as a result of motor-vehicle pedestrian crashes.
- Child pedestrians from lower income families are at higher risk of dying from a road traffic injury.

Recommendation:

Include strategies, such as community design, that can lead to decreases in road traffic injuries and fatalities for all populations in the region, in particular for children. Further:

- Prioritize strategies that lead to decreases in road traffic injuries and fatalities for all populations in the region; in particular for children and older adults. The community design, pricing and incentives strategies that lead to reductions in VMT may also increase safety in the region.
- Mitigate potential increases in pedestrian and bicyclist injuries and fatalities through proven design strategies, such as increasing the visibility of vulnerable road users; separate facilities like sidewalks, bike boulevards or cycle tracks; and traffic calming or speed control measures [134, 156]. The feeling of safety given by these mitigations may also expand the percentage of the population willing to bike and walk.

Further assessment

Carry out additional quantitative health impact assessment of the three scenarios that are identified in spring 2013 to further inform development and adoption of a final preferred scenario. OHA recommends the use of ITHIM or a similar health impacts model for this future assessment. Further:

- OHA recommends that when the CSCS Project develops the preferred scenario in 2013-14, health stakeholders (in particular, local health departments) be consulted in order to incorporate local health expertise and to continue building relationships between public health and planning professionals and policymakers.
- OHA recommends that future related HIAs include consideration of land use, housing affordability, location relative to employment, gentrification and displacement, or air pollution other than $PM_{2.5}$.

Appendix A. List of Climate Smart Communities Scenarios HIA Advisory Committee members

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Appendix B. Population travel and health characteristics of Portland Metro region

Table 1. Metropolitan Region Travel Characteristics Comparison, County and State

Travel Characteristic	Clackamas County	Multnomah County	Washington County	State of Oregon
Commute to Work – Drove Alone	76%	62.9%	73.9%	72%
Commute to Work – Carpooled	9.6%	9.8%	10.2%	10.8%
Commute to Work – Public Transportation	3.2%	11%	5.7%	4.2%
Commute to Work – Walked	2.4%	4.8%	2.9%	3.9%
Commute to Work – Other Means	1.2%	5.4%	2.1%	3.1%
Average Commute Time (minutes)	26	24.3	24.1	22.1

Source: 2006-2010 American Community Survey - Oregon, U.S. Census Bureau, 2011.

Table 2. Multnomah County Travel Characteristics Comparison, Cities

Travel Characteristic	Fairview	Gresham	Lake Oswego	Maywood	Milwaukie	Portland	Troutdale	Wood Village	State of Oregon
Commute to Work Drove Alone (%)	**73**	**73.5**	**76.7**	**79.4**	**74.8**	**60.4**	**76.7**	**74.7**	**72**
Commute to Work Carpooled (%)	**10.3**	**12.2**	**6**	**13.2**	**8.9**	**9.4**	**13.7**	**6.8**	**10.8**
Commute to Work Public Transport (%)	**4.8**	**7.4**	**3.8**	**1.5**	**8.1**	**12**	**3.3**	**12.2**	**4.2**
Commute to Work Walked (%)	**4.5**	**2.5**	**1.7**	**1**	**2.5**	**5.4**	**0.5**	**2.4**	**3.9**
Commute to Work Other Means (%)	**0.6**	**1.1**	**1.5**	**2.2**	**1.3**	**6.4**	**2.1**	**0.9**	**3.1**
Average Commute Time (minutes)	**22.1**	**26.2**	**21.5**	**24.8**	**24.3**	**23.9**	**27.3**	**26.2**	**22.1**

Yellow = **Positively** different from state average Pink = **Negatively** different from state average

Source: 2006-2010 American Community Survey - Oregon, U.S. Census Bureau, 2011.

Table 3. Portland Metropolitan Region Health Conditions Comparison, 2006 – 2009

Health Condition	Clackamas County	Multnomah County	Washington County	State of Oregon
Asthma Prevalence	9.7%	9.2%	9.0%	9.7%
Diabetes Prevalence	6.6%	6.2%	5.9%	6.8%
Stroke Prevalence	2.6%	1.8%	1.9%	2.3%
Heart Attack Prevalence	2.5%	2.9%	2.5%	3.3%
Obesity Prevalence	23.6%	21.8%	23.2%	24.5%
Meets CDC Physical Activity Recommendation	55.6%	55.1%	53.8%	55.8%
Fatal/Injury Crash Rate (per 1,000 population)	5.2	8.03	5.25	5.51
Source: 2006-2009 BRFSS County Combined Dataset				

Appendix C. Integrated transport and health modeling (ITHIM) results, detailed tables

Table 1. GreenSTEP model inputs for Base Year (2010) and Scenario Clusters 1-6 (2035)

	Walk Trips Per Person Per Week	Bike Miles Per Person Per Week	Household Vehicle Miles Per Person Per Week	Roadway Light Duty Vehicle Miles Per Person Per Week	Bus Revenue Miles Per Person Per Week	Rail Revenue Miles Per Person Per Week
Base Year (2010)	2.81	2.24	129.36	139.03	0.32	0.23
Scenario Cluster 1	3.53	2.16	122.41	131.56	0.44	0.11
Scenario Cluster 2	3.69	3.71	99.00	106.48	0.66	0.66
Scenario Cluster 3	3.90	4.57	76.77	82.61	1.10	1.10
Scenario Cluster 4	3.53	2.16	107.99	116.08	0.44	0.11
Scenario Cluster 5	3.69	3.71	87.49	94.13	0.66	0.66
Scenario Cluster 6	3.90	4.57	68.65	73.90	1.10	1.10

Table 2. Premature deaths, years of life lost, and attributable fractions* due to increased physical activity, Scenario Clusters 1-6, Portland metropolitan region

	Burden of Disease						Attributable Fraction, Percent					
Item by Cause	Scenario Cluster 1	Scenario Cluster 2	Scenario Cluster 3	Scenario Cluster 4	Scenario Cluster 5	Scenario Cluster 6	Scenario Cluster 1	Scenario Cluster 2	Scenario Cluster 3	Scenario Cluster 4	Scenario Cluster 5	Scenario Cluster 6
Premature Deaths												
Ischemic Heart Disease	-25	-58	-73	-34	-69	-82	-1.6%	-3.8%	-4.8%	-2.2%	-4.5%	-5.4%
Hypertensive Heart Disease	-5	-11	-14	-7	-13	-16	-1.7%	-3.8%	-4.8%	-2.3%	-4.5%	-5.5%
Stroke	-12	-27	-33	-16	-31	-37	-1.7%	-3.8%	-4.7%	-2.3%	-4.5%	-5.3%
Diabetes	-3	-8	-9	-4	-9	-11	-1.4%	-3.2%	-3.7%	-1.6%	-3.6%	-4.2%
Dementia	-3	-5	-6	-4	-6	-7	-0.7%	-1.3%	-1.6%	-0.9%	-1.6%	-1.8%
Breast Cancer	0	-1	-2	0	-1	-2	-0.3%	-0.8%	-1.0%	-0.2%	-0.6%	-0.9%
Colon Cancer	-1	-2	-2	-1	-2	-2	-0.4%	-0.9%	-1.1%	-0.5%	-0.9%	-1.1%
Depression	0	0	0	0	0	0	-0.6%	-1.1%	-1.3%	-0.6%	-1.1%	-1.2%
Total	-49	-112	-139	-66	-131	-157	-1.4%	-3.2%	-3.9%	-1.9%	-3.7%	-4.4%
Years Life Lost												
Ischemic Heart Disease	-247	-617	-820	-335	-717	-915	-1.6%	-3.9%	-5.2%	-2.1%	-4.6%	-5.8%
Hypertensive Heart Disease	-53	-134	-187	-73	-156	-208	-1.5%	-3.8%	-5.3%	-2.1%	-4.4%	-5.9%
Stroke	-109	-275	-354	-147	-320	-395	-1.6%	-4.0%	-5.1%	-2.1%	-4.6%	-5.7%
Diabetes	-47	-118	-149	-55	-133	-165	-1.3%	-3.2%	-4.1%	-1.5%	-3.6%	-4.5%
Dementia	-18	-37	-43	-21	-40	-46	-0.7%	-1.4%	-1.7%	-0.8%	-1.5%	-1.8%
Breast Cancer	-10	-28	-43	-8	-20	-37	-0.3%	-0.8%	-1.3%	-0.2%	-0.6%	-1.1%
Colon Cancer	-7	-19	-26	-7	-17	-24	-0.3%	-0.8%	-1.1%	-0.3%	-0.7%	-1.0%
Depression	0	0	0	0	0	0	-0.5%	-1.1%	-1.5%	-0.5%	-1.0%	-1.3%
Total	-492	-1230	-1623	-647	-1403	-1789	-1.3%	-3.2%	-4.3%	-1.7%	-3.7%	-4.7%

Years Living With Disability												
Ischemic Heart Disease	-18	-44	-56	-21	-49	-61	-1.4%	-3.4%	-4.3%	-1.6%	-3.8%	-4.7%
Hypertensive Heart Disease	-7	-15	-17	-9	-17	-19	-1.5%	-2.9%	-3.4%	-1.8%	-3.4%	-3.9%
Stroke	-41	-107	-142	-48	-118	-155	-1.3%	-3.4%	-4.5%	-1.5%	-3.7%	-4.9%
Diabetes	-49	-137	-182	-57	-152	-200	-1.1%	-3.1%	-4.2%	-1.3%	-3.5%	-4.6%
Dementia	-47	-109	-127	-53	-110	-128	-0.6%	-1.5%	-1.7%	-0.7%	-1.5%	-1.7%
Breast Cancer	-3	-7	-11	-2	-5	-10	-0.3%	-0.8%	-1.3%	-0.2%	-0.6%	-1.1%
Colon Cancer	-2	-4	-6	-2	-4	-6	-0.3%	-0.8%	-1.1%	-0.3%	-0.7%	-1.1%
Depression	-33	-104	-168	-24	-70	-124	-0.2%	-0.7%	-1.1%	-0.2%	-0.5%	-0.8%
Total	-201	-528	-710	-216	-526	-703	-0.6%	-1.6%	-2.1%	-0.6%	-1.6%	-2.1%
DALYs												
Ischemic Heart Disease	-265	-661	-876	-356	-766	-976	-1.6%	-3.9%	-5.2%	-2.1%	-4.5%	-5.8%
Hypertensive Heart Disease	-61	-149	-204	-82	-173	-228	-1.5%	-3.7%	-5.1%	-2.0%	-4.3%	-5.6%
Stroke	-150	-382	-496	-195	-438	-550	-1.5%	-3.8%	-4.9%	-1.9%	-4.4%	-5.5%
Diabetes	-96	-255	-332	-112	-285	-365	-1.2%	-3.2%	-4.1%	-1.4%	-3.6%	-4.5%
Dementia	-65	-146	-170	-75	-150	-174	-0.6%	-1.5%	-1.7%	-0.7%	-1.5%	-1.7%
Breast Cancer	-13	-36	-54	-10	-25	-46	-0.3%	-0.8%	-1.3%	-0.2%	-0.6%	-1.1%
Colon Cancer	-9	-24	-32	-9	-21	-29	-0.3%	-0.8%	-1.1%	-0.3%	-0.7%	-1.0%
Depression	-34	-104	-168	-24	-70	-125	-0.2%	-0.7%	-1.1%	-0.2%	-0.5%	-0.8%
Total	-693	-1758	-2333	-863	-1929	-2492	-1.0%	-2.5%	-3.3%	-1.2%	-2.7%	-3.5%

*The attributable fraction (AF) is the proportional reduction in population disease or mortality that would occur if exposure to a risk factor were reduced to an alternative ideal exposure scenario. Many diseases are caused by multiple risk factors, and individual risk factors may interact in their impact on overall risk of disease. As a result, AFs for individual risk factors often overlap and add up to more than 100 percent.

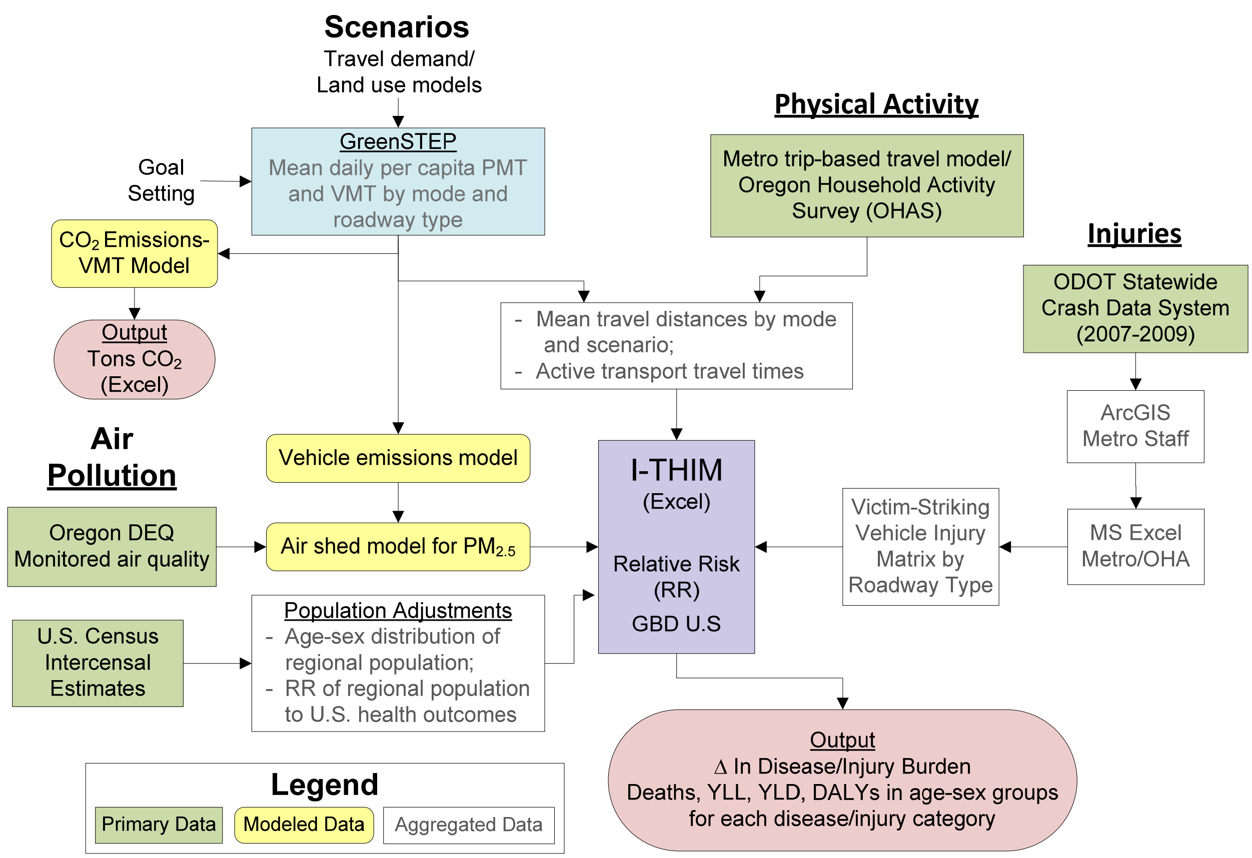
Table 3. Annual mean miles traveled per person by mode and percent mode share for Base Year (2010) and Scenario Clusters 1-6 (2035)

Scenario	Units	Automobile/ Light Truck	Bus	Rail	Bicycle	Walk	Total
Base Year	Miles	6,727	17	12	116	70	6,942
	%	96.9	0.2	0.2	1.7	1.0	100.0
Scenario Cluster 1	Miles	6,365	23	6	112	88	6,594
	%	96.5	0.3	0.1	1.7	1.3	100.0
Scenario Cluster 2	Miles	5,148	34	34	193	92	5,501
	%	93.6	0.6	0.6	3.5	1.7	100.0
Scenario Cluster 3	Miles	3,992	57	57	238	97	4,442
	%	89.9	1.3	1.3	5.4	2.2	100.0
Scenario Cluster 4	Miles	5,616	23	6	112	88	5,844
	%	96.1	0.4	0.1	1.9	1.5	100.0
Scenario Cluster 5	Miles	4,549	34	34	193	92	4,903
	%	92.8	0.7	0.7	3.9	1.9	100.0
Scenario Cluster 6	Miles	3,570	57	57	238	97	4,020
	%	88.8	1.4	1.4	5.9	2.4	100.0

Table 4. Total injuries and fatalities by roadway and mode of travel for Scenario Clusters 1-6, Portland Metropolitan ITHIM model

Roadway/Victim	Baseline	Scenario Cluster 1	Scenario Cluster 2	Scenario Cluster 3	Scenario Cluster 4	Scenario Cluster 5	Scenario Cluster 6
1. Highway							
Walk	0.7	0.7	0.7	0.6	0.7	0.6	0.6
Bicycle	0.3	0.3	0.4	0.4	0.3	0.3	0.3
Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Car	26.3	24.9	20.2	15.8	22.0	17.9	14.1
Truck	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Motorcycle	6.3	6.3	6.2	6.2	6.3	6.2	6.1
2. Arterial							
Walk	39.0	42.8	39.8	36.8	40.3	37.6	35.0
Bicycle	10.3	9.9	12.0	12.1	9.4	11.3	11.6
Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Car	128.0	121.2	98.5	76.7	107.2	87.2	68.7
Truck	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Motorcycle	11.0	10.8	10.2	9.6	10.5	9.9	9.4
3. Local street							
Walk	17.7	19.3	17.8	16.3	18.2	16.8	15.5
Bicycle	18.3	17.5	20.7	20.3	16.5	19.5	19.2
Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Car	61.7	58.4	47.4	36.9	51.6	42.0	33.1
Truck	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Motorcycle	12.0	11.8	11.2	10.5	11.5	10.9	10.3
Total	332.6	325.1	286.2	243.2	295.4	261.4	224.8

Appendix D. ITHIM diagram and data inputs



Data inputs

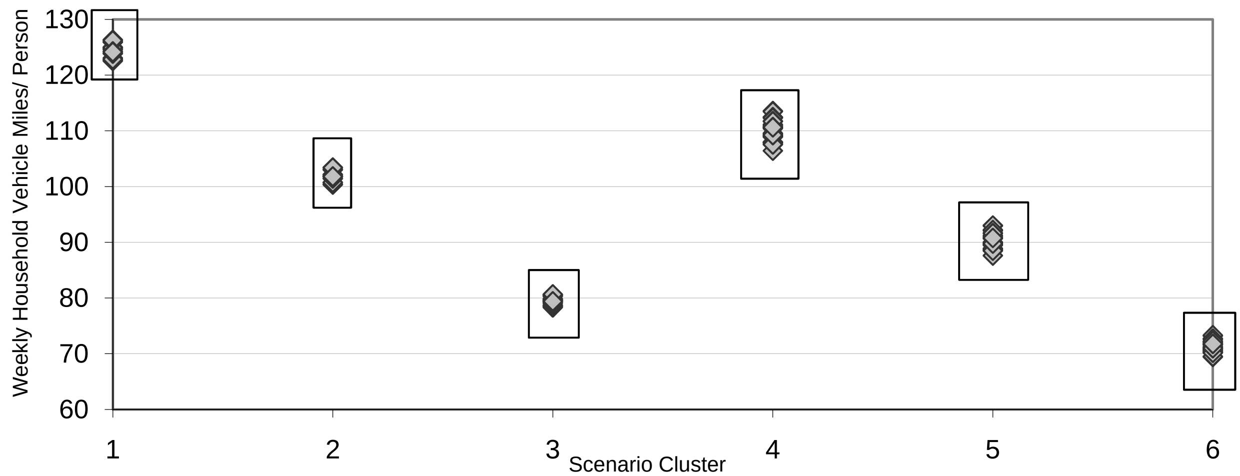
OHA obtained data from various sources for the ITHIM data inputs. These sources and more detailed descriptions of the data follow.

Selection of sample scenarios for assessment in ITHIM

During Phase One of the Climate Smart Communities Scenarios Planning effort, Metro estimated the GHG-reducing properties of 144 specific scenarios. OHA did not assess the health impacts of each of the Phase One scenarios. Instead, 6 sample scenarios were assessed to provide information about the health impacts of the types of policies and investments decision-makers will consider including as they develop the final three Phase Two scenarios.

The sample scenarios are actually averages of 6 clusters of scenarios for the Portland metropolitan region in 2035 and the 2010 base year. The clusters were identified based on similarities in household travel and emissions characteristics as shown in the figure below and in Appendix C, Table 1.

Figure Household Vehicle Travel By Scenario Cluster



The distinguishing features of the sample scenarios are detailed below:

- Scenario Cluster 1 includes all community design level 1 and pricing level 1 scenarios.
- Scenario Cluster 2 includes all community design level 2 and pricing level 1 scenarios.
- Scenario Cluster 3 includes all community design level 3 and pricing level 1 scenarios.
- Scenario Cluster 4 includes all community design level 1 and pricing level 2 and level 3 scenarios.
- Scenario Cluster 5 includes all community design level 2 and pricing level 2 and level 3 scenarios.
- Scenario Cluster 6 includes all community design level 3 and pricing level 2 and level 3 scenarios.

More detailed descriptions of the scenario assumptions for each policy area level can be found in the Phase One Findings Report [66].

Road Traffic Injuries

In 2011, Metro extracted three years of collision data between 2007 and 2009 from Oregon Department of Transportation's (ODOT) statewide crash data system for use in the Metro State of Safety Report. Metro formatted ODOT's crash data to show injury severity by travel mode (motorized vehicles, bicyclists, pedestrians) of injured parties and roadway type where the collision occurred for state of safety report. OHA averaged serious injuries and fatalities for the three years of data used in the report by road type and travel mode of injured parties and applied it in ITHIM's baseline injuries module. Fatal injuries are deaths occurring within 30 days of the collision. Serious injuries are injuries that the victim is not able to walk away from.

Air Pollution

Estimates of average, annual airborne concentration of fine particulate matter (aerodynamic diameter of 2.5 microns, $PM_{2.5}$) were based on two sources. Mobile $PM_{2.5}$ from light duty vehicles was calculated inside ODOT's Greenhouse Gas Statewide Transportation Emissions Planning Model (GreenSTEP) from estimated household vehicle travel, fuel consumption by fuel type and emission rates for each scenario. Fluctuations in emissions from heavy vehicle travel were not included in GreenSTEP scenario outputs.

Annual mean ambient $PM_{2.5}$ concentration was calculated from monitors distributed around the Washington and Multnomah Counties. Most $PM_{2.5}$ monitors measure air quality every sixth day, some every third day and a few measure every day. Monitored $PM_{2.5}$ data was not available for Clackamas County, but it is assumed that air pollution is similar to Multnomah County based on input from DEQ. Mobile emissions calculated for existing conditions in GreenSTEP were treated as a percentage of the total annual mean ambient $PM_{2.5}$ concentration and subtracted from the total to estimate stationary $PM_{2.5}$ for the alternative scenarios. Stationary $PM_{2.5}$ was held constant for the alternative scenarios and only mobile emissions fluctuated.

Census

US Census data were used to create the demographic profile of the three counties in the Metro region. The 2004 population was estimated from the 2000 and 2010 census population growth trend for populations inside Metro's Urban Growth Boundary geography. Relative risk factors were applied in ITHIM to describe risk reduction for several diseases from physical exercise associated with active travel. Age group and sex determine relative risk factors. Population distribution was also used to adjust U.S. health outcomes from the Global Burden of Disease database for the Metro region.

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