SAN FRANCISCO CLIMATE & HEALTH PROFILE

Prepared By

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Executive Summary

The San Francisco Department of Public Health's (SFDPH) Climate and Health Program works to address the public health consequences of climate change at the local level and improve climate change preparedness and resilience in San Francisco. Using the Centers for Disease Control's (CDC) national framework, Building Resilience Against Climate Effects (BRACE), the SFDPH's Climate and Health program is assessing climate trends, defining disease burden, developing specific intervention methods, and evaluating the effects of change for at-risk populations within San Francisco.

This Climate and Health Profile identifies the scope of local climate impacts and associated potential health outcomes, and highlights populations and locations especially vulnerable to these health impacts. By systematically using climate projections to prioritize the health impacts and risk factors to pave the way for San Francisco public health adaptation efforts, the Climate and Health Profile reveals essential information needed to take future action. By utilizing the best climate science available and engaging community partners to understand vulnerabilities and interventions for communities and populations at highest risk for illness, the profile is a useful resource to help advance urban health and environmental justice in the climate and health field.

As a temperate city with housing and infrastructure built for a cool coastal climate, higher temperatures, more extreme-heat days, and longer heat waves will test San Francisco's health infrastructure. Heat hazard events will increase heat-related illness and heat-related mortality. As extreme heat days increase, poor air quality will lead to higher rates of respiratory illness, asthma, and allergies. Similarly, cold snaps during winter will increase rates of hypothermia, shortness of breath, cough, and risk for influenza.

San Francisco is particularly vulnerable to sea-level rise and flood inundation. Surrounded by coastline on three sides, many homes, businesses, and infrastructure are located in current or future flood plains. As sea-levels rise along the Bay and Pacific Ocean, an increase in the frequency and severity of extreme storms may exacerbate instances of flood inundation. Flood inundation, especially along vulnerable coastline, will lead to an increase in fatal and non-fatal injuries, water-borne disease, and rodent and vector borne disease.

Climate models predict San Francisco precipitation levels to fluctuate between wet and dry extremes. As extreme storms increase in especially wet years, especially dry years will bring drought conditions. These drought conditions are likely to impact agricultural output which could both reduce access and increase the price of healthy produce in San Francisco and surrounding communities.

Even those San Franciscans not directly affected by the health effects of climate events may be affected indirectly. Indirect effects include increased physical and social isolation after hazard events, employment and income loss, exacerbated mental and behavioral health stressors, and a strained health response infrastructure.

Although all San Franciscans will be affected by climate change, certain San Franciscans will be affected more than others. Residents that live, work, or recreate along San Francisco's waterfront are more vulnerable to flood risk. Those in areas with poor air quality or limited access to open space are vulnerable to heat-related hazards.

In particular, the urban poor are most vulnerable to climate change as its impacts amplify socioeconomic and racial disparities. The degree to which San Franciscans are impacted by climate change often depends on his-or-her age, race, income, language, educational attainment, housing conditions, and pre-existing physical conditions such as diabetes and mobility disabilities.

After analysis of environmental, demographic and socioeconomic infrastructure and individual pre-existing indicators, the profile concludes that there are certain neighborhoods in San Francisco that will be disproportionately affected by climate change: Chinatown & Downtown, Bayview Hunters Point, SOMA, Excelsior, Crocker Amazon, Visitacion Valley and Treasure Island.

Moving forward, addressing inequities in neighborhoods and prioritizing the needs of our most vulnerable populations will build resilient communities. Community resiliency has been a core part of the Climate and Health Program through data driven planning, education, empowerment and engagement. Using information from this profile, SFDPH and its partners need to continue to

work with vulnerable neighborhood groups to address the projected health impacts of climate change and support the community in its self-identified mitigation, preparedness, response, restoration and recovery goals. This will be accomplished by 1) continuing to develop assessments, emergency plans and educational and outreach material for adaptation and resilience efforts, 2) strengthen collaboration across government agencies, 3) supporting vulnerable communities in building capacity and leadership, and 4) seeking innovative solutions from diverse partnerships as the impacts of climate change escalate and unfold.

Highlights of the Climate and Health Impacts include:

HAZARD	CLIMATE IMPACT	HEALTH IMPACT
Heat	Average yearly temperature to increase between 4.1 and 6.2 degrees Fahrenheit by 2100	Heat-Related Illness o Dehydration o Heat Stroke
	Extreme Heat Days (over 85F) to increase by 15-40 by 2050, potentially 90 by 2100	Heat-Related Mortality o Heart Disease Air Quality Effects
	Increase in heat wave length and frequency	o Respiratory Illness o Asthma o Allergies Mental and Behavioral Health
Sea-level Rise	Sea-levels projected to rise between 7 - 15 inches by 2050, 26-46 inches by 2100	Fatal and Nonfatal Injury Water-borne disease Mental and Behavioral Stressors Income Loss
Extreme Storms	As precipitation levels fluctuate year-to-year, in rainy years, the frequency and severity of extreme storms is predicted to increase	Fatal and Nonfatal Injuries Water-borne Disease Mental and Behavioral Stressors Strain on public health infrastructure Income Loss
Drought	As precipitation levels fluctuate year-to-year, in dry years where the high-pressure system off the coast does not dissipate, the frequency and severity of droughts will increase	Food Insecurity o Malnutrition Air Quality / Allergens o Respiratory Illness o Asthma o Allergies Mental and Behavioral Health Income Loss

1. *Introduction*

For the last decade, cities have invested in developing climate action plans to reduce their greenhouse gas emissions, yet lesser attention has been paid to developing adaptive measures to protect the public's health in the event of climate change related extreme weather events, prepare the public for the gradual indirect effects of climate change, or to expand the capacity of public health departments to plan and prepare for such events.

For the past four years, the San Francisco Department of Public Health (SFDPH) has engaged in several initiatives to both better understand the potential health impacts of climate change at the local level, and improve climate change preparedness and resilience in San Francisco. The SFDPH Environmental Health Branch received a grant from the Centers for Disease Control (CDC) which funded the creation of the Department's Climate and Health Program. The Climate and Health Program addresses the public health consequences of climate change and its implications on human health. The CDC has developed a framework, entitled Building Resilience Against Climate Effects, or BRACE, to facilitate effective public health climate adaptation. Using the BRACE framework, SFDPH will assess climate trends, define disease burden, develop specific intervention methods, and evaluate the effects of change for at-risk populations within San Francisco to:

- *Promote community resilience through education, empowerment, and engagement to reduce vulnerability to health impacts of climate change.*

- *Increase both local level capacity and internal department capacity to utilize climate health science.*

- *Incorporate stakeholder engagement in the development of climate change mitigation and adaptation actions.*

- *Implement adaptation efforts which achieve health co-benefits and improve health disparities.*

- *Serve as a model for local health departments.*

The BRACE framework begins with the San Francisco Climate and Health Profile, which will identify the scope of climate impacts, associated potential health outcomes, and populations and locations vulnerable to these health outcomes. Within the profile, climate related risk factors and the linkages between climate change health outcomes will be described, with special attention to vulnerable populations. The Climate and Health Profile will systematically use climate projections to prioritize the health impacts and risk factors to pave the way for future San Francisco public health adaptation efforts.

While climate change considerations are relatively new for the public health community, the CDC advocates for public agencies to approach the health effects of climate change in the same way as they would prepare for the possibilities of bioterrorism or pandemic influenza: **forecast impacts and assess vulnerabilities, project disease burden, assess public health interventions, and develop and implement a climate and health adaptation plan.** While the Climate and Health Profile will focus on public health concerns, we hope the report will be intersectoral in nature and inform San Francisco's wider climate adaptation process.

2. History of SFDPH Engagement with Climate and Health

In 2010, the San Francisco Department of Public Health, Environmental Health Branch received a three-year grant from the CDC which funded the creation of the Department's Climate and Health Program to implement a strategic plan as part of a national "Climate-Ready States and Cities Initiative". Our intent was to use the results of our planning process and the resources provided by the implementation grant to put in place a public health response to climate change that could be sustained over the long term. The San Francisco Department of Public Health, which included the Environmental Health Branch, The Public Health Emergency Preparedness & Response Branch and Emergency Medicine, along with its partner city agencies, has successfully created a program to build capacity and to address the public health impacts of climate change. In 2013, SFDPH was awarded additional funding for three years to empower San Francisco communities to address the health effects of climate change.

The first several years of the Climate and Health program focused on 1) Planning initiatives to prevent and address the health impacts of heat stress morbidity and mortality from extreme heat events and associated air quality hazards and 2) Rebranding climate change in San Francisco as a public health issue and partnering with many city agencies to educate them about the health impacts of climate change including asthma, allergies, spread of infectious diseases, food insecurity, injuries and deaths from extreme weather events. We have conducted strategic planning for the development of a City and County of San Francisco heat wave disaster response plan and appropriate surveillance and health education/outreach activities to protect San Franciscans. Through this process, we have engaged community partners to have a comprehensive approach to understanding vulnerability and interventions that will target those communities and populations at highest risk for illness in order to advance urban health, social and environmental justice.

SFDPH's priority activities of have focused on vulnerability assessments, outreach/education, building partnerships and community resilience, developing tools and indicators, and planning. Upon development of CDC's Building Resilience Against Climate Change Effects

(BRACE) framework, The San Francisco Department of Public Health began targeting activities which incorporated aspects of the BRACE. The major accomplishments are list below.

Vulnerability Assessments

- Developed an environmental health assessment methodology to map determinants of heat vulnerability to assess the spatial distribution of extreme heat and associated air quality impact vulnerability. The outcome was summarized in the *Understanding the Risk: An Assessment of San Francisco's Vulnerability to Extreme Heat Events* report and an *atlas that mapped out heat vulnerability*.

Outreach and Education

- Developed a website (*http://www.sfhealthequity.org/elements/climate*) and press releases for information dissemination.

- Identified strategies to reach vulnerable populations and health education/outreach

- Disseminated research, plans and information on climate health by presenting at the local, state and national forums.

- Developed factsheets, flyers, brochures, posters, newsletters, presentations and trainings on climate and health topics. Selected materials include:
  - *Heat Training Presentation*
  - *Staying Heathy in the Heat Brochure*
  - *Public Information for Heat Events*

Indicators, tools and innovation

- Developed an *Environmental Health Indicators of Climate Change* report.
- Created *infographics* to graphically visualize the health impacts of climate change and to understand factors that contribute to heat vulnerability in San Francisco.
- Created an *Interactive Heat Vulnerability Map* to help city leaders understand which areas of San Francisco are the most at risk during an extreme heat event.
- Made all of the data from this Climate and Health project available for researchers, civic developers, and private industry in an effort to promote transparency in our work and challenge developers to create tools that will help mitigate the impacts of complex problems like climate change. Health, environment and climate datasets are available on DataSF (datasf.org) and the San Francisco Indicator Project.
- Developed Community Resiliency Indicators (page 15 of this report).

Planning

- Conducted an analysis of extreme heat events and illness. Data on temperature, hospitalizations and emergency department (ED) visits in San Francisco were acquired and analyzed to understand the relationship between extreme heat events and illness and documented in the Analysis of Extreme Heat Events and Illness in San Francisco, CA report.
- Developed *Heat Wave Disaster Response Plan* which is an annex to San Francisco's new Emergency Operation Plan.
- Conducted an operation based exercise to test activating the heat wave disaster response plan and an evaluation with recommendations.
- Assessed the Health Co-benefits of San Francisco's Climate Action Plan and released finding in the *Assessing the Health Co-benefits of San Francisco's Climate Action Plan*.
- Produced a gap analysis of San Francisco's public health capacity and adaptations to reduce human health effects of climate change by utilizing national performance standards and the analysis was documented in *The Use of Environmental Health Assessment for a Gap Analysis to Measure Current Extreme Heat Response Plans in San Francisco* report.

Community Resilience

- Stakeholder interviews were conducted to gather advice and insight into the needs of vulnerable populations and the strategies best suited toward planning and protecting them during a heat emergency. *The Report of an Assessment of Community Perspectives About the Protection of Vulnerable Populations During a Heat Emergency in San Francisco* summarized those themes and presented a series of recommendations built on information shared by the interviewees.
- The San Francisco Department of Public Health began to partner with The Resilient Bayview Initiative – which is a community managed program which brings together stakeholder organizations from one of San Francisco's most vulnerable neighborhoods, to work together to increase the community's capacity to respond to climate change. Through this process an executive leadership group was formed and four working groups were established focusing on seniors and people living with disabilities, immigrant and mono-lingual residents, families and children and small businesses. Each group has identified a disaster mission statement and are in the process of finalizing a neighborhood action plans.

Partnerships/collaborations

Local

Our work would not be possible without engaged partners and collective collaboration. SFDPH has a long history of collaborating with local, state, and federal public agencies, and community organizations. On a local level, in addition to the city agencies named in this grant, outreach was conducted with the San Francisco Human Services Agency (SFHSA) and the San Francisco Department of Environment (SFDOE). SFHSA is responsible for Mass Care, Housing, and Human Services under Regional and Local Disaster Response Plans, which includes operation of cooling center shelters during extreme heat events and SFDOE is charged with creating the City's Climate Action Plan and co-leading SF Adapt. SF Adapt is the city's coordinated effort, led by the Department of the Environment and the City Administrator, to bring together agencies on climate adaptation. SF Adapt includes SFDPH and a multitude of other city agencies. SF Adapt is currently focused on four adaptation topics; 1) Public health, 2) Sea-level rise, 3) Energy assurance planning and 4) Incorporating adaptation into the city's hazard mitigation planning.

Also, as noted above, SFDPH partnered with the San Francisco's City Administrators Office, Neighborhood Empowerment Network Program, in an effort to work with a coalition of neighborhood and merchant organizations, non-profits, academic institutions and city agencies address the health impacts of climate change.

There were also are several community organizations involved in City and County of San Francisco Disaster response activities, which helped the inter-agency task force, design the public Outreach and the education phase of the project. These include the following:

- American Red Cross
- San Francisco Collaborating Agencies Responding to Disaster (SFCARD)
- Family Service Agency of San Francisco
- Chinatown Community Development Center
- American Red Cross Bay Area
- GLIDE Church

Private Partnerships

SFDPH has partnered with a local technology company, Appallicious, to bring public awareness to vulnerable communities to support disaster preparedness. Appallicious developed a Disaster Assessment and Assistance Dashboard (DAAD) which is an online emergency management application that is aimed at supporting preparedness, response and recovery efforts through an open data, social media and sharable economy platform. DAAD integrates the Community Resiliency Indicator system created by SFDPH. By centralizing and formalizing the collection of neighborhood-level community resiliency data, SFDPH is providing neighborhood organizations, city departments, and private partners, such as Appallicious, a simple, streamlined way to access resiliency data for their own projects.

Regional

On a regional level, SFDPH participated in the PIER (Energy Commission's Public Interest Program) Climate change adaptation study. The PIER study was focused on coordination with all the relevant state/regional/local agencies (which included SFDPH). The overall approach for the proposed study is a combination of local/regional case studies with state-wide vulnerability assessments. SFDPH also participated in the Bay Area Climate & Energy Resilience Project, which produced an Action Plan Outline based on the climate adaptation needs assessment. That assessment included interviews with more than 100 Bay Area

climate adaptation stakeholders including SFDPH, plus four special reports on equity, governance, science information, and integrated "win-win" climate strategies.

The Bay Area Joint Policy Committee coordinates regional planning efforts and overseeing the Bay Area Climate & Energy Resilience Project. This project is a collaborative of more than 100 public, private, and non-profit stakeholders in the nine-county San Francisco Bay Area. The primary purpose of the project is to support and enhance the local climate adaptation efforts of cities, counties and other organizations. SFDPH participates in the Climate and Health working group in supporting actions that will help all Bay Area stakeholders to move forward in a more efficient and powerful manner.

State

On a state level, The California Department of Public Health's Environmental Health Investigations Branch collaborated with SFDPH on using the Heat Vulnerability Index as a tool for use by other counties, as well as guidance on drafting local heat wave disaster response plans, surveillance and health education/outreach activities which could be tested for applicability to other local jurisdictions. We will continue to work closely with CDPH to ensure our work is in line with state guidelines and provide examples of best practices for local public health agencies on climate and health initiatives.

National

On a national level, The National Resources Defense Council, a non-profit policy-focused organization, has partnered with the San Francisco Department of Public Health in providing expertise to furthering our strategic planning. The National Oceanic and Atmospheric Administration (NOAA)/ National Weather Service (NWS) has extended its customized Heat Health Watch/Warning System to the City and County of San Francisco, which has enhanced its ability to issue accurate and timely heat-related advisories, watches and warnings and inform the public to take action to avoid health risks associated with periods of unusually high heat. National strategic partners have also included the U.S. Environmental Protection Agency (EPA) Region 9, NASA, CDC and FEMA.

3. *Climate Assessment and Projections*

Geography and Demography of San Francisco

San Francisco has 37 planning neighborhoods. When possible, data used in the Climate and Health Profile report will be summarized at the neighborhood level while the maps will be at the finer census tract level.

San Francisco, California

City and County of San Francisco Department of Public Health: Environmental Health Branch

Legend:
- San Francisco Neighborhoods
- Freeways and Highways
- Major Roads
- Water Bodies
- Open Space

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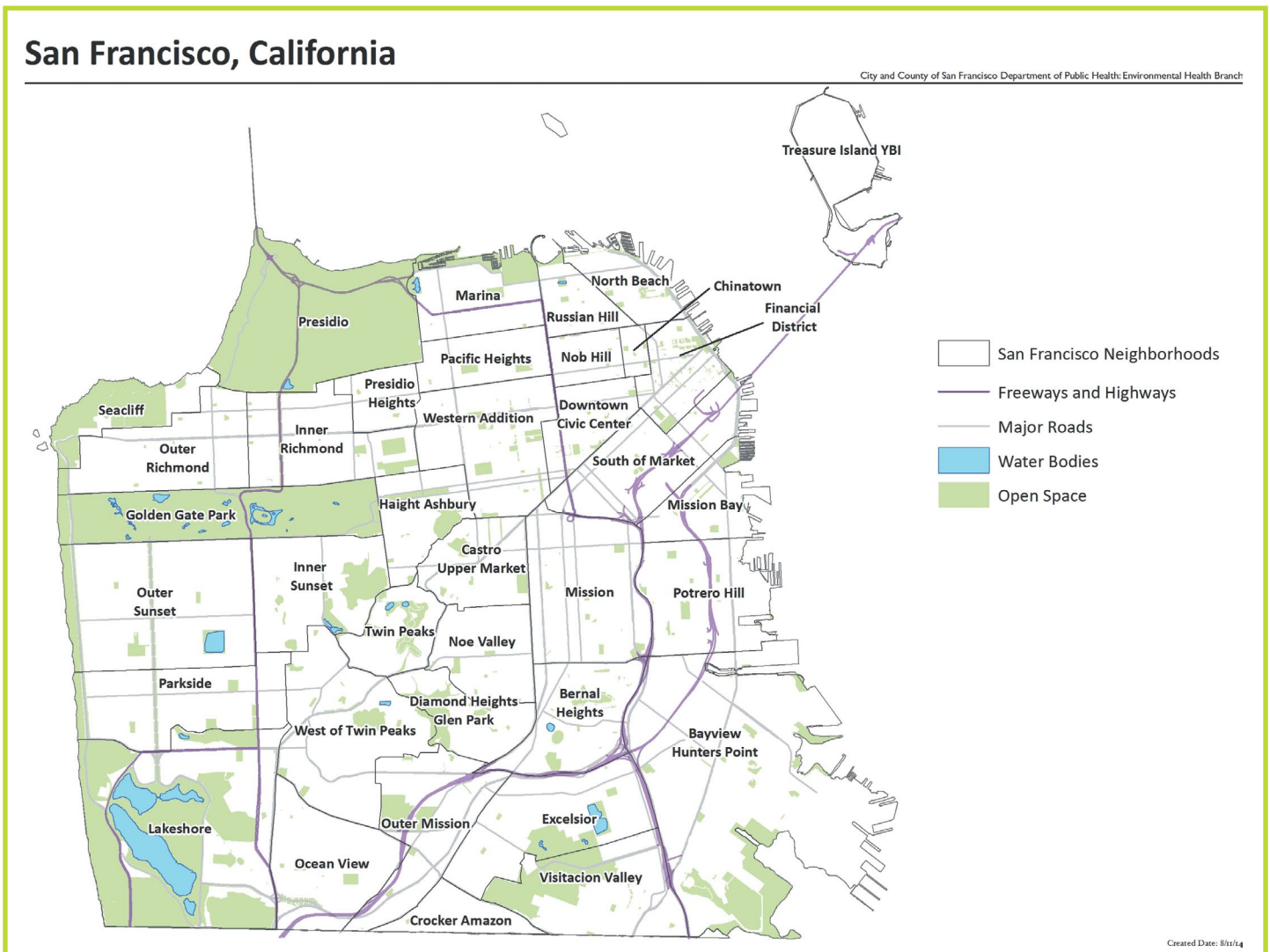
With about 30 miles of coastline, San Francisco's fate is intertwined with that of its waterfront. San Francisco has a population of roughly 830,000 people[1], over 538,000 jobs[2], and an estimated 16.89 million visitors per year[3], and all of them are within a few miles of either the Pacific Ocean or the San Francisco Bay.
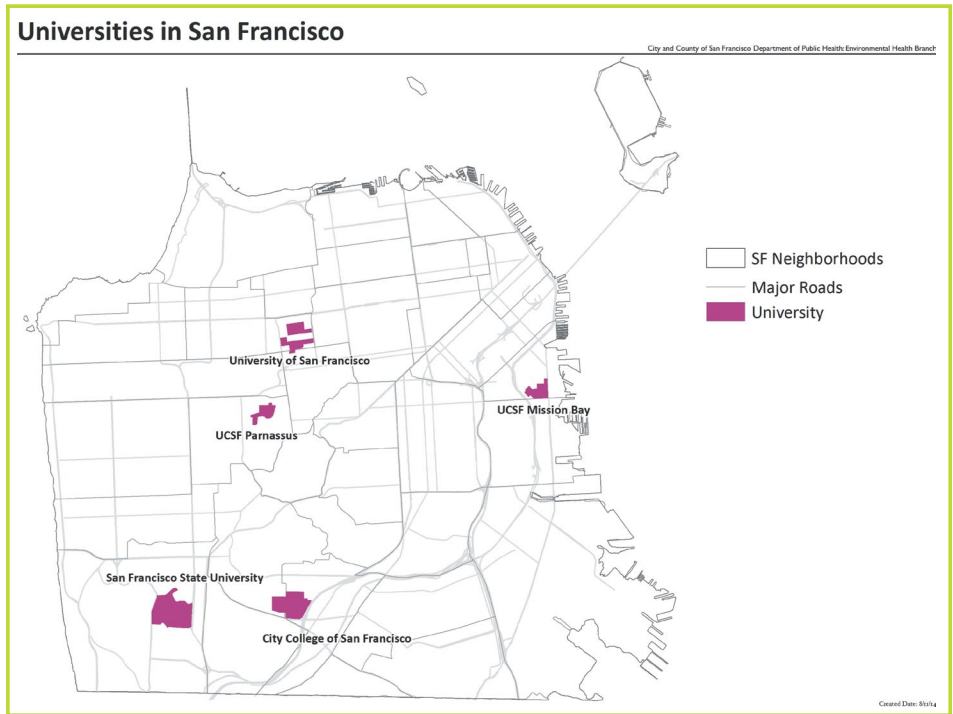
San Francisco is one of the most densely populated cities in the country. The densest neighborhood, Chinatown, is home to over 70,000 people per square mile[4]. As one of the major economic centers of the Bay

Area, the population of San Francisco balloons during the day as commuters from the East Bay, Marin, and the peninsula take Bay Area Rapid Transit (BART), ferries, cars, and busses into the city to work. The Financial District, SOMA (South of Market), and Downtown have the highest concentration of employees and businesses. San Francisco is also home to some major universities: University of San Francisco along the border of the Western Addition and Inner Richmond, City College of San Francisco in Outer Mission and Ocean View neighborhoods, San Francisco State in the Lakeshore Neighborhood, and two University of California Medical School campuses in the Inner Sunset and Mission Bay.

Universities in San Francisco

City and County of San Francisco Department of Public Health Environmental Health Branch

University of San Francisco
UCSF Parnassus
UCSF Mission Bay
San Francisco State University
City College of San Francisco

SF Neighborhoods
Major Roads
University

Created Date: 8/11/14

San Francisco is a wealthy city. The median household income of $73,802[1] is more than $10,000 greater than the median household income of California statewide. However, **San Francisco's wealth is not evenly distributed** and many San Franciscans are economically threatened by low wages coupled with a higher-than-average cost of living. Some neighborhoods with the highest concentration of low-income households (households earning under 200% of the poverty rate) include the Bayview Hunters Point and Visitacion Valley neighborhoods, and the centrally located Downtown/Civic Center, SOMA, and Chinatown neighborhoods[5]. The urban poor are most vulnerable to climate change as social justice issues amplify pre-existing socioeconomic and racial disparities.
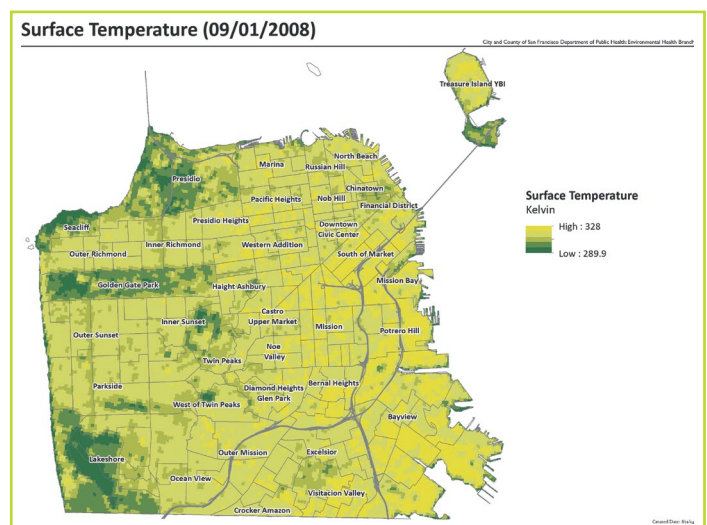
Baseline Climate Assessment

Temperature

Although San Francisco enjoys a temperature climate, with average daily temperatures ranging from the low-50s in the winter to the mid-60s in the summer, the climate has warmed over the last 100 years[6]. Since 1920, average annual temperatures in California have been increasing, including in the San Francisco Bay Area.

The temperature of San Francisco is affected by its natural and built environment. The built environment's effect on temperature is called the urban heat effect. Impervious surfaces such as asphalt and concrete absorb heat, large buildings block wind, and windows reflect and direct sunlight onto the surface below. These factors create urban heat islands where the surface temperature can be far warmer than that of rural environments.

Surface temperature can be used to assess the heat intensity for specific neighborhoods. To study the surface

Surface Temperature (09/01/2008)

City and County of San Francisco Department of Public Health Environmental Health Branch

Treasure Island YBI

Presidio, Marina, Russian Hill, North Beach, Pacific Heights, Nob Hill, Chinatown, Seacliff, Presidio Heights, Downtown, Financial District, Outer Richmond, Inner Richmond, Western Addition, South of Market, Mission Bay, Golden Gate Park, Haight Ashbury, Castro Upper Market, Mission, Outer Sunset, Inner Sunset, Noe Valley, Potrero Hill, Twin Peaks, Parkside, Diamond Heights, Bernal Heights, Glen Park, West of Twin Peaks, Bayview, Lakeshore, Outer Mission, Excelsior, Ocean View, Visitacion Valley, Crocker Amazon

Surface Temperature
Kelvin
High : 328
Low : 289.9

Created Date: 8/11/14

heat distribution of the city, satellite images were acquired from NASA. The map illustrates the most heat intensive regions of the city. The warmer regions of the city include the SOMA and Mission neighborhoods that have both large concentrations of impervious surface, but are adjacent to interstates, highways, and other high-traffic arterials. The coolest areas of the city include the Presidio of San Francisco and Golden Gate Park. Both of these areas have trees to provide shade, and vegetation to absorb heat.

As the marine layer off the Pacific Coast moves over San Francisco in the late afternoon or early evening, the City tends to cool. According to historical weather and mortality data gathered by the San Francisco Department of Public Health, there appears to be a significant increase in health risk when temperatures 'spike' for two or more consecutive days without an adequate drop in nighttime temperature. Days with temperatures at or above 85-degrees are considered 'extreme heat days' in San Francisco and trigger the activation of the SFDPH extreme heat response[7].

Precipitation

While San Francisco has averaged about 21 inches of rainfall over the last 50 years, the year-to-year precipitation levels are subject to dramatic variation[8]. In 1983, San Francisco received 43.75 inches of precipitation while in 1977, San Francisco received just 8.73 inches[8]. Because of the variation in precipitation levels in California, the region is vulnerable to both extremes: storms and drought.

Much of California's yearly precipitation (35% - 45%) comes in the form of "Pineapple Express" storms[9]. These storms occur when warm, moist air from Hawaii travels along an atmospheric river across the Pacific.

San Francisco annual Precipitation, in inches[8]

These storms, like most of San Francisco's precipitation, occur between the months of November and March. The rest of the year, San Francisco experiences little or no precipitation due to a semi-permanent high-pressure system that sits over the Northeastern Pacific and blocks storm systems[10]. This high-pressure system did not dissipate during winter 2013-2014, and contributed to the season's low precipitation levels and reduced snowpack in the Sierras. The 2013-2014 drought strained California water and agricultural resources and reduced many state reservoirs to under 30% of capacity.
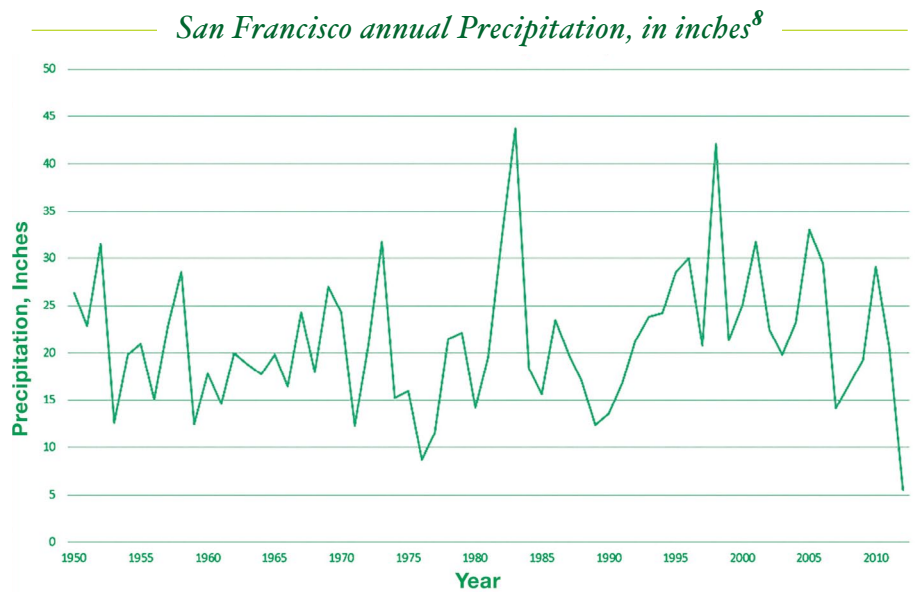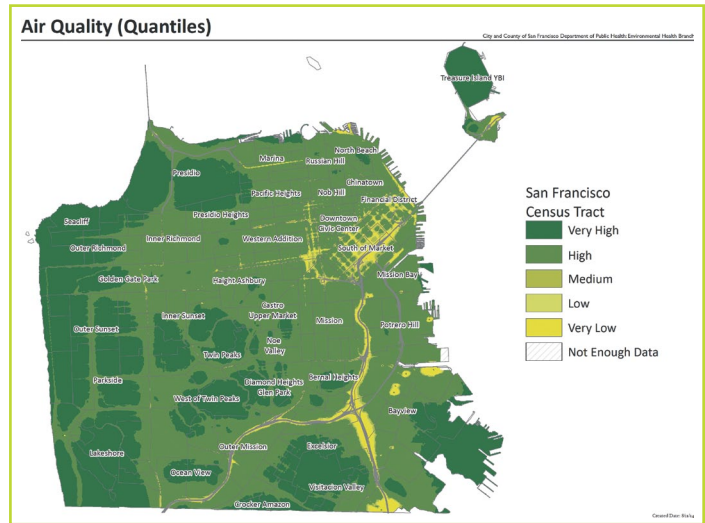
Sea-Level Rise

Water levels measured from the San Francisco gage indicate that the mean sea-level has risen about eight inches in the past century[50]. The region's most vulnerable to sea-level rise include the eastern and northern coastline along the San Francisco Bay. Sea-level rise will increase flooding, storm damage, pollution and pose threats to coastal infrastructure, such as roads, bridges, piers, and waterfront property. Much of this coastline is landfill, which has altered the coastline's natural protective barrier and reduced the ability to buffer the effects of storms and floods, and filter pollutants. The landfill coastline is subject to additional saltwater intrusion and increased groundwater salinity which can lead to increased contamination.

Air Quality

As water flows around the edge of the high-pressure system, the upwelling of cold water produces cold ocean temperatures[10]. The cold ocean temperature and the warm temperatures higher up in the atmosphere create an inversion layer. The inversion layer traps particulate matter from industrial processes and automobile traffic, and negatively affects Bay Area air quality[11].

PM2.5 is the shorthand term for fine particulate matter with a diameter of less than 2.5 micrometers. In 2010, the San Francisco Department of Public Health mapped the PM2.5 concentration in San Francisco neighborhoods[12]. The map shows the highest PM2.5 concentrations along the freeways, highways and major arterials, along the waterfront in North Beach, SOMA, and in the industrial Potrero, Bayview Hunters Point and Visitacion Valley neighborhoods.

Air Quality (Quantiles)

San Francisco Census Tract
- Very High
- High
- Medium
- Low
- Very Low
- Not Enough Data

Source of Climate Projections

Scientists use historical weather data and mathematical models to analyze historical trends and predict future conditions. This report uses climate projections from the National Oceanic and Atmospheric Administration (NOAA), the United States Geological Survey (USGS), California Energy Commission's Public Interest Research Program (PIER), and the San Francisco Department of the Environment. PIER data was developed with support from the Scripts Institute of Oceanography at University of California at San Diego, and housed on the Cal-Adapt website. All temperature data in the Climate and Health Profile Report will be presented in Fahrenheit.

Cal-Adapt model uses two different emissions scenarios to project future climate trends. The first scenario, B1, assumes that emissions begin to decline around mid-century as our economy shifts towards more sustainable industries and technologies. The second scenario, A2, assumes current industrial and technological trends continue. In this medium-high emissions scenario, emissions increase throughout the century and CO_2 concentration triples relative to pre-industrial levels. This report will use the A2 scenario projections as the basis of our climate health impact projections.

Sea-level rise data was provided by the Sea-Level Rise Committee of SF Adapt. The development of the sea-level rise projections coincided with the development of the Sewer System Improvement Plan[9]. The projections are based on the 2012 National Research Council Report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past Present and Future, and recommendations from the California Coastal Commission*[14]. The sea-level rise projections consider storm surge, sea-level rise, wave-run up, and overtopping.

The Sea-Level Rise Committee used data from 2012 for their projections, and have included projections for 2025, 2050, and 2100 at King Tide, 2-Year, 5-Year, 10-Year, 25-Year, 50-Year, and 100-Year storm surge levels. For the purpose of this report we will use the projection for 2050 with a 100-Year storm. The flood inundation projections assume no adaptative measures enacted by the City of San Francisco.

Climate Projections and Impacts

Temperature

Cal-Adapt's A2 emissions scenario projects San Francisco's average yearly temperature to increase between 4.1 and 6.2 degrees between 2010 and the end of the century. The California Governor's Office of Emergency Services similarly

projects temperatures to rise 4-5 degrees in the winter, and 5-6 degrees in the summer[17]. The number of extreme heat days per year is predicted to increase from around 10 currently to 25-50 by 2050, and upwards of 100 by the end of the century[16]. Heat waves are similarly expected to increase in both frequency and severity. Warmer conditions state-wide are also expected to reduce and expedite snowmelt, and exacerbate drought conditions.

Precipitation and Sea-Level Rise

Bay Area precipitation levels are sub-ject to wide variation. Although the overall trend forecasts a slight decline in precipitation, the climate models project the year-to-year variations to continue. San Francisco is susceptible to both wet and dry years. Climate change will increase the severity of both extremes. The consequence of wet years, especially coupled with a rising sea-level, will be an increase in flooding events.

As our atmosphere warms, both the melting of the ice caps and the thermal expansion of oceans will cause global sea-levels to rise. If no infra-structure improvements are made, based on 2010 conditions, the sea-level on the bay-side of San Francisco is pro-jected to rise between 7 and 15 inches by 2050, and between 26 and 46 inches by 2100.

As the sea-level rises, California will experience an increase in atmo-spheric-river extreme storm events. Currently, California receives 35% - 45% of its annual precipitation from extreme storm events. This is expected to increase by up to 11% by the end of the century[9]. As extreme storm events occur with greater frequency, experts expect 100-year high tides to similarly occur with greater regularity. As sea-levels rise and storms inten-sify in severity and frequency, San Francisco will be increasingly vulner-able to flooding, especially along the waterfront and in the Mission Bay neighborhood.
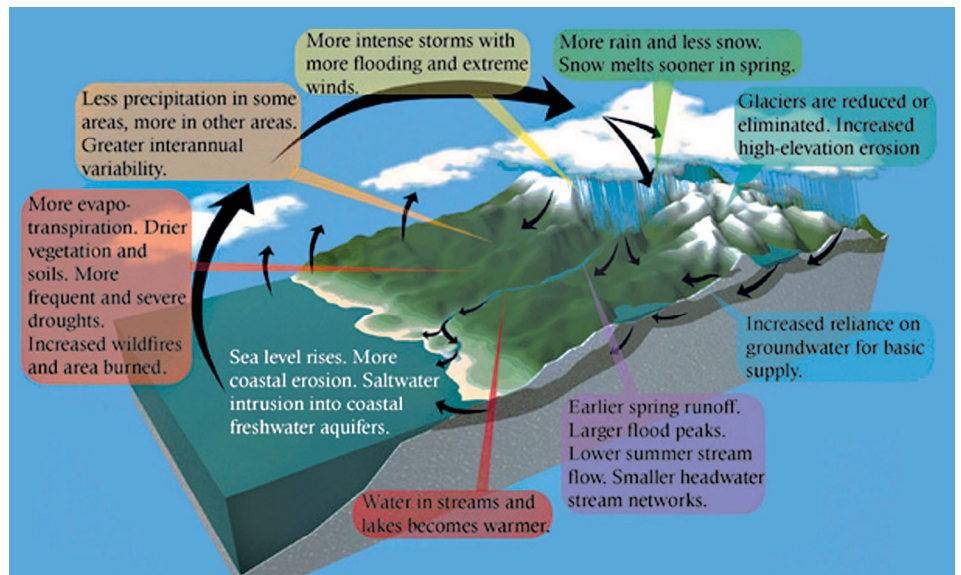
National Research Council Sea-Level Rise Projections for California, Oregon, and Washington (Inches)[14]
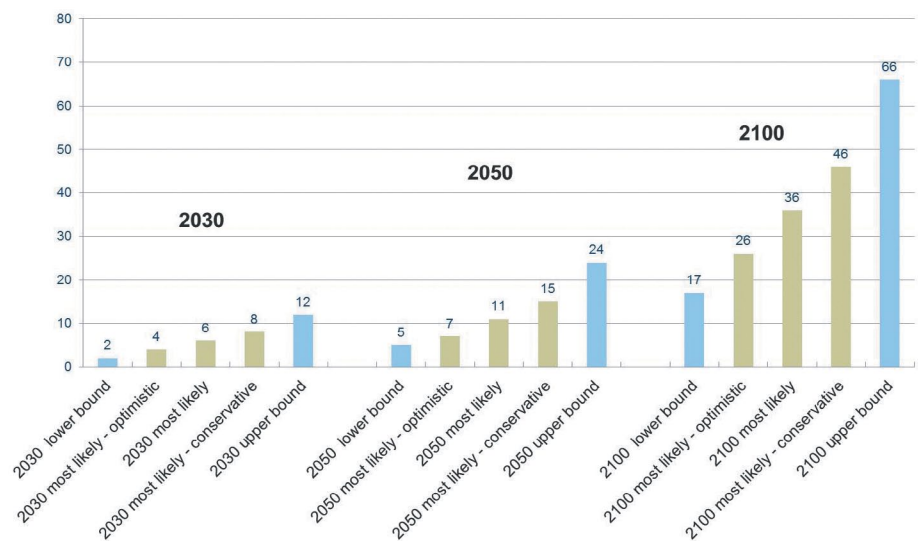
If the summer high-pressure system either does not dissipate or takes longer to dissipate, and atmospheric rivers are pushed north over California, the state may receive very little rainfall or rainfall only in the late winter or spring when the temperature is warmer. Warm temperature storms will add less snow to the Sierra Nevada snowpack than cold-weather storms. During low-or-late-precipitation years, the state will be increasingly vulnerable to extreme drought.
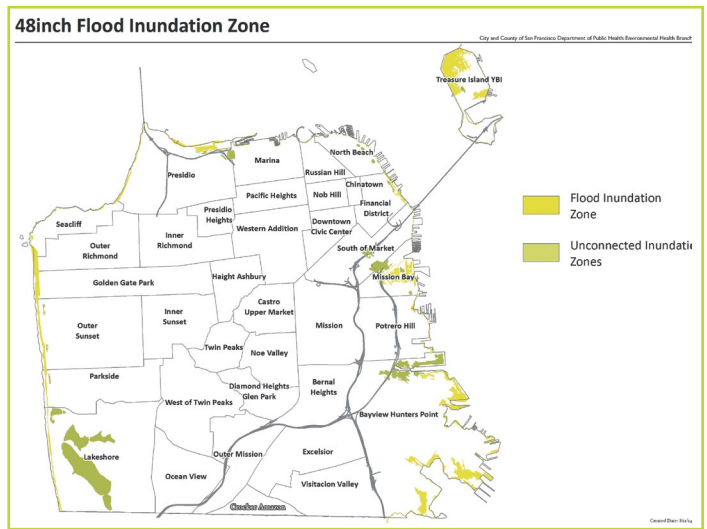
Air Quality

Changes to temperature and precipitation patterns could worsen San Francisco air quality. Ground level ozone is formed when sunlight and heat cause nitrogen oxide to react with volatile organic compounds[19]. Not to be confused with ozone that develops in the stratosphere, ground level ozone stays in our atmosphere and is the main ingredient of smog. As temperatures increase, the warm, dry and stagnant air will accelerate the creation of ground level ozone and other fine particulates[20]. Similarly, in seasons where California's high-pressure system does not dissipate, a prolonged inversion layer could trap particulates in the atmosphere.

Additionally, hot-dry years, especially after wet years, could increase wildfire risk in California[21]. Although San Francisco is less vulnerable to wildfires than other regions of the state, the city could be indirectly affected by worsened air quality due to particle drift.
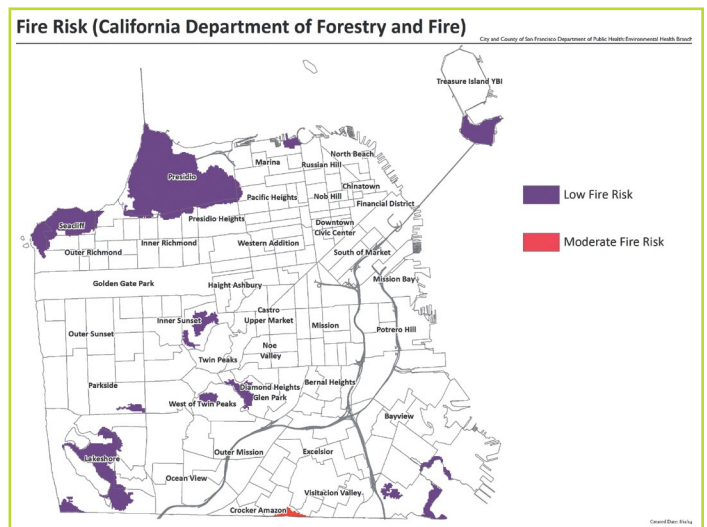
4. Health Impacts of Climate Change

In the previous chapter of the Climate and Health Profile, we summarized how climate projections will affect San Francisco's temperature, precipitation, sea-level, and air quality. This chapter will summarize the health impacts from the climate projections. Researchers have examined the climate-related changes in exposures that will cause adverse health effects. The pathways that lead to human health impacts are both direct and indirect. Direct effects are health impacts resulting directly from the hazard event. These impacts include heat stroke from extreme heat, lacerations and non-fatal injuries from extreme storm, or respiratory illness from poor air quality. Indirect effects are downstream health impacts that

Impact of Climate Change on Human Health

include food insecurity caused by poor agricultural output caused by a particularly low precipitation year, health effects associated with income loss and job insecurity due to flood inundation, and increased rates of anxiety and depression as a result of isolation during extreme heat events. Climate change impacts are complex and one pathway can lead to a wide range of health outcomes. The picture above illustrates the most salient climate change impacts, their effect on exposures, and the subsequent health outcomes that result from these changes in exposures. The effect of the exposure can be altered or intensified by the complex interactions of factors which include pre-existing conditions, environmental determinants for exposure, and socioeconomic and demographic factors for response. This chapter will identify linkages between climate related hazards and health outcomes most relevant to San Francisco. The next chapter will examine factors of community resiliency and vulnerability that can potentially modify the health outcomes.
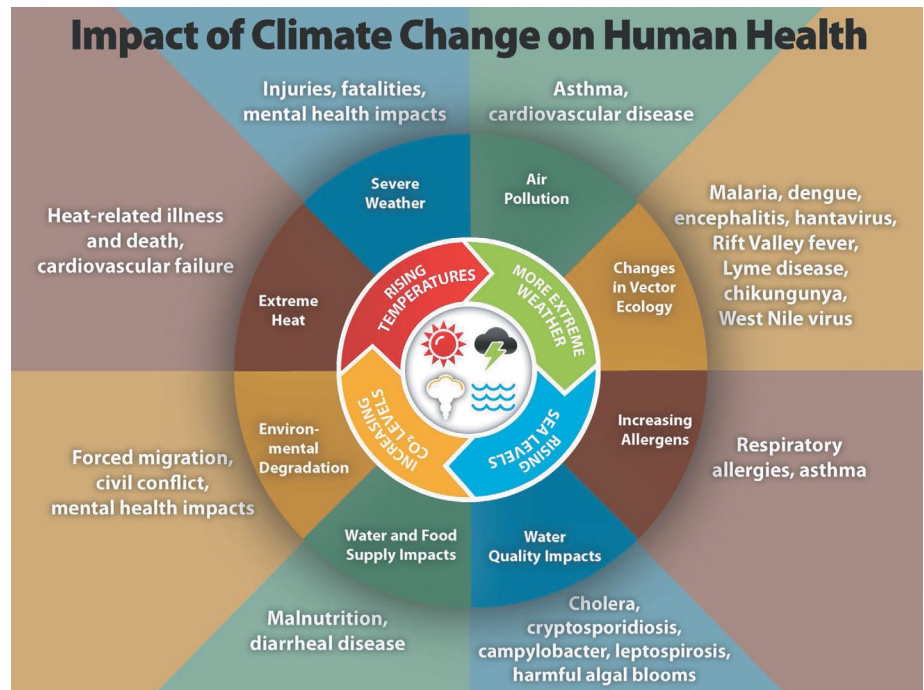
What are the climate health impacts?

Extreme Heat

San Francisco is particularly vulnerable to extreme heat. San Francisco and its residents lack many of the physiologic and technologic adaptations necessary to withstand heat events[21]. Many buildings were built without consideration to the effect of direct sunlight on thermal comfort and many older homes and apartments lack proper ventilation or air conditioning. Additionally, research has shown it typically takes human bodies two weeks to adapt to extreme temperatures. Because San Francisco experiences extreme temperatures so infrequently, residents have a more difficult time thermoregulating—the process of maintaining a stable

internal body temperature[7].

Due to the relative novelty of extreme heat events on San Francisco residents, the health impacts of these events can be severe. Extreme heat will increase cases of **heat-related illnesses** such as **heat-stroke, dehydration** and **heat-related mortality** such as **heart disease**[7]**.** Higher temperatures and dry and stagnant air will produce smog and ground level ozone and fine particulates[20]. This will worsen San Francisco air quality, and lead to higher rates of **respiratory illness, asthma, and allergies**[7]. Another consequence of heat waves may be an increase in mental and behavioral health problems for those trying to cope with the hazard[23]. An Australian study of heat and hospital admissions found there to be a positive association between temperature and hospital visits for mental and behavioral

disorders[24]. The increase in heat-related hospitalizations and emergency room visits will strain the city's public health resources and affect care for all San Franciscans.

High temperatures may also have unforeseen indirect effects on infrastructure. For example, heat can affect food storage. Studies have shown pathogens such as salmonella and campylobacter to be closely associated with temperature increases, and can exacerbate the effects of pre-existing conditions such as renal failure and diabetes[25]. During heat waves, heavy air conditioning usage may tax the city electrical grid. Both households with central air conditioning and individual air conditioning units might see heavy usage reflected in higher electricity charges.

Cold Snaps

Prolonged cold weather can be a potential impact to San Francisco residents, especially those who are the homeless and housing insecure. Similar to heat events, because San Francisco has historically enjoyed moderate temperature, city infrastructure and residents' physiology are not as prepared to deal with freezing temperatures as cities in colder climates. A winter 2013 cold snap killed at least 5 people in the San Francisco Bay Area[26]. Health impacts from cold snaps include **hypothermia, increased mucus secretion and cough, shortness of breath,** and **increased**

risk for influenza and other diseases[27].

Additionally, cold snaps may indirectly affect San Francisco indoor and outdoor air quality. During cold weather months, a cold weather inversion layer can trap particulate matter including smoke from wood-burning fireplaces. Smoke from fireplaces can aggravate pre-existing respiratory conditions including asthma and bronchitis[28]. Internal air quality can be affected by cold weather when a resident does not open windows in homes with inadequate ventilation.

Sea-Level Rise

San Francisco is particularly vulnerable to sea-level rise and flood inundation because it is surrounded by coastline on three sides. As many of the city's residents live, work, or recreate along the waterfront, the impacts of flood inundation on San Franciscans' health and well-being will be significant.

Direct impacts of sea-level rise include an **increase in fatal and nonfatal injuries**[29] and **water-borne disease**[29]. Fatal and nonfatal injuries are injuries caused directly by sea-level rise or flood inundation. These injuries may include drowning, lacerations, and other injuries caused by debris or damaged infrastructure. Standing water or the corruption of the city sewage, wastewater, or drinking-water infrastructure may create an environment where bacteria, viruses and parasites flourish such as Cryptosporidium. After Hurricane Katrina, the most common water-borne infectious conditions were skin and wound infections, respiratory infections caused by airborne sewage, and diarrhea[30]. Although uncommon in the United States, cholera and Hepatitis A thrive in a post-flood environment (standing water, sewage, garbage).

As flooding becomes more frequent and severe,

displacement from homes and communities will be a **mental and behavioral stressor**[31] and increase cases of depression and anxiety. Flood inundation could also affect the San Francisco transportation network. In 2012, Hurricane Sandy flooded New York City's subway tunnels, causing residents to be stranded from their homes, work, and impeding access to hospitals and other care facilities. With public transportation networks down, the added reliance on automobiles resulted in gas shortages and traffic jams. Additionally, slick and crowded roads may lead to an increase in automobile, bicycle and pedestrian collisions.

Indirect effects of sea-level rise and flood inundation could include housing shortages due to stalled development along the coastline, economic loss from reduced or altered Port of San Francisco activity, and increased severity of earthquakes due to possibly expansion of liquefaction zones[32]. Indirect impacts could also include **income loss** from housing displacement, business and employment loss, and reduced connectivity. Income loss can exacerbate mental and behavioral stressors, food insecurity, and social isolation[33].

Extreme Storms

The increase in extreme storms will exacerbate flood inundation caused by sea-level rise. The impacts on health will be an **increase in fatal and nonfatal injuries**[29], an **increase in water-borne disease**[29], and **additional mental and behavioral stressors**[31].

Although flood inundation, like sea-level rise, will primarily affect residents along the coast, the impact of extreme storm events can affect all San Franciscans. Heavy rains may inhibit the mobility of San Francisco residents and can limit access to medication, food, and other vital resources.

Extreme storms also have unique health impacts. Heavy winds, lightning, and rains could cause fatal and nonfatal injuries by either damaging infrastructure or increasing automobile or pedestrian-related accidents. Any impact to roads or public transportation may prevent sick or injured residents from getting to a hospital or other medical facility. A severe storm that causes power outages may impact those who are oxygen dependent and electric dependent.

Droughts

A severe drought will strain the state water supply, disrupt California's agricultural output, and could result in an increase in the price of produce. The impact on San Francisco residents will be **income loss** and **food insecurity**[34].

Studies have shown income and poverty to be closely associated with health impacts[35]. An increase in the price of produce could disincentivize the purchase of healthy fruits or vegetables. If residents consume an inadequate amount of fruits and vegetables, the impact may be nutritional deficiencies. As sales fall, stores in low-income communities may respond by limiting fresh produce supply. If this happens, it could limit healthy food access and increase food deserts. Families unable to afford or access produce, and could find themselves food insecure.

Additionally, as drought conditions increase, dry plants and underbrush will feed wildfires. Although San Francisco probably will not see an increase in drought-fueled wildfires, smoke from nearby fires might affect San Francisco air quality and exacerbate **respiratory illnesses** and **asthma**[36,37]. Warm and dry conditions could increase exposure to ragweed and other **allergens**[36].

Climate change is projected to worsen air quality in San Francisco. Drought and higher temperatures conditions could expand the blooming season for ragweed and other allergens[36]. Greater wildfire risk has the potential to send smoke particulates blowing into the City. Instances of **respiratory illness**, **asthma** and **allergies** are correlated with air quality[7].

According to the Union of Concerned Scientists, increased exposure to ground-level ozone and PM2.5 particulates will have many negative effects for San Francisco residents. Higher concentrations of ground-level ozone will increase rates of asthma attacks, shortness of breath, coughing, chest-tightness, irritated mucus membranes, pulmonary inflammation and respiratory illnesses and diseases[19]. PM2.5 concentration can exacerbate asthma, bronchitis, and acute and chronic respiratory disease. These ailments will especially affect children both because their lungs are still developing, and because their rapid breathing rates increase their exposure to these pollutants. In adults, worsened air quality from ground-level ozone or other pollutants could increase rates of chronic lung disease such as emphysema, and premature death[19]. Any increase in hospitalizations and illness during days with extreme heat and poor air quality will test the city's health infrastructure.

Income Loss

While injuries and illnesses are among the most recognizable impacts of climate related hazard events, more subtle indirect effects have the potential to be equally devastating to residents and communities. The most common indirect impact is income loss.

An extreme storm coupled with sea-level rise could make businesses along San Francisco's waterfront vulnerable. If a resident loses a job, not only will the resident be impacted by income loss, but also by the loss of their employer-provided health insurance. Currently, much of San Francisco's planned residential and commercial development in San Francisco is located in the flood-vulnerable Mission Bay and Bayview Hunters Point neighborhoods[38]. If sea-level rise threatens these developments, San Francisco will lose the associated construction and office jobs, and property tax revenue. Additionally, any reduction of San Francisco's already limited housing stock will further increase rental and real-estate costs.

Not only could a San Francisco resident have their property damaged by a climate change related hazard event,

loss. A statewide drought could affect agricultural output and increase the price of produce, placing additional strain on San Franciscans. A lengthy heat wave could force residents to rely on air conditioning, increase energy consumption, and add to the financial burden.

Food insecurity

Extreme weather events, such as heat waves, storms, and droughts, may decrease San Franciscan's access to healthy food. Heat, flooding, and poor air quality may dissuade or prevent residents from traveling to stores or markets to purchase food, while droughts might increase the price of produce and make items too expensive for many low-income San Francisco families. Food insecurity, living without reliable access to nutritious and affordable food, is related to the health status of both children and adults.

In children, food insecurity has been linked to increased rates of **cognitive developmental deficits** and **behavioral and psychological dysfunction, and increased frequency of headaches, stomachaches, colds, ear infections, and other illnesses**[39]. In adults, food insecurity can **decrease dietary intake, increase body weight in women, increase rates of hypoglycemia in diabetics**, and increase the likelihood of **nutrition-related chronic disease**[40]. Additionally, being food insecure can be a trigger for those pre-disposed to mental and behavioral illnesses, including **depression, anxiety, and stress.**

Mental Health

In addition to physical injury, climate hazard events can exacerbate instances of mental health disorders. These events can have the immediate effects of establishing or exacerbating anxiety reactions such as post-traumatic stress disorder and long-term effects of establishing or exacerbating instances of depression or other anxiety disorders correlated with income loss, poverty, and social isolation. In years after the 2010-2011 Christchurch, New Zealand earthquakes, the city's rates of depression and bipolar disorder both increased as residents both tried to recover from the disaster while simultaneously having to prepare for the next disaster[41].

Mental health effects of climate hazard events are not limited to the disaster itself. Social isolation caused by displacement, and loss of people or property can lead to depression, distress or generalized anxiety. The mental health effects of climate change will increase the need for public health interventions.

Rodent and Vector-Borne Disease

Temperature and precipitation change can accelerate the spread of rodent and vector-borne disease. Mosquitoes flourish in warm and wet climates. West Nile Virus is active in the Bay Area. Since 2012, there have been three reported cases (human or dead bird) of West Nile Virus in San Francisco, six in San Mateo County, and over 350 in Santa Clara County[42]. As temperatures rise, a year with high spring rain totals could grow the mosquito population and increase San Francisco residents' risk for West Nile Virus. Although no cases have been reported in California, mosquitoes are also capable of transmitting Dengue Fever, Rift Valley Fever, Malaria, Japanese encephalitis, yellow fever, and Venezuelan encephalitis viruses[43]. Chikungunya is a mosquito-borne virus that causes fevers, headache, and a long period of severe joint pain, has been recently reported for the first time in Florida and has the capability to spread further[44].

Longer summers will also increase exposure to ticks and Lyme disease.

The effect of climate change on host populations could increase instances of hantavirus, a rodent-borne illness that can cause hemorrhagic fever with renal control syndrome, and hantavrius cardiopulmonary sydrome. A 1993 Hantavirus outbreak in Southwestern United States was caused by a steep and sudden increase in the deer mice population. Researchers speculate that a particularly rainy season after six years of drought caused an overabundance of food[45]. Climatologists predict precipitation levels to fluctuate and the environmental conditions that caused increased exposure to rodents will occur with greater regularity due to climate change.

5. *Vulnerable Population and Community Resiliency Indicators*

According to the Intergovernmental Panel on Climate Change (IPCC), "Vulnerability to climate change is the degree to which geophysical, biological and socioeconomic systems are susceptible to, and unable to cope with, adverse impacts". Key vulnerabilities are associated with vital systems to our communities such as the environment, transportation, civic engagement, public facilities, education, housing, socioeconomic and health systems. Although climate change impacts will affect all San Franciscans, not all San Franciscans will suffer the impacts evenly. Though exposure to climate conditions influences health related impacts, many other factors, such as physiology, ethnicity, infrastructure, behavior, and social and demographic characteristics can compound that risk. These factors can affect either the immediate exposure to climate related health impacts, the sensitivity of someone to a given exposure, and/or access to treatment. These risks often exacerbate pre-existing economic, racial, or social societal divisions. The socioeconomic stratification of climate change impacts is known as the "Climate Gap".

Major point-source polluters are often clustered in low income communities and communities of color and these communities often lack the political capital and economic resources to mitigate exposure risk[46]. Because all residents are not evenly impacted by climate change, in order to understand health effects, we must analyze the variables that compound risk.

To identify the extent to which neighborhoods are impacted by stressors associated with climate change-related hazard events, the San Francisco Department of Public Health spearheaded a process to determine the specific indicators that most aptly approximate a neighborhood's vulnerability and resiliency. The SFDPH used the following definition of resiliency: the ability of groups or communities to cope with external stresses and disturbance as a result of social, political and environmental change.

After a comprehensive academic literature and best practices review, and input from a working group comprised of city and community representatives, a final list of community resiliency indicators were established.

These indicators have been split into the following categories: Hazard Indicators, Environmental Indicators, Transportation Indicators, Community Indicators, Public Realm Indicators, Housing Indicators, Economy Indicators, Health Indicators, and Health Indicators. The goal of the indicator system is to assess resilience to climate change stressors in San Francisco's neighborhoods to advance interventions that increase the city's collective adaptive capacity. Because of the overlap between climate change resiliency and other preparedness efforts, SFDPH hopes that resiliency data will be used by departments focused on the related fields of earthquake preparedness, fire safety, and other city endeavors.

The indicators, comparative maps, and analysis can be found in the following pages. A list of all resources used in the literature review can be found in Appendix A. A spreadsheet with more information on indicators and data sources can be found in Appendix B.
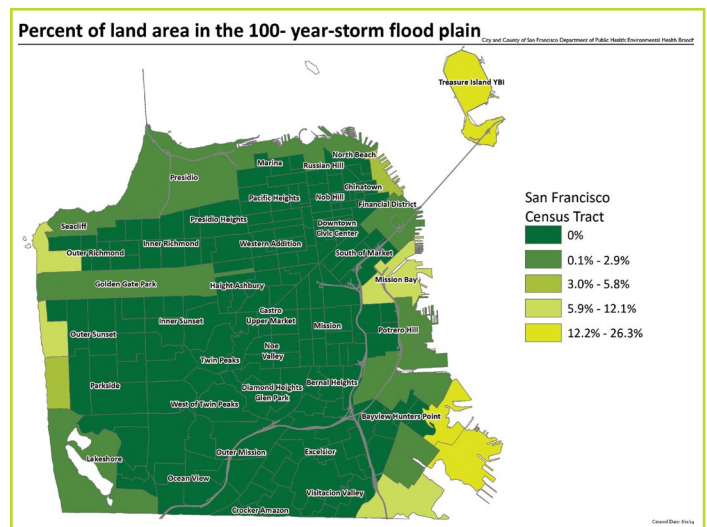
Hazard Indicators

Flood Inundation and Storm Surge

The 100 year flood plain is the area most susceptible to flooding due to waves, storm-surge, and high tides. The plain is generally adjacent to the waterfront, at a relatively low elevation, and is currently not protected by a sea-wall or other preventative infrastructure. Residents, businesses, students and tourists in the flood plain are the most vulnerable to flooding, and will need additional resources in the case of a hazard event. For our analysis, we will examine the most likely 2050 sea-level rise projection with a 100-year storm event. Because maps were not available for 52 inch inundation, we have used a 48-inch inundation zone which equals a 2050 time frame with a 50-year storm.

Although the flood inundation projections forecast some flooding along the Pacific Ocean shoreline, the neighborhoods most vulnerable are on the eastern edge of the City along the San Francisco Bay. These communities include along the waterfront in North Beach and the Financial District, Mission Bay, SOMA, Bayview Hunters Point, and much of Treasure Island.
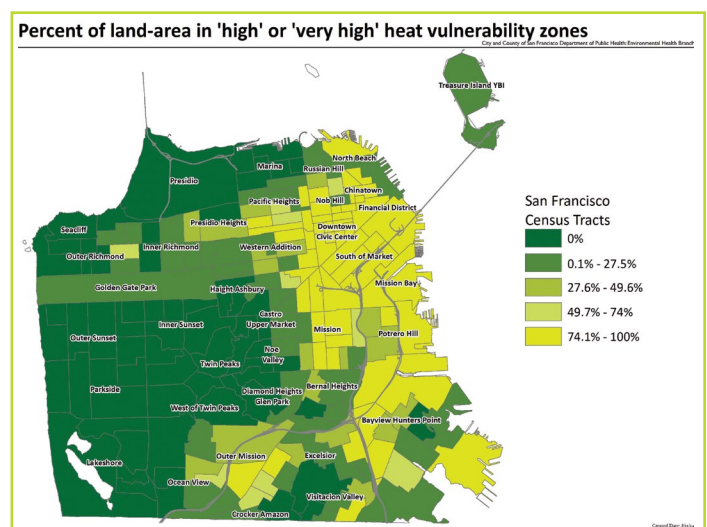
Sea Level Rise Scenario	Daily Tide Water Level above MHHW	Extreme Tide (Storm Surge) Levels						
		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Existing Conditions	0	12	19	23	27	32	36	41
MHHW + 6-inch	6	18	25	29	33	38	42	47
MHHW + 12-inch	12	24	31	35	39	44	48	53
MHHW + 18-inch	18	30	37	41	45	50	54	59
MHHW + 24-inch	24	36	43	47	51	56	60	65
MHHW + 30-inch	30	42	49	53	57	62	66	71
MHHW + 36-inch	36	48	55	59	63	68	72	77
MHHW + 42-inch	42	54	61	65	69	74	78	83
MHHW + 48-inch	48	60	67	71	75	80	84	89
MHHW + 54-inch	54	66	73	77	81	86	90	95
MHHW + 60-inch	60	72	79	83	87	92	96	101
MHHW + 66-inch	66	78	85	89	93	98	102	107

Percent of land area in the 100- year-storm flood plain
City and County of San Francisco Department of Public Health Environmental Health Branch

San Francisco Census Tract
- 0%
- 0.1% - 2.9%
- 3.0% - 5.8%
- 5.9% - 12.1%
- 12.2% - 26.3%

Heat Vulnerability

In 2012, the San Francisco Department of Public Health developed a Heat Vulnerability Index to identify neighborhoods most vulnerable to extreme heat conditions. Elements of the index include impervious surface, tree coverage, traffic, air quality, age, and density.

The neighborhoods most vulnerable to extreme heat include the densely populated Chinatown and Downtown neighborhoods, the Financial District, Mission District, SOMA, Bayview Hunters Point, and parts of the Western Addition.

Percent of land-area in 'high' or 'very high' heat vulnerability zones
City and County of San Francisco Department of Public Health Environmental Health Branch

San Francisco Census Tracts
- 0%
- 0.1% - 27.5%
- 27.6% - 49.6%
- 49.7% - 74%
- 74.1% - 100%

Tsunami and Liquefaction/Landslide Zones

Although not climate change-related in nature, San Francisco is susceptible to both tsunami and earthquake hazard events. Liquefaction and landslide zones are those most vulnerable to shaking in an earthquake. Liquefaction zones are areas where the soil is less stable and more prone to liquefying. If the soil liquefies, the structures above are prone to more extreme and erratic movements in times of stress, such as an earthquake. The areas with the largest liquefaction zones are along the eastern border of the city and the Marina district. These areas are comprised of landfill as opposed to natural hard rock or other solid surfaces. Similar to extreme heat, flood inundation, and air quality concerns, tsunami and earthquake vulnerability are exacerbated by pre-existing socioeconomic inequalities. The process for preparing for these events is similar to that of climate change-related disasters. In tsunamis and earthquakes, resiliency is affected by quality of housing, financial resources available, neighborhood amenities, government services, public transportation, and individual pre-existing physical and mental health conditions.

Liquefaction and Landslide Zones

Tsunami Inundation Zones
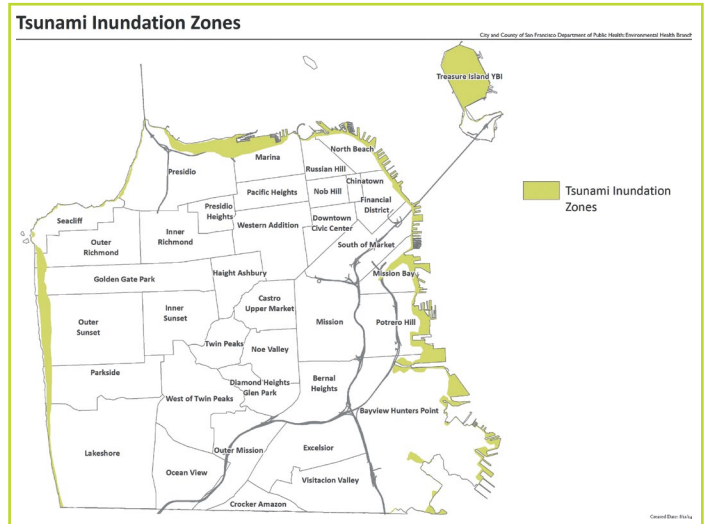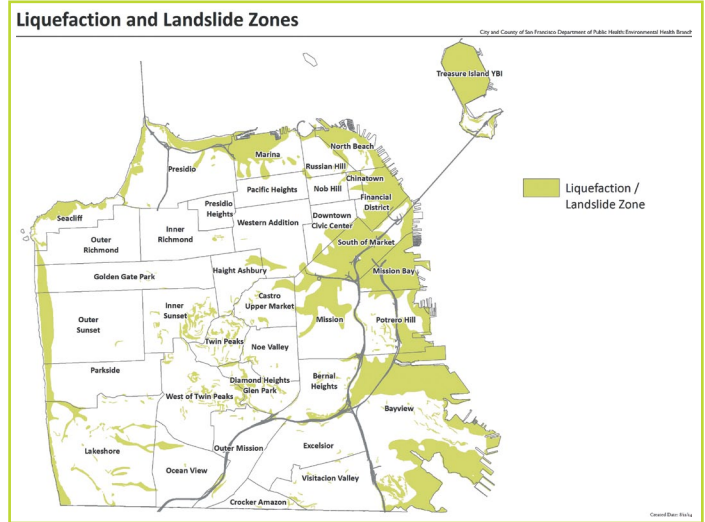
Environmental Indicators

Impervious Surface

Impervious surfaces can exacerbate the impact of flood inundation and extreme heat. Neighborhoods without natural areas can experience both increased storm-water runoff and diminished heat absorption.

The neighborhoods with the highest concentration of impervious surfaces include both the urban core of the city: Downtown, the Financial District, Chinatown, SOMA and Nob Hill. The SOMA neighborhood is vulnerable to both extreme heat and flood inundation. Its high concentration of impervious surface compounds this risk.

Percent Impervious Surface
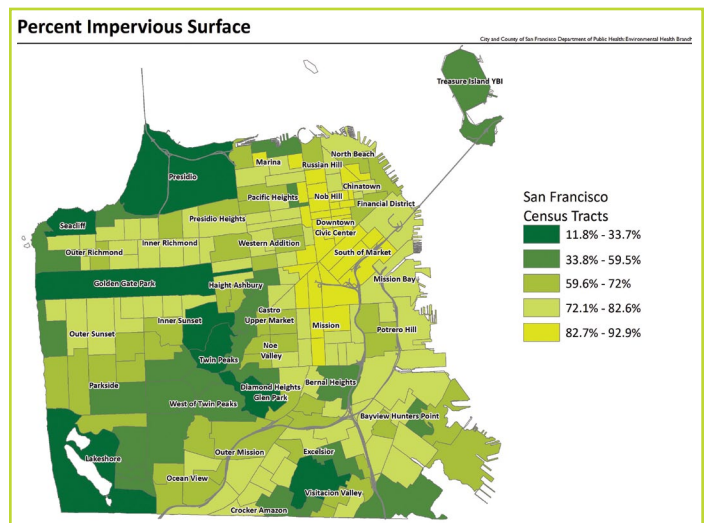
Tree Cover / Canopy

In contrast to the impervious surface indicator, tree canopy can both increase storm-water absorption and provide shade during heat waves. Trees can improve air quality by absorbing carbon dioxide, producing oxygen, and trapping and filtering other pollutants.
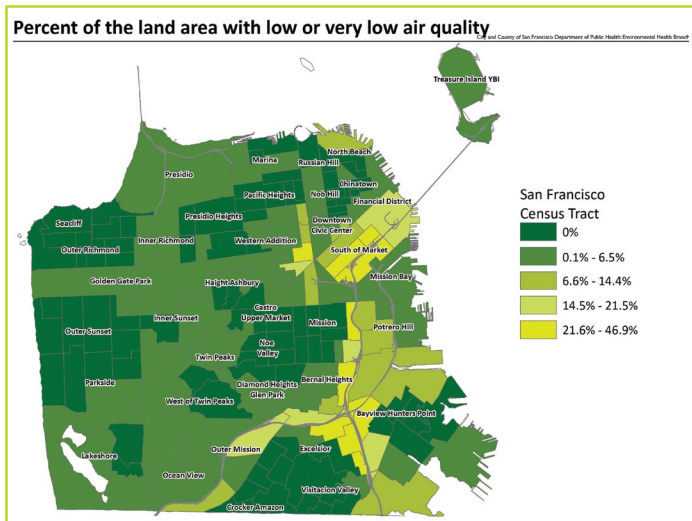
While the areas with the highest concentration of tree cover are Golden Gate Park, the Presidio, and other natural areas. The Mission District, Noe Valley, and the Western Addition have higher-than-average tree coverage. SOMA, Chinatown, Bayview Hunters Point, Mission Bay, and the Downtown neighborhoods have lowest percentage of tree cover in the city.

Percent Tree Cover

San Francisco Neighborhoods
- 48% - 24.1%
- 24% - 15.1%
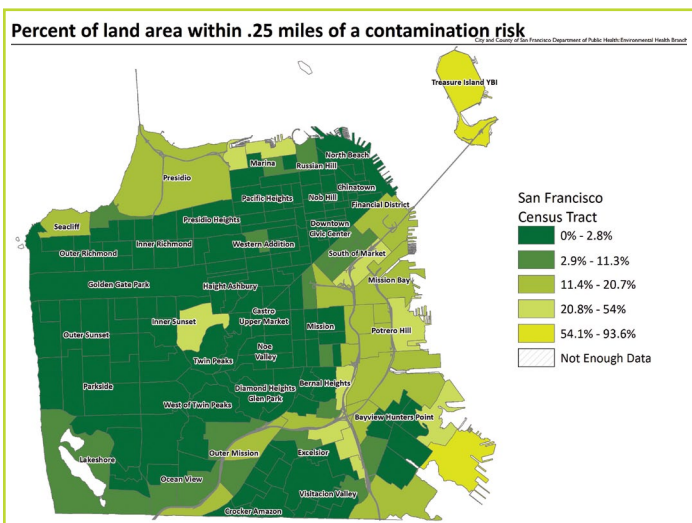- 15% - 10.8%
- 10.7% - 6.5%
- 6.4% - 1.3%
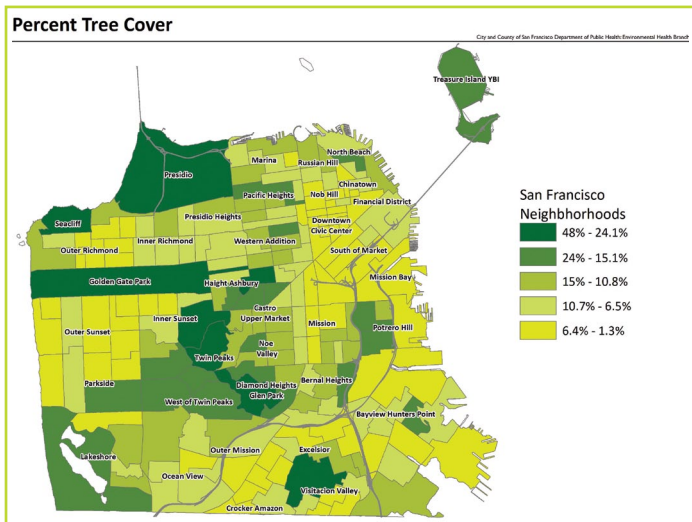
Air Quality

The number of San Franciscans who live in census tracts with PM2.5 concentration above California standards is set to increase. Using data from the Bay Area Air Quality Management District (BAAQMD), the San Francisco Department of Public Health modeled total PM2.5 concentration from all sources in the city.

The San Francisco neighborhoods with the worst air quality include those along the freeway corridors, heavily-trafficked arterials, and/or adjacent to industrial activities. These communities include Bayview Hunters Point, Outer Mission, the Mission, Bernal Heights, the Financial District, and SOMA.

Percent of the land area with low or very low air quality

San Francisco Census Tract
- 0%
- 0.1% - 6.5%
- 6.6% - 14.4%
- 14.5% - 21.5%
- 21.6% - 46.9%

Contaminated Sites

In a hazard event, living or working within close proximity of a contaminated site can increase risk of exposure to hazardous materials. Runoff from inundation events may contaminate drinking water or storm water, and fumes caused by extreme heat may worsen nearby air quality. In San Francisco, many sites adjacent to the Bay Side of the waterfront have had heavy-industrial uses. These sites, in the Mission Bay, Bayview Hunters Point and SOMA neighborhoods, would pose a significant risk to surrounding communities in a hazard event.

Percent of land area within .25 miles of a contamination risk

San Francisco Census Tract
- 0% - 2.8%
- 2.9% - 11.3%
- 11.4% - 20.7%
- 20.8% - 54%
- 54.1% - 93.6%
- Not Enough Data

Transportation Indicators

Active Transportation

Active Transportation is correlated with health outcomes including lower rates of obesity, diabetes and heart disease. Those that routinely bicycle or walk will be less dependent on city services in the case of a hazard event. The urban design of neighborhoods effects active transportation totals, and the neighborhoods that are the densest and closest to jobs, stores, and other services encourage active transportation. The transportation districts with the highest percentages of residents who make trips by foot or bicycle are Downtown, Chinatown, SOMA and the Mission.

Average minutes of active transport (walk + bike) per day

San Francisco Transportation Districts
- 43 - 38 minutes
- 38 - 23 minutes
- 23 - 16 minutes
- 16 - 15 minutes
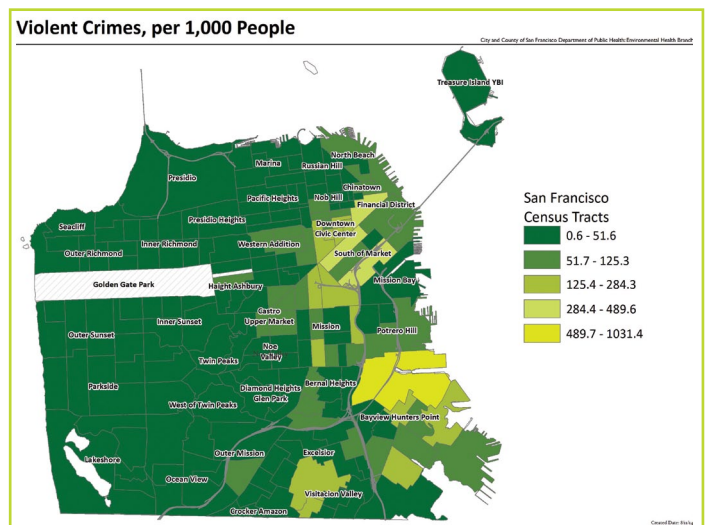- 15 - 14 minutes
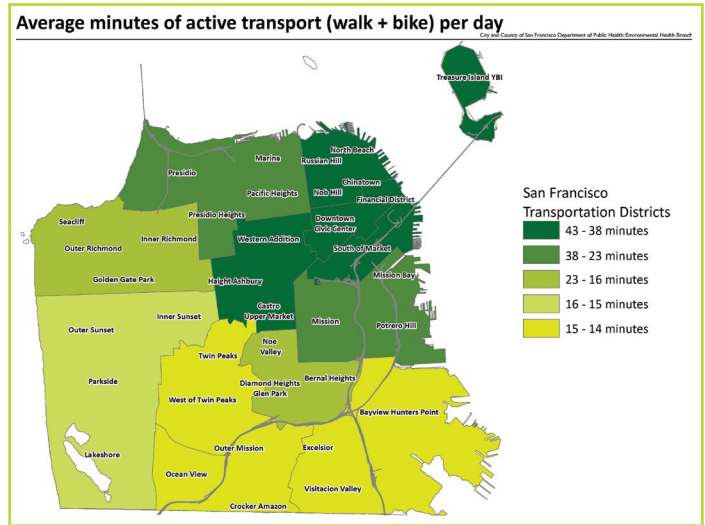
Public Transit Score

The public transit score is a relative measure of the number of transit routes within one mile, weighted by frequency and distance. Those served best by public transit live in neighborhoods that are generally more compact, and offer more social services. The areas with the best public transit service are the downtown neighborhoods of Downtown, Financial District, Chinatown, Nob Hill, and SOMA, and along the BART line to Mission and Bernal Heights. The areas with the least transit access are the Bayview Hunters Point, Parkside and the Outer Sunset. These populations are more likely to be car-dependent.

Public transit Score

San Francisco Census Tract
- Very High
- High
- Medium
- Low
- Very Low
- Not Enough Data
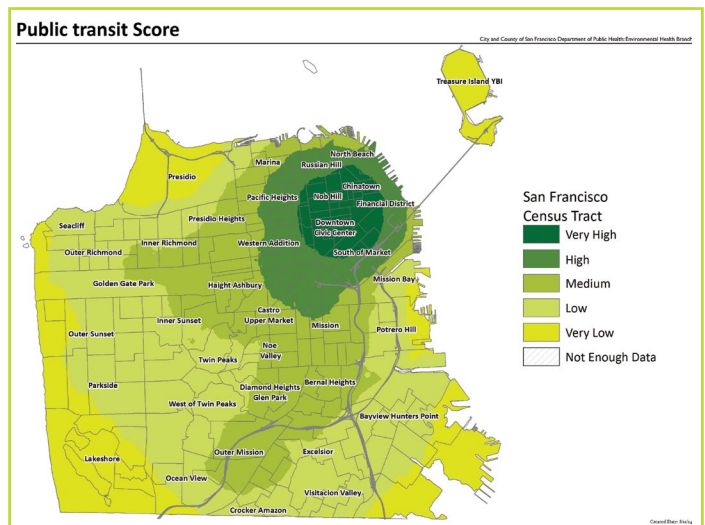
Community Indicators

Violent Crime

High rates of violent crime exacerbates distrust among neighbors and communities. Violence is negatively correlated with social cohesion. Using the measurement of offenses / 1000 people, the areas with the highest violent crime rate include the Bayview Hunters Point, SOMA, Downtown, and the Financial district.

Violent Crimes, per 1,000 People

San Francisco Census Tracts
- 0.6 - 51.6
- 51.7 - 125.3
- 125.4 - 284.3
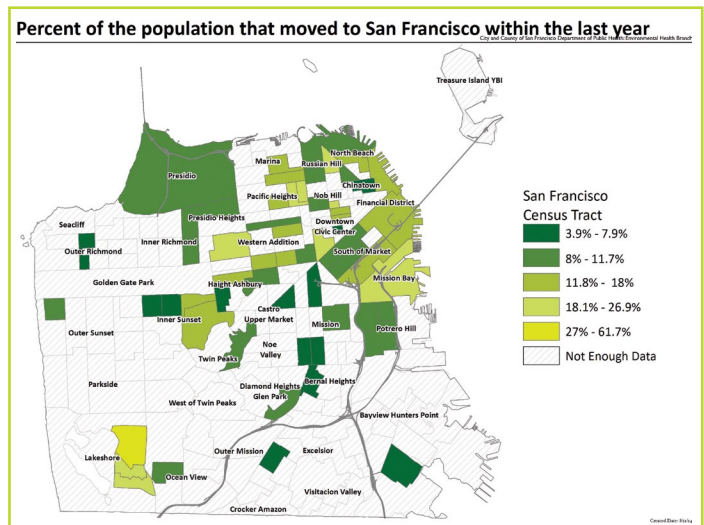- 284.4 - 489.6
- 489.7 - 1031.4

Voting Rates

Voting rates can approximate the degree to which residents are tapped into city services. Political engagement has been proven to be correlated with health effects—those that are more politically aware also have greater awareness of government policies and procedures. The areas with the highest voter turnout are the Twin Peaks, West of Twin Peaks, Noe Valley and the Castro/Upper Market neighborhoods. These tend to be some of the more affluent neighborhoods in the city. Conversely, some of the neighborhoods with the lowest turnout include the Bayview Hunters Point and Visitacion Valley neighborhoods.

Voting rates in the 2012 presidential election

San Francisco Voting Precincts
- 87.4% -80.1%
- 80% - 74.2%
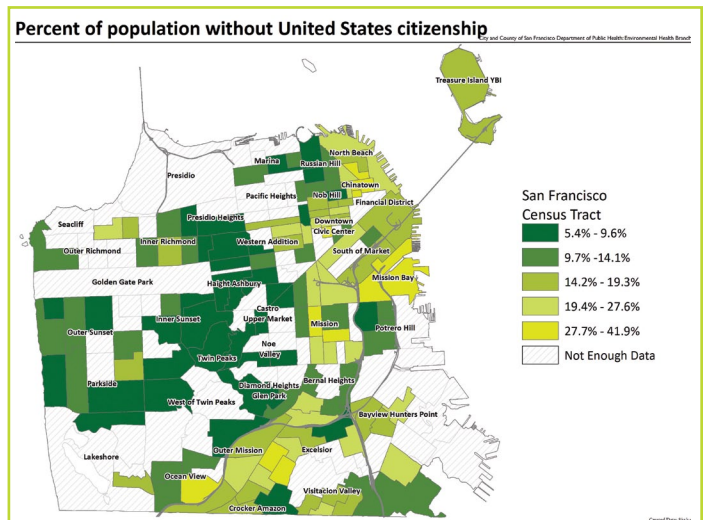- 74.1% - 67.1%
- 67% - 57.4%
- 57.3% - 41.8%
- No Data
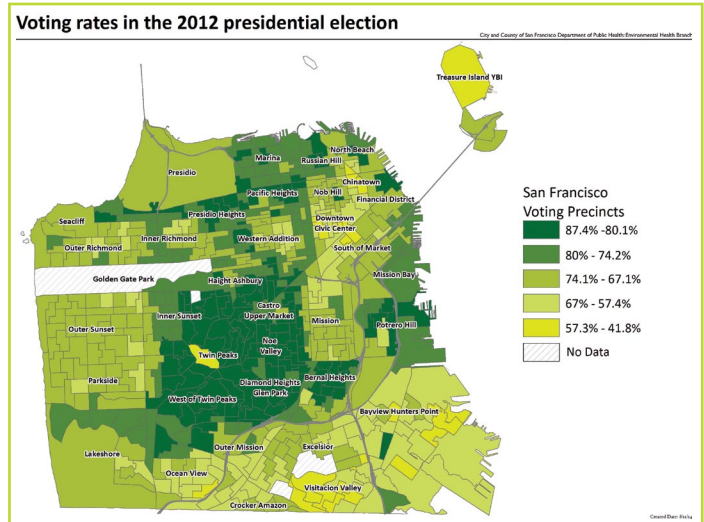
New to the Region

Those new to a community may not be as aware of local organizations, evacuation plans, and private businesses, and may be more likely to be socially isolated. The neighborhoods with the highest concentration of residents who have lived in San Francisco for a year or less include the neighborhoods with universities like Lakeshore (SF State), the Inner Richmond (USF) and Mission Bay (UCSF), and neighborhoods like SOMA with large concentrations of biotech firms and other large employment centers.

Percent of the population that moved to San Francisco within the last year

San Francisco Census Tract
- 3.9% - 7.9%
- 8% - 11.7%
- 11.8% - 18%
- 18.1% - 26.9%
- 27% - 61.7%
- Not Enough Data

Citizenship

Those without United States citizenship have less access to many public resources. Those without citizenship are less likely to have health insurance, less likely to ask police and health officials for assistance in the case of emergency, less likely to be employed, and are more likely to be low-income. Although non-citizens may have robust informal networks that strengthen their social capital, this population is more likely to be isolated from the government and public service sectors. The neighborhoods with the highest concentration of residents without American citizenship are Chinatown, Mission Bay, North Beach, and the southern Visitacion Valley and Excelsior neighborhoods.

Percent of population without United States citizenship

San Francisco Census Tract
- 5.4% - 9.6%
- 9.7% -14.1%
- 14.2% - 19.3%
- 19.4% - 27.6%
- 27.7% - 41.9%
- Not Enough Data

Non-English Speaking

Those who cannot speak English will have a more difficult time recognizing warnings and public service announcements, and interacting with public health officials. Though this population may have strong informal social capital, isolation from city services puts those without English comprehension at risk in a hazard event. The neighborhoods with the highest proportion of non-English speaking residents include the Chinatown, Visitacion Valley, and Crocker-Amazon, Outer Sunset, and Outer Richmond neighborhoods.

Percent of population living in households without English spoken 'Very Well'

San Francisco Census Tract
- 4.6% - 9.6%
- 9.7% - 22.6%
- 22.7% - 35.8%
- 35.9% - 51.5%
- 55.6% - 77.4%
- Not Enough Data
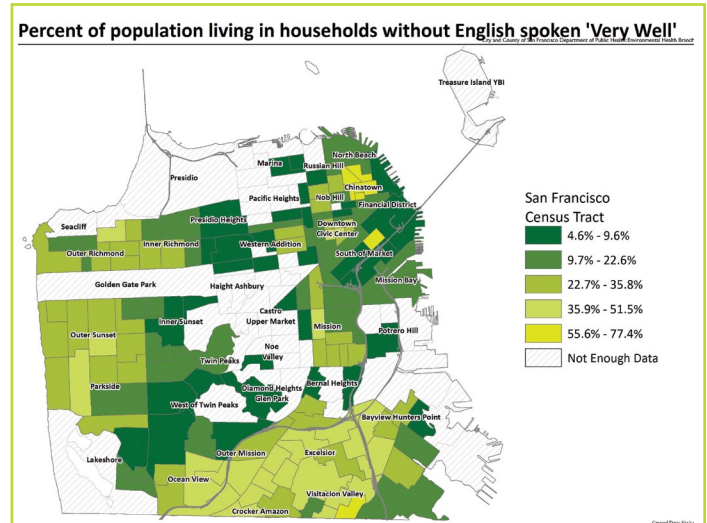
Public Realm Indicators
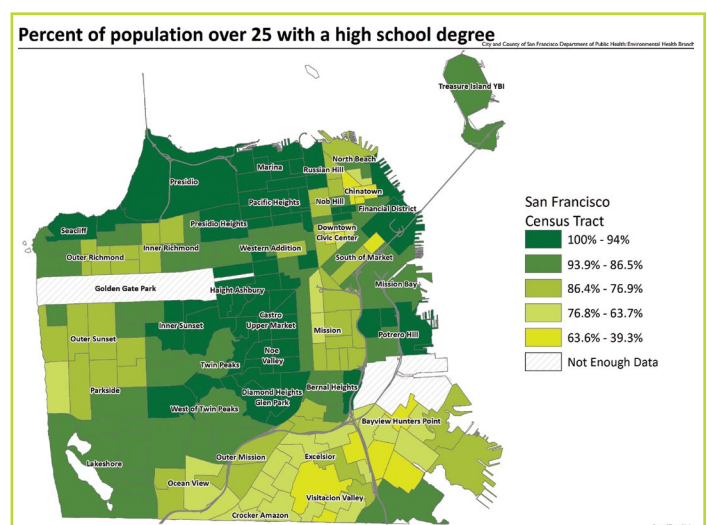
Healthy Food Score

Those in proximity to healthy food are generally less vulnerable before, during, and after a hazard event. During a hazard event, populations near food retail establishments will have the access to healthy food options that may prove more difficult for auto-dependent populations. The food market score is a relative measure of the number and variety of retail food resources within one mile, weighted by food offerings and distance. The neighborhoods that have the highest food retail score are some of the densest neighborhoods in the city, including the Financial District, Castro/Upper Market, Nob Hill, and Chinatown.

Healthy Food Score

San Francisco Census Tracts
- Very High
- High
- Medium
- Low
- Very Low
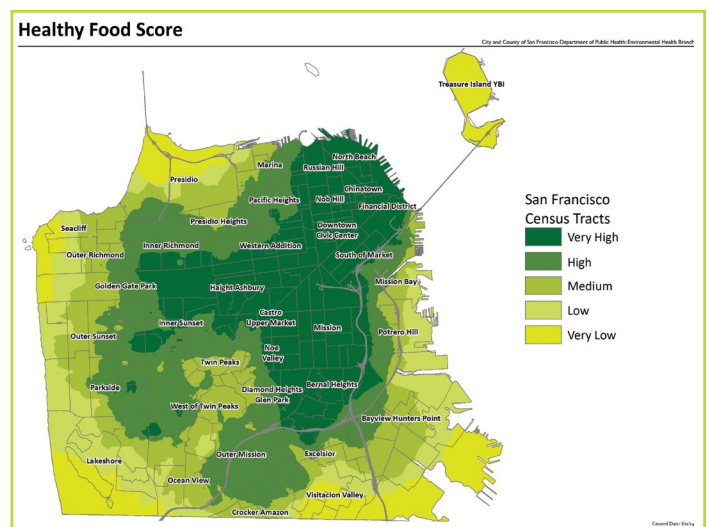
Educational Attainment

According to a Vienna University of Economics and Business study, there is no indicator more correlated with resilience to climate hazard events than educational attainment. Education allows a resident to more adequately prepare for, respond to, and recover from disaster events. Those with higher levels of educational attainment have more job opportunities and are likelier to have higher wages. The neighborhoods with the lowest percentage of residents 25-and-older with a high school diploma include Chinatown and Downtown, and the southeastern neighborhoods of Bayview Hunters Point, Crocker Amazon, Visitacion Valley and Excelsior.

Percent of population over 25 with a high school degree

San Francisco Census Tract
- 100% - 94%
- 93.9% - 86.5%
- 86.4% - 76.9%
- 76.8% - 63.7%
- 63.6% - 39.3%
- Not Enough Data

Proximity and Access to Pharmacies

Those dependent on medication are especially vulnerable in hazard events. If residents are forced to shelter in place or the transit ne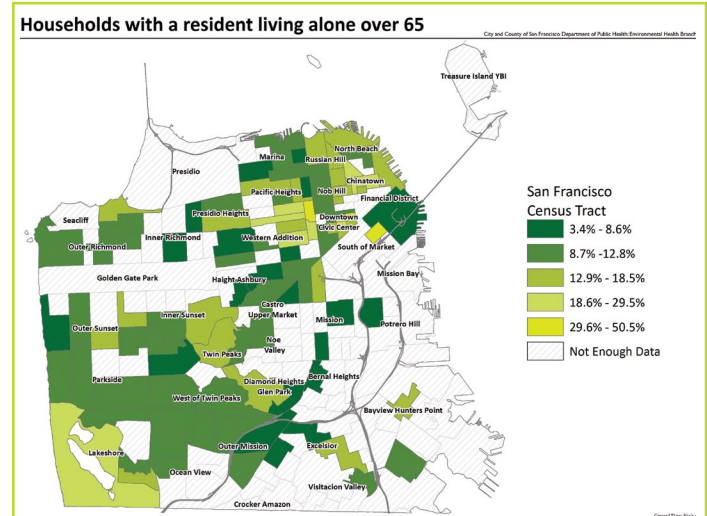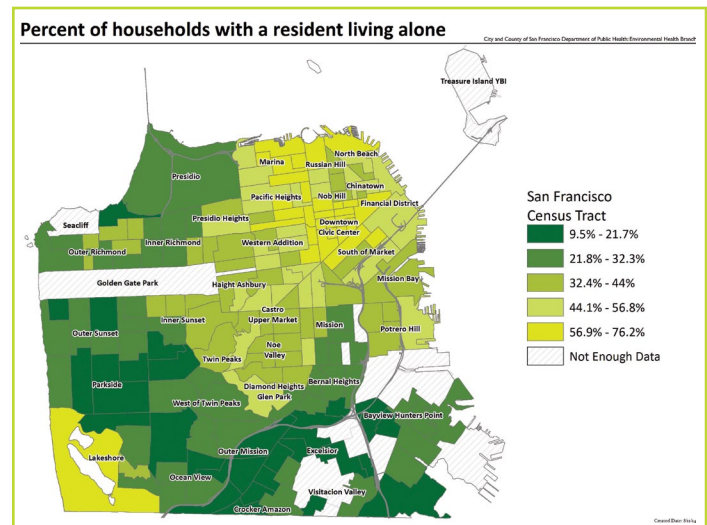twork becomes disrupted, many residents might not be able to access a pharmacy to pick up necessary prescriptions. The neighborhoods with the largest percentage of residents within a quarter-mile of a pharmacy are the dense heavily-commercial Downtown, Financial District, Chinatown, and Nob Hill neighborhoods. The Excelsior, Visitacion Valley, Outer Sunset, and Treasure Island, all primarily residential, lack access to pharmacies.

Residents within .25 Miles of a Pharmacy

City and County of San Francisco Department of Public Health: Environmental Health Branch

San Francisco
Census Tract
- 100% - 83.2%
- 83.1% - 54.7%
- 34.1% - 54.6%
- 54.7% - 83.1%
- 83.2% - 100%
- Not Enough Data
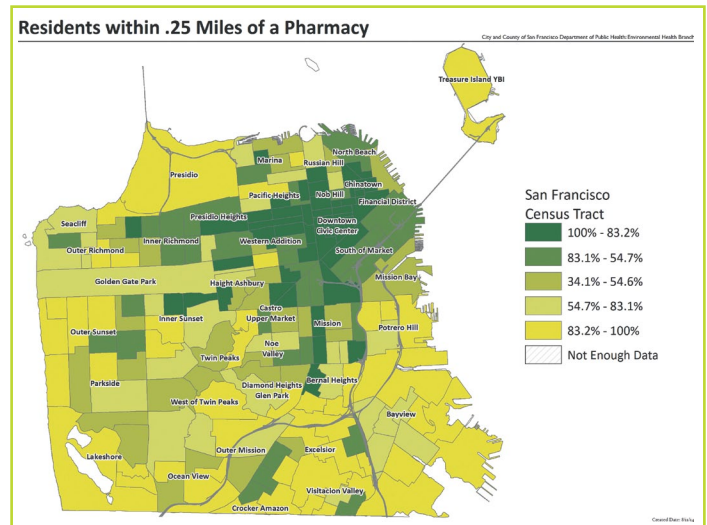
Housing Indicators

Living Alone

Those that live alone are at greater risk of illness or injury. They are more likely to be socially isolated, and will need more assistance to prepare for a disaster, to shelter during a disaster, and to recover after a disaster. In the 2003 Paris heat wave, 92% of all hospitalized lived alone. At even greater risk are elderly residents living alone. This population may need assistance evacuating and obtaining necessary medication or care. The neighborhoods with the highest percentage of one person households are Downtown / Civic Center, Marina and Lakeshore. Downtown / Civic Center also has a relatively high percentage of people aged 65-and-older living alone. This population will need extra city resources in the case of a hazard event.

Percent of households with a resident living alone

City and County of San Francisco Department of Public Health: Environmental Health Branch

San Francisco
Census Tract
- 9.5% - 21.7%
- 21.8% - 32.3%
- 32.4% - 44%
- 44.1% - 56.8%
- 56.9% - 76.2%
- Not Enough Data

Households with a resident living alone over 65

City and County of San Francisco Department of Public Health: Environmental Health Branch

San Francisco
Census Tract
- 3.4% - 8.6%
- 8.7% -12.8%
- 12.9% - 18.5%
- 18.6% - 29.5%
- 29.6% - 50.5%
- Not Enough Data

Overcrowding

SFDPH defines an overcrowded household as a household with 1 or more resident per room. Residential overcrowding has long been identified as an important housing issue and health concern. Residential overcrowding is a complex issue which involves several push factors such as housing affordability, low income, and immigration concentrations. Overcrowding results in poorer living conditions and can contribute to higher levels of ill-health, including respiratory and infectious disease such as tuberculosis. Overcrowding also tends to be linked to poor ventilation and increased moisture in the house. Damp housing encourages mites, cockroaches, virus and molds, which lead to chronic illness. Overcrowding not only impacts physical health, but also mental health, through high noise levels and lack of privacy. Crowding within housing units can increase the effect of extreme heat and heat hazard events, and can impede evacuation. Chinatown has the largest percent of overcrowded households, but SOMA, the Financial District, and Downtown all have large concentrations of overcrowding.

Percent of households with 1 or more person per room (overcrowded)
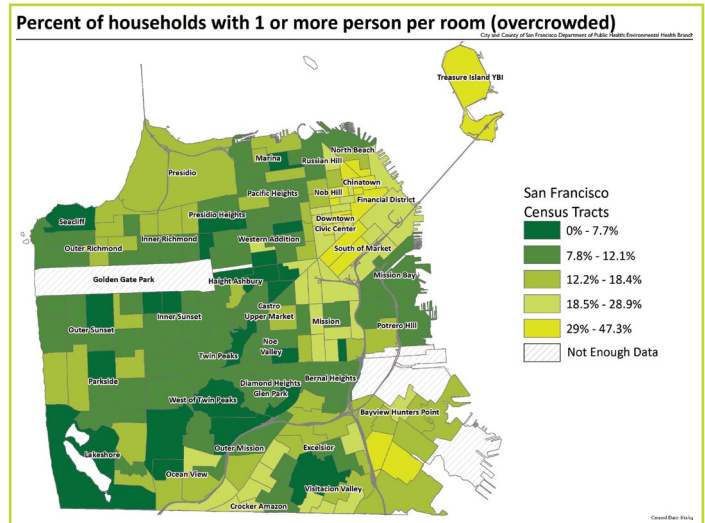
Residential Health and Safety Violations

Housing quality is an important measure of risk and vulnerability in hazard events. Passive cooling systems can prevent heat-related illnesses in extreme heat events. The effects of cold snaps can be mitigated with good insulation. Flood inundation events might exacerbate mold and rot. Residences with high volumes of health and safety violations are more likely to be in either states of neglect or disuse. The Downtown neighborhood has the highest concentration of residential code violations from the Department of Building and Inspections, the Fire Department, and the Department of Public Health.

Residential Housing Violations, per 1,000 People
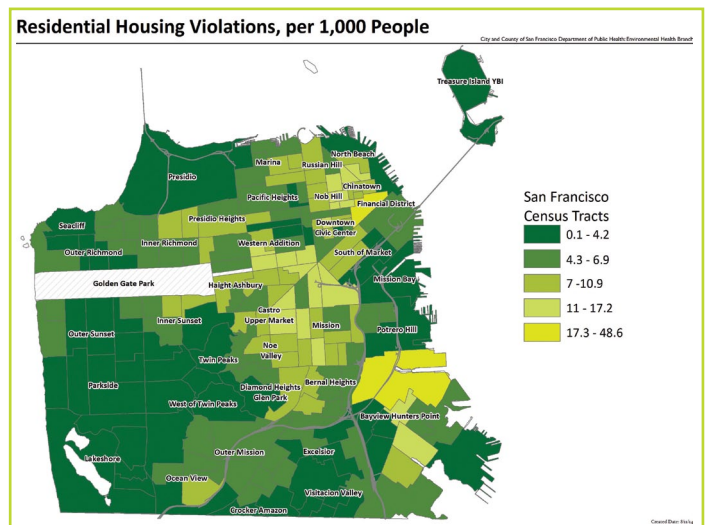
Air Conditioning

Despite some disagreement between the climate change mitigation and adaptation communities over the use of air conditioning units, in housing stock without other forms of ventilation, air conditioning can prevent the health effects of extreme heat. Residents in buildings with centralized air conditioning units are at far lesser risk of internal heat stress. In multi-unit buildings without centralized air, personal units often place the financial burden of cooling on low income residents and incentivize disuse. According to a 2009 California Residential Appliance Saturation Study (RASS), most San Francisco residents live without access to air conditioning.

Percent of buildings with air conditioning
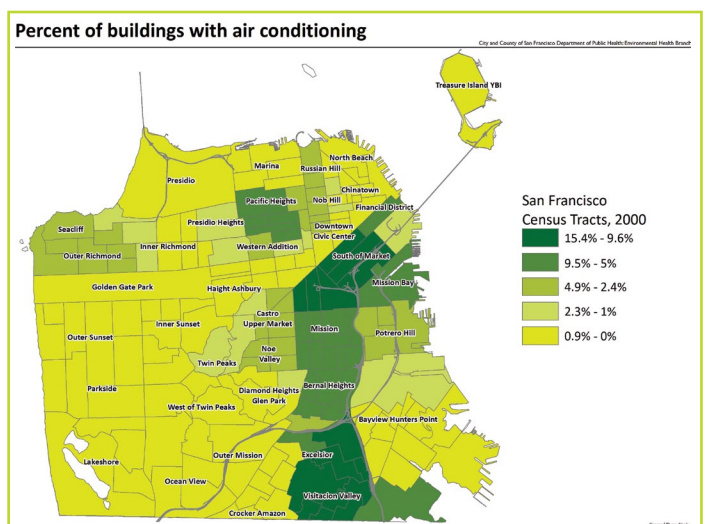
Excessive Rent Burden

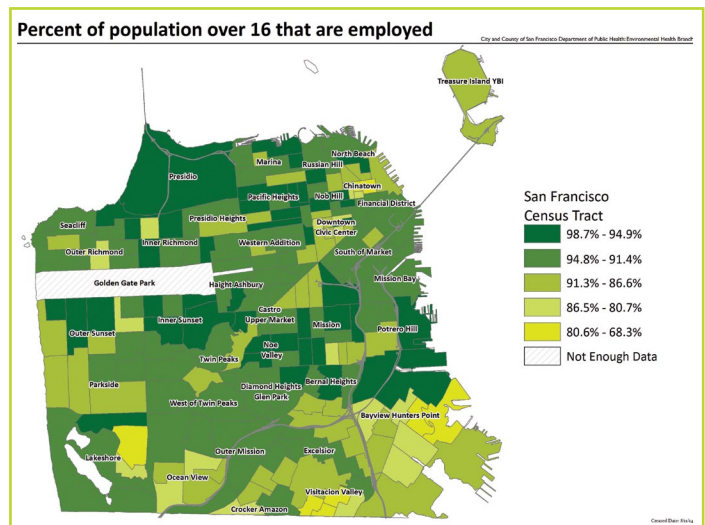Those that dedicate at least 50% or more of their monthly income to rent are likely to be vulnerable to any financial effects of climate hazard events. This population is the most at risk to become food insecure if agricultural prices increase, and some of the least likely to seek health care in the event of injury. The areas with the highest concentration of rent burdened households are the Downtown and Bayview Hunters Point neighborhoods. Lakeshore and Oceanview have high concentrations as well, but that could be due to San Francisco State University and its large student population.

Percent of renter households whose gross rent is 50% or more of their household income

San Francisco Census Tract
- 9% - 17.1%
- 17.2% - 22.9%
- 23% - 29.4%
- 29.5% - 37.9%
- 38% - 59.1%
- Not Enough Data
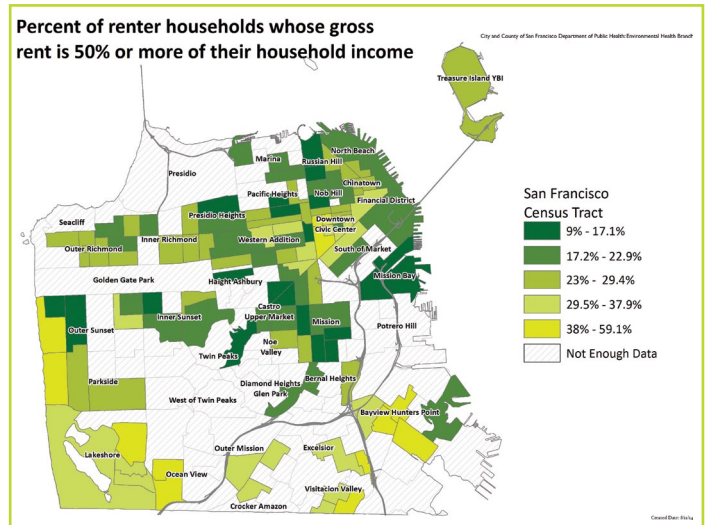
Economy Indicators

Employment Status

Those that are employed are more likely to have the financial resources to prepare for and respond to, and absorb the indirect impacts of hazard situations. A community of coworkers can be an important resource to disseminate information before and after hazard events. Because health insurance is provided through an employer, those without steady employment forced to pay for out-of-pocket coverage may be disincentivized to seek health care. The neighborhoods with the highest concentration of unemployment are Bayview Hunters Point, Downtown, and Excelsior.


Percent of population over 16 that are employed

San Francisco Census Tract
- 98.7% - 94.9%
- 94.8% - 91.4%
- 91.3% - 86.6%
- 86.5% - 80.7%
- 80.6% - 68.3%
- Not Enough Data

Health Indicators

Proximity and Access to Shelters and Cooling Centers

In the case of a hazard event, walkable access to shelters and cooling centers allows residents without safe housing or air conditioning ability to get the assistance they require. The neighborhoods with the largest percentage of residents within a quarter-mile of a shelter or cooling center are Downtown, Western Addition, and Marina neighborhoods. Visitacion Valley, Twin Peaks, and Mission Bay have little access to shelters and cooling centers. Those without automobiles may need assistance to reach a shelter or cooling center in the case of a hazard event.

The development of cooling centers started in 2012. There are various resources from across many city departments and agencies that will be utilized in preparation for or during an extreme heat emergency event and organizing cooling centers. SFDPH in conjunction with DEM has been developing a list of cooling centers and is developing MOUs with those sites. This process is still on going. The initial list of cooling shelters was developed from analysis of high heat vulnerability areas and cross referencing those areas with the DEM shelter database. In addition, the San Francisco library has agreed for their facilities (where appropriate) to be used as cooling centers. San Francisco Human Service Agency (HSA) with support from American Red Cross (ARC) will be the lead agency to open and setup cooling centers
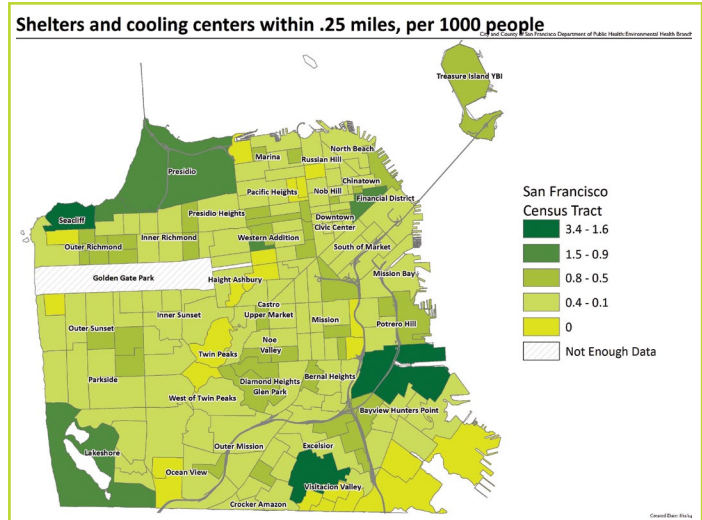
(including provision of staff and supplies). HSA will contact ARC, DPH, and other departments if additional resources are needed. Because identifying and selecting cooling center and shelter locations is a fluid process, the proximity and access map is subject to change in the coming months and years.

Proximity and Access to Hospitals and Clinics

The ability to access a hospital or clinic is tantamount in extreme hazard events. For populations without access to an automobile, the city transportation and health network influences the ease and accessibility of medical care. The Outer Richmond, Outer Sunset, and Parkside neighborhoods to the west, and the southern Crocker Amazon, Visitacion Valley, Excelsior, and Ocean View neighborhoods all have a low density of medical care facilities while simultaneously in areas with low or very low transit scores.
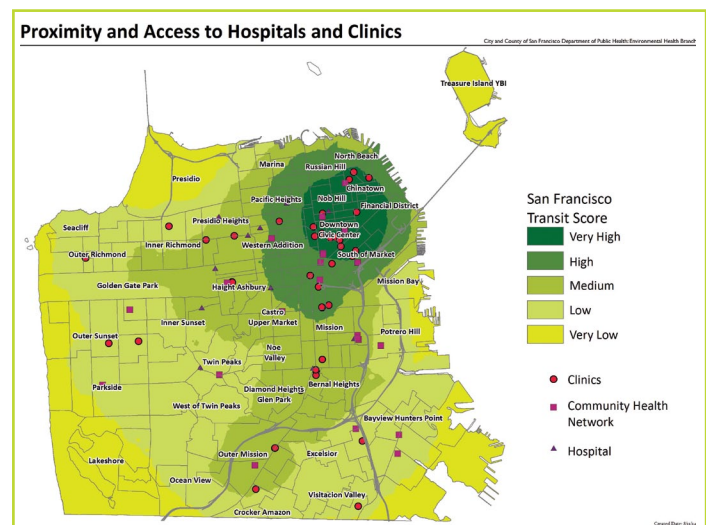
Mobility Disability

Those with disabilities are at greater risk during a hazard event and may need assistance evacuating or getting to a cooling center during a hazard event. Chinatown, Financial District, Downtown and SOMA have the highest percentage of disabled residents. These locations are all high-density, and well-served by public transit and healthy food options. Conversely, t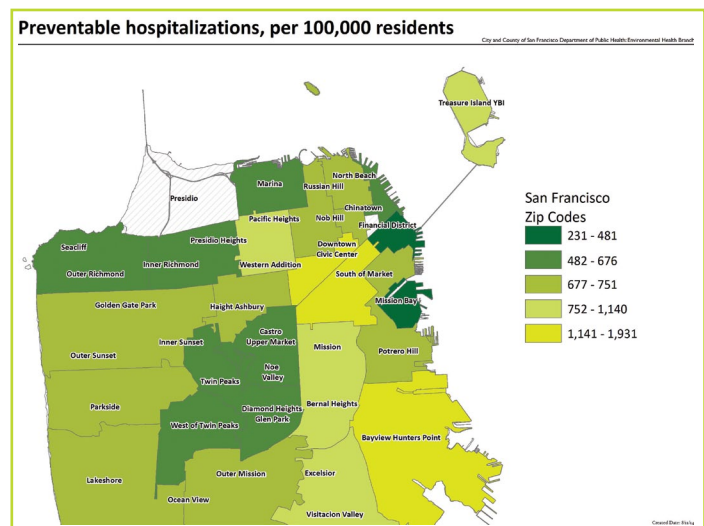he relatively isolated Twin Peaks neighborhood's large concentration of disabled residents may need more public assistance in the case of major hazard event.

Percent of population reporting a disability

San Francisco Census Tract
- 3.4% - 7.8%
- 7.9% - 11.3%
- 11.4% - 17%
- 17.1% - 26%
- 26.1% - 46.6%
- Not Enough Data
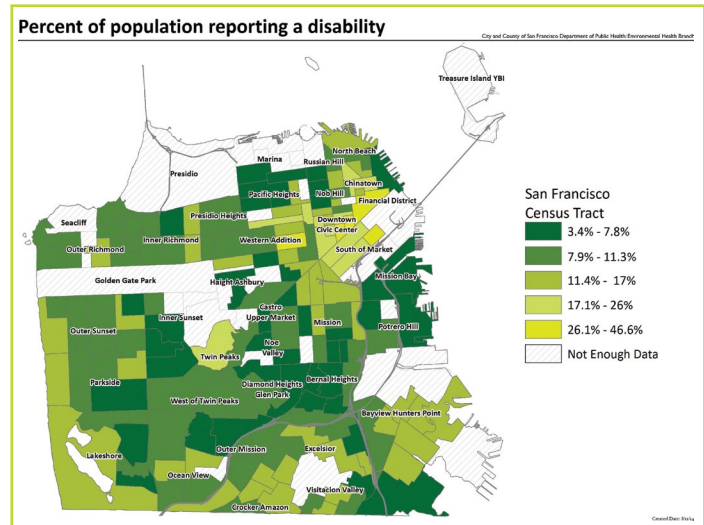
Preventable Hospitalizations

The preventable hospitalizations indicator measures the reach of San Francisco outpatient care. Preventable hospitalizations include diabetes, chronic obstructive pulmonary disease, hypertension, heart failure, dehydration, bacterial pneumonia, urinary tract infection, angina without procedure, and asthma. Those that have any of these pre-existing health conditions are highly vulnerable to hazard events. If a resident is hospitalized for one of these conditions, it also indicates that they might not receiving proper care on a routine basis. The areas with the highest rate of preventable hospitalizations include the Bayview Hunters Point, Chinatown, Western Addition and SOMA.
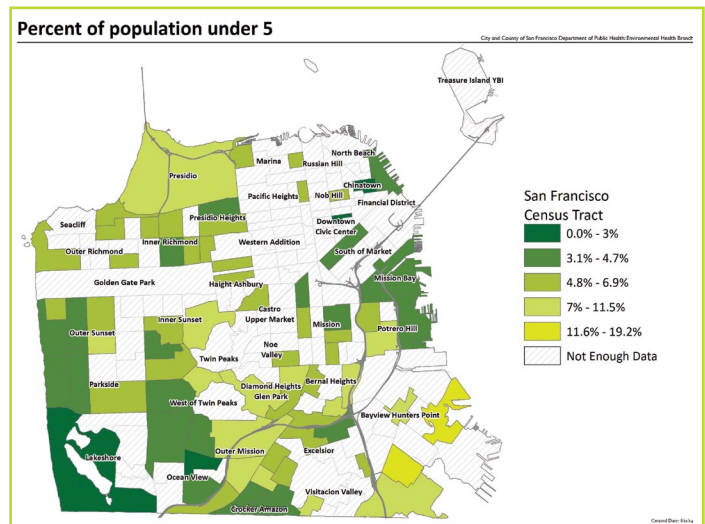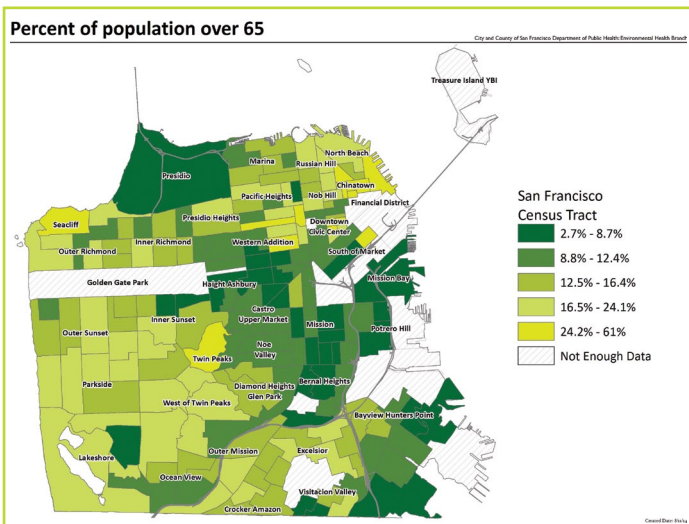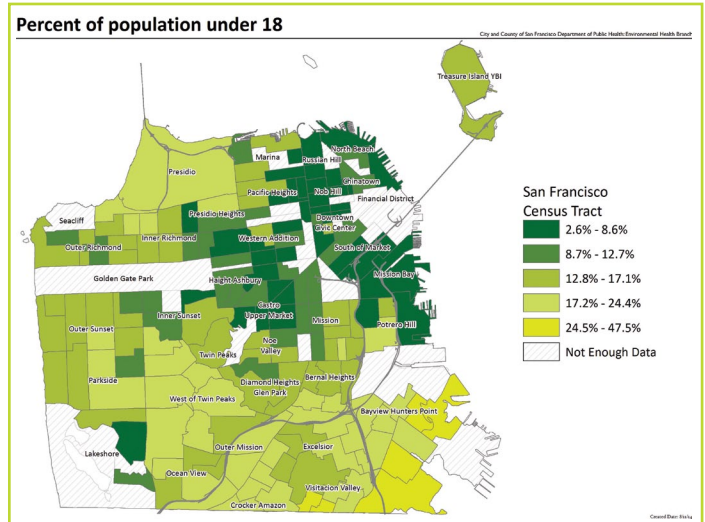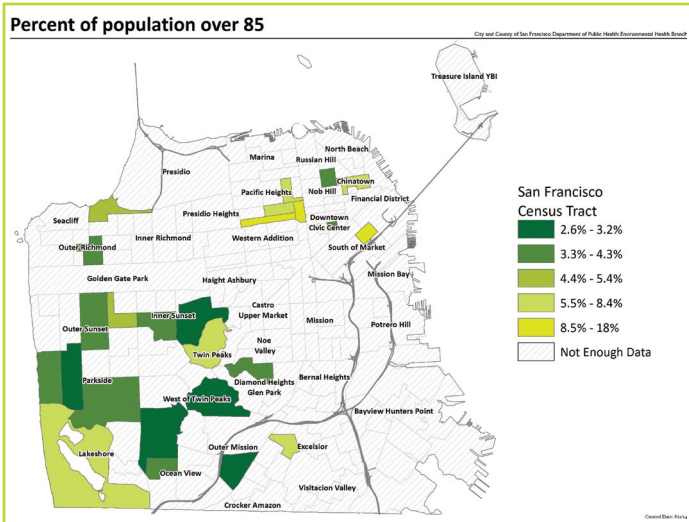

Preventable hospitalizations, per 100,000 residents

San Francisco Zip Codes
- 231 - 481
- 482 - 676
- 677 - 751
- 752 - 1,140
- 1,141 - 1,931

Demographic Indicators

Age (Over 85, Over 65, Under 18, and Under 5)

Elderly populations are at an increased risk for mortality. They are vulnerable to cardiovascular, respiratory disease, and other heat-related illnesses. The elderly are also more likely to have mobility constraints that decrease resilience in disaster situations, are more likely to be socially isolated, and dependent on city and federal resources such as social security income. Children are similarly vulnerable. Children develop dehydration, malnutrition and exhaustion more quickly than adults. A child's respiratory rate can be two-to-three times higher than an adult respiratory rate, so children experience the effects of poor air quality to a greater degree than an adult. During hazard situations, children may need assistance and resources to evacuate or seek shelter. Post-disaster, parents with children are more likely to be financially burdened if day care facilities and schools are affected.

The elderly residents of Chinatown are especially at risk due to the neighborhood's high residential density, overcrowded living conditions, and urban heat island vulnerability. Some of the neighborhoods with the highest elderly population are located in the northeast quadrant of the city. These neighborhoods include Chinatown, Nob Hill, Russian Hill, and Pacific Heights. The neighborhoods with the highest concentration of elderly residential care facilities are the Western Addition and Presidio Heights. The elderly residents of Chinatown are especially at risk due to the neighborhood's high residential density, overcrowded living conditions, and urban heat island vulnerability.

The areas with the largest percentage of children include the southern Bayview Hunters Point, Visitacion Valley, Crocker Amazon and West of Twin Peaks neighborhoods.

Percent of population over 85

San Francisco Census Tract
- 2.6% - 3.2%
- 3.3% - 4.3%
- 4.4% - 5.4%
- 5.5% - 8.4%
- 8.5% - 18%
- Not Enough Data

Percent of population under 18

San Francisco Census Tract
- 2.6% - 8.6%
- 8.7% - 12.7%
- 12.8% - 17.1%
- 17.2% - 24.4%
- 24.5% - 47.5%
- Not Enough Data

Percent of population over 65

San Francisco Census Tract
- 2.7% - 8.7%
- 8.8% - 12.4%
- 12.5% - 16.4%
- 16.5% - 24.1%
- 24.2% - 61%
- Not Enough Data

Percent of population under 5

San Francisco Census Tract
- 0.0% - 3%
- 3.1% - 4.7%
- 4.8% - 6.9%
- 7% - 11.5%
- 11.6% - 19.2%
- Not Enough Data

In addition to large concentration of children, the daytime population of the Parkside and the Outer Sunset neighborhood includes many students. In the event of a hazard event, these areas would require additional support and services.
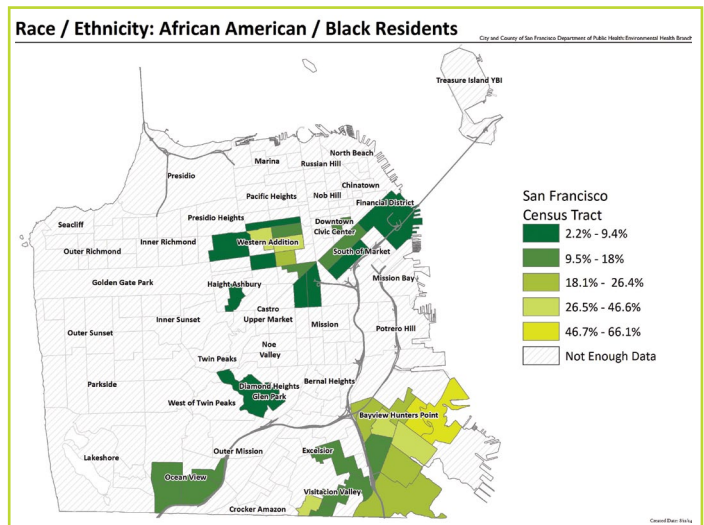
Ethnicity

Race and ethnicity are major indicators of community resilience. Because of historical and current structural, political, cultural, and economic power imbalances, many minority groups lack the political access and economic resources to recover from hazard events. Many of these same groups are often concentrated in at-risk neighborhoods of the city, live in vulnerable housing stock, and have greater rates of poverty. During the 2006 California heat wave, there were comparative increases in the rates of emergency department visits for most non-white racial and ethnic groups.

Much of San Francisco's African American population is concentrated in the Bayview Hunters Point and Western Addition neighborhoods. Chinatown, the Outer Sunset, Outer Richmond, Parkside, Crocker Amazon, and Visitacion Valley are all majority Asian. The Latino population is concentrated in the Mission District and Bernal Heights. The rest of the city is predominately white, with the highest concentrations in the Marina, Pacific Heights, Noe Valley, and the Castro/Upper Market neighborhoods.

Race / Ethnicity: Latino Residents

City and County of San Francisco Department of Public Health: Environmental Health Branch

San Francisco Census Tract
- 2.9% - 8.5%
- 8.6% - 14.4%
- 14.5% - 25.1%
- 25.2% - 40.3%
- 40.4% - 59.1%
- Not Enough Data

Race / Ethnicity: Non-White Residents

City and County of San Francisco Department of Public Health: Environmental Health Branch
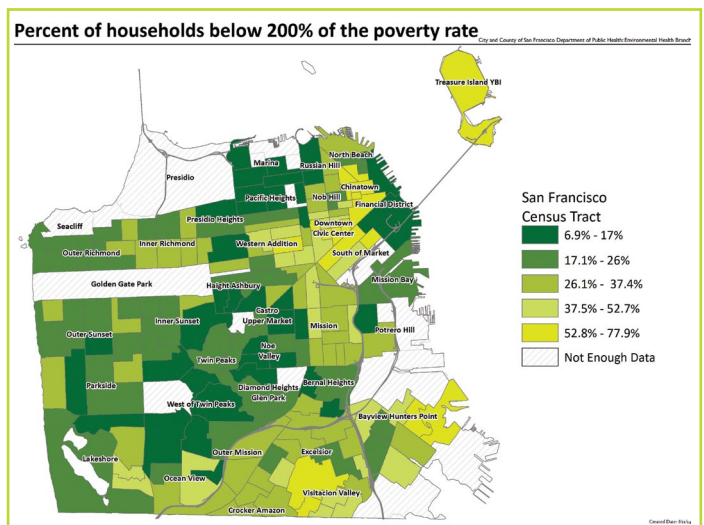
San Francisco Census Tract
- 10.4% - 27.7%
- 17.8% - 43.6%
- 43.7% - 58.4%
- 58.6% - 74.5%
- 74.6% - 94.1%
- Not Enough Data

Race / Ethnicity: Asian Residents

City and County of San Francisco Department of Public Health: Environmental Health Branch

San Francisco Census Tract
- 6.1% - 16%
- 16.1% - 25.5%
- 25.6% - 36.6%
- 36.7% - 52.9%
- 53% - 90.6%
- Not Enough Data

Race / Ethnicity: African American / Black Residents

City and County of San Francisco Department of Public Health: Environmental Health Branch

San Francisco Census Tract
- 2.2% - 9.4%
- 9.5% - 18%
- 18.1% - 26.4%
- 26.5% - 46.6%
- 46.7% - 66.1%
- Not Enough Data

Low Income Families (Families at or below 200% of the poverty rate)

Wealth enables communities to absorb and recover from losses more quickly. There is a strong correlation between people that live below the poverty level and infant mortality, heart disease, cancers, and homicide. People who live in poverty also tend to suffer from social deprivation and are less resilient in disasters. Poverty institutes barriers on everyday life such as poor nutrition, lack of preventive medical services, and unhealthy housing conditions[47]. The damage from poverty not only comes from material determinants but also from the social and psychological problems that it causes[48].

Because San Francisco's average median income and cost-of-living are both so high, we have defined a 'low income family' as one at or below 200% of the poverty rate. The neighborhoods with the highest concentration of low income households are in the dense Chinatown, Financial District, and Downtown neighborhoods and Treasure Island.

Percent of households below 200% of the poverty rate

City and County of San Francisco Department of Public Health: Environmental Health Branch

San Francisco Census Tract
- 6.9% - 17%
- 17.1% - 26%
- 26.1% - 37.4%
- 37.5% - 52.7%
- 52.8% - 77.9%
- Not Enough Data

Population and Daytime Density

The higher the density in a particular neighborhood, the more resources needed to mitigate the impacts of all hazard events before, during, and after the disaster. Population density can affect heat vulnerability by raising surrounding temperatures in urban areas. During and after a hazard event, density might challenge evacuation efforts and strain public health resources. Because a population fluctuates over the course of the day, we've decided to create two density indicators: one that counts residents, and one that approximates those present during normal work hours. Daytime density measures commute patterns, local school enrollment population, and employment density. The daytime population indicator does not account for university student enrollment and tourism.

The neighborhoods with the highest residential density are Nob Hill, Downtown, Chinatown, the Mission, and parts of the Inner Richmond. The neighborhoods with the highest daytime density are SOMA, Downtown, the Financial District, North Beach, and the Inner Sunset. Although the indicator does not include university populations, the major San Francisco universities: San Francisco State in the Lake Shore neighborhood, University of San Francisco in the Inner Richmond, and City College of San Francisco in the Outer Mission all will have high daytime populations.
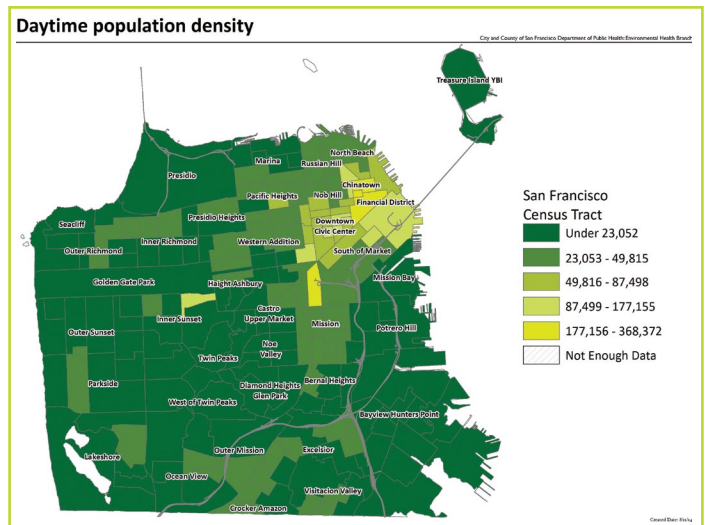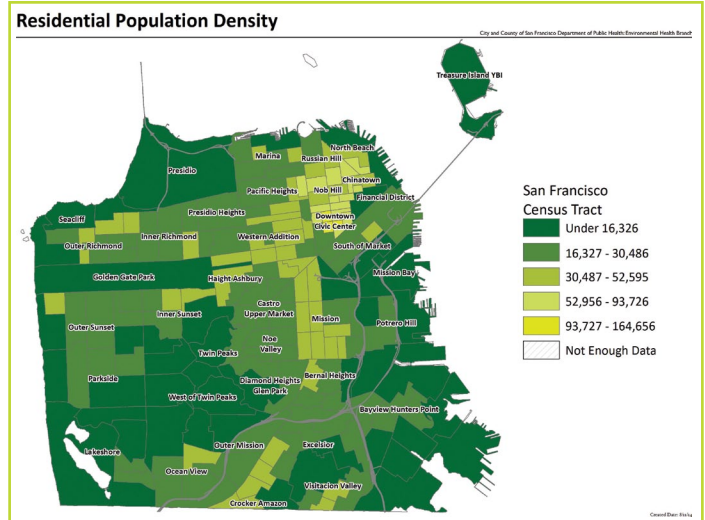
Problem Assessment

By Hazard

As a city government with limited capacity to respond to and prepare for hazard events, San Francisco must prioritize adaptation efforts. Historically, the San Francisco Department of Public Health has focused on Heat Events. In 2010, SFDPH began its 'Climate and Health' program to focus specifically on extreme heat, heat waves, and internal heat stress. This process resulted in vulnerability maps, educational and training materials, the development of a citywide heat emergency plan, and the ongoing process of identifying and selecting cooling centers.

Flood inundation is a hazard of high priority for the City of San Francisco. As the sea-levels rise, precipitation levels fluctuate, spring storms become more intense,

and San Francisco develops along the vulnerable SOMA, Mission Bay, Hunter's Point, and Treasure Island Coastline, the health impact of flood inundation will increase fatal and nonfatal injuries, water-borne disease, and could compromise the city water and wastewater resources.

Although progress has been made, San Francisco still needs to prepare for **extreme heat** events as they increase in both frequency and severity. More education and outreach to vulnerable communities, in conjunction with the development of sophisticated extreme heat response infrastructure, is necessary to adapt to increasing temperatures. Additionally, work must be done to prepare for extreme heat and its effect on **air quality**.

Chinatown and Downtown

The high concentrations of impervious surface, low percentage of tree coverage, heavy traffic volume, and high residential density, make the Chinatown and Downtown neighborhoods both at particularly risk for extreme heat impacts. These two neighborhoods are home to some of the most vulnerable populations in the city. They have the highest percentage of low-income families, relatively large elderly populations, low English comprehension, and high percentage of disabled residents. 67% of Downtown residents live alone, the highest total in the City. Only 40% of Chinatown residents have a high school diploma. Chinatown and Downtown are the neighborhoods with the two highest concentrations of housing code violations. This population demands careful attention and city resources to ensure that citizens are safe from extreme heat situations.
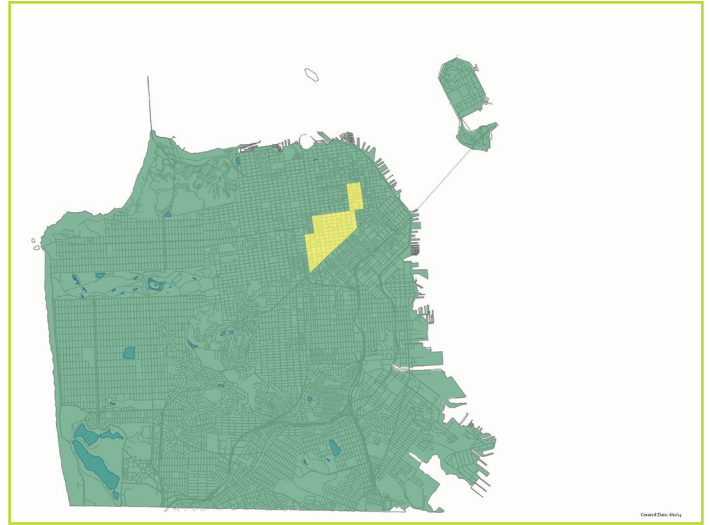

Bayview Hunters Point

Both because of its location along the waterfront, and because of socioeconomic considerations, the Bayview Hunters Point neighborhood is especially vulnerable to hazard events. Much of Bayview Hunters Point and the nearby Hunter's Point neighborhood sits in flood plain or liquefaction zones. The neighborhood has a lower employment rate than any other neighborhood in San Francisco, and a higher concentration of low-income families than any neighborhood besides Chinatown and Downtown. Unlike Chinatown and Downtown, Bayview Hunters Point has fewer public transit options and fewer healthy food options. Low voter turnout and high crime rate in the Bayview Hunters Point demonstrates a necessity to increase social capital.
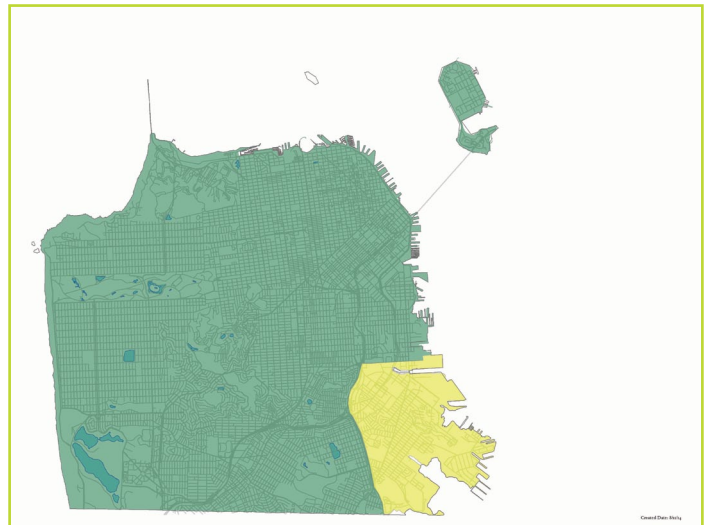
SOMA and Mission Bay

Places with new development are also vulnerable to hazard events. Although the quality of the housing stock is likely to be high, the large influx of new residents will add strain to transportation lines, local health care, and other municipal resources. Additionally, because many of the residents of these neighborhoods will be new to the neighborhood, the residents may not be familiar with evacuation or emergency procedures, may not know where to find local resources, and may be socially isolated.

In San Francisco, much of the new development is planned for the South of Market, Mission Bay, and Bayview Hunters Point neighborhoods. A large portion of these neighborhoods lie in 100 year flood plain and on top of liquefaction zones.
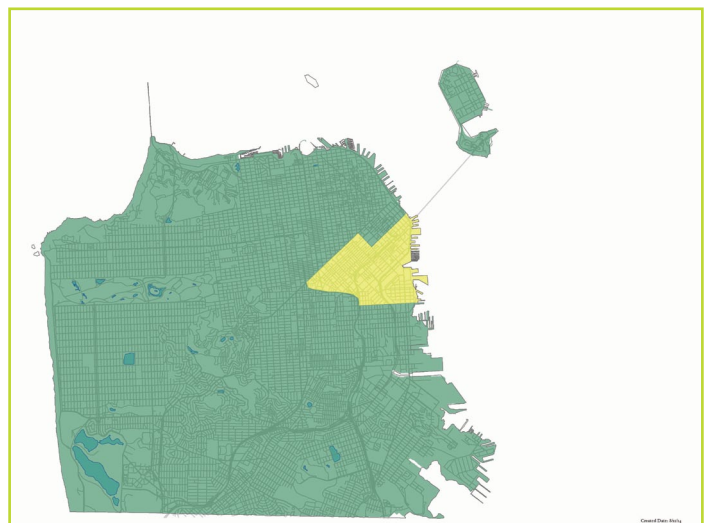
6. Next Steps and Conclusion

Next Steps

The Climate and Health Profile will guide future actions of San Francisco's Climate and Health program. This profile will serve as a foundation to conduct additional vulnerability assessments for climate-related environmental hazards, help prioritize and provide assistance for neighborhood adaptation planning, support City-wide adaptation efforts, and support public health emergency preparedness. Specifically, in 2015, SFDPH will conduct additional vulnerability assessments on direct effects of climate change (which will include flooding and air quality) and will engage experts in workgroups on indirect effects of climate change (food security and economic impacts) to better understand the health impacts and burden of disease. We will continue to develop capacity and provide technical assistance for neighborhood adaptation plans in the form of assessments that include data analytics and accompanying educational materials and outreach strategies for vulnerable populations and disadvantaged areas. We will support the creation of additional emergency plans to respond to climate related extreme weather events and seek new ways protect our most vulnerable populations in the wake of a disaster. Lastly, we will continue a communication strategy that raises awareness of the connections between climate change and health.

Our Climate and Health Program will focus on growing partnerships on a local level. Within San Francisco, we will strengthen our existing relationship with the Department of Environment to better coordinate outreach efforts and strategize how our climate programs can continue to support San Francisco's long history of mitigation planning while seeking new innovations for climate preparedness and response. We will continue to seek guidance from climate experts within our Public Utility Commission and work with key agencies that oversee infrastructure, transportation, as well as planning and emergency management. Over the last couple years, the City of San Francisco has elevated efforts to build climate resilience by hiring both a Chief Resilience Officer as part of the Rockefeller Foundation's 100 Resilient Cities Challenge and a Senior Advisor on the Environment to the Mayor's Office. The SFDPH will work to develop partnerships with the Chief Resilience Officer and the Mayor's Office to further San Francisco's resiliency efforts and integrate health impacts and health-based evidence into San Francisco's planning process and policies. We will work with regional, state and national agencies to share best these practices and adaptation interventions that support health and build community resilience.

The Climate and Health Program will expand work with community based organizations and community members in disadvantaged areas to identify and describe current capabilities to respond and adapt to climate change. With an understanding of the social, environmental and economic conditions that enable these capabilities or create barriers, we will continue to develop a model of community capacity and use the set of indicators developed in this report to describe community resilience and measure impact overtime. We also acknowledge that communities and businesses are ready and willing to work toward protecting themselves, and are here to support those efforts underway. With a better understanding of community resiliency from community experts and our work at the health department and collaboration with key city agencies, we will deliver public health interventions and adaptation plans specific to San Francisco communities that will mitigate increases in climate-related health impacts, help eliminate existing health disparities and develop local adaptive capacity.

Conclusion

This profile allows us to begin to understand how the climate change and public health are interrelated, and that the resiliency of a particular community is dependent on both the local climate impacts, and the socioeconomic and demographic factors that affect one's ability to prepare, adapt, and respond to the impacts. While San Francisco may be small geographically, this profile examines how community resiliency can vary significantly from neighborhood to neighborhood. There are neighborhoods that may be particularly vulnerable to hazard events because of pre-existing socioeconomic and cultural inequalities, neighborhoods that may be particularly vulnerable to hazard events because of increased exposure to the hazard, and neighborhoods that may be vulnerable because of some combination of the two factors. Because resiliency and vulnerability vary from neighborhood to neighborhood, it is the role of the City to ensure planning efforts to protect human health and safety are directed at the most vulnerable neighborhoods.

Through San Francisco's collective efforts and continued investment, communities will become better positioned to address and respond to known and unknown impacts on their neighborhood residents' health and well-being. In addition, they will have increased capacity to partner with organizations and agencies from a wide variety of sectors that engage them over time as the impacts of climate change escalate and unfold. As a result of this multi-sectorial collective impact, San Francisco communities will be on the forefront of climate change preparedness and resilience. The SFDPH believes proactively building resilience to climate change is a powerful opportunity to improve the health of our city's residents.

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Appendix B

Indicator Spreadsheet

COMMUNITY VULNERABILITY FACTOR	DATA COLLECTED	SOURCE	SAN FRANCISCO	LOS ANGELES	CALIFORNIA	NOTES
100 Year Storm Plane	Percentage of each census tract and neighborhood in a 100 year storm plane.	San Francisco Capital Planning Committee, 2014	Available in Map	Not Available	Not Available	*Projections are based on San Francisco Capital Planning Committee Sea Level Rise and Flood Inundation Forecasts. By 2050, the San Francisco Capital Planning Committee projects an 70% likelihood sea levels on the bay side of San Francisco to rise between 7 and 15 inches. Although a 100 Year Storm flood inundation forecasts to increase sea levels by 41 inches, SFDPH has used a lower 36 inch threshold.*
Extreme Heat	Percentage of residents living in 'high' or 'very high' extreme heat risk block groups.	San Francisco Department of Public Health	26.7%	Not Available	Not Available	
Liquefaction Zones	Percentage of each census tract and neighborhood in a liquefaction or landslide zone.	Association of Bay Area Governments, downloaded 2014	Available in Map	Not Available	Not Available	
Impervious Surface	Percentage of each census tract and neighborhood covered by impervious surfaces.	National Landcover Database	63.5%	Not Available	Not Available	
Air Quality	PM 2.5 Concentration from All Sources	Bay Area Air Quality Management District (BAAQMD) and The San Francisco Department of Public Health	Available in Map	Not Available	Not Available	
Contaminated Parcels	Percentage of each census tract and neighborhood covered by 'contaminated sites'	California State Water Resources Control Board, Environmental Protection Agency	Available in Map	Not Available	Not Available	

COMMUNITY VULNERABILITY FACTOR	DATA COLLECTED	SOURCE	SAN FRANCISCO	LOS ANGELES	CALIFORNIA	NOTES
Active Transportation	Proportion of commute trips made by walking, biking or public transportation.	San Francissco County Transportation Authority	49%	Not Available	Not Available	
Transit Score	A relative measure of the number of transit routes within one mile, weighted by frequency of service and distance.	San Francisco Department of Public Health, San Francisco Municipal Transportation Agency	Available in Map	Not Available	Not Available	
Violent Crime Rate	Violent crimes per 1000 people, by census tract and neighborhood.	San Francisco Police Department	53.1 per 1000 people	Not Available	Not Available	
Voting Rates	Percentage of registered voters casting ballots in the November, 2012 gubernatorial election, by election precinct.	San Francisco Department of Elections	72.50%	51.60%	55.20%	
New to the Region	Percentage of residnets 1 year or older in each neighborhood and census tract who have lived in the county for less than a year.	American Community Survey Estimate, 2008 - 2012	7.60%	2.90%	Not Available	
Citizenship	Percentage of residents of each neighborhood and census tract who have United States citizenship.	American Community Survey Estimate, 2008 - 2012	18%	18.9%	14.5%	
Linguistic Isolation	Percentage of residents 5 years and older in each neighborhood and census tract who live in households where someone does not speak english "very well".	American Community Survey Estimate, 2008 - 2012	23.2%	26.5%	19.6%	
Food Market Score	A relative measure of the number and variety of retail food resources within one mile, weighted by food offerings and distance.	Dun and Bradstreet 2011, San Francisco Department of Public Health, 2011.	Available in Map	Not Available	Not Available	

COMMUNITY VULNERABILITY FACTOR	DATA COLLECTED	SOURCE	SAN FRANCISCO	LOS ANGELES	CALIFORNIA	NOTES
Educational Attainment	Percentage of residents of each neighborhood and census tract over 25 with at least a high school degree.	American Community Survey Estimate, 2008 - 2012	85.9%	76.4%	81.0%	
Persons Living Alone	Percentage of nonfamily households of each neighborhood and census tract where the householder is living alone.	American Community Survey Estimate, 2008 - 2012	39.4%	25.6%	24.3%	
Elderly Living Alone	Percentage of nonfamily households of each neighborhood and census tract where the householder is living alone and is over 65 years old.	American Community Survey Estimate, 2008 - 2012	10%	7.90%	8.40%	
Overcrowding	Percentage of households in each neighborhood and census tract with 1 or more people per room	American Community Survey Estimate, 2008 - 2012	94%	88%	92%	
Residential Housing Violations	Department of Building Inspections, Department of Public Health, and Fire Department violations in residential buildings per 1000 people, by census tract and neighborhood.	San Francisco Department of Building Inspections, San Francisco Department of Public Health, San Francisco Fire Department	12.1 per 1000 people	Not Available	Not Available	
Air Conditioning Prevelance	Percentage of residents in each neighborhood and 2000 census tract without air conditioning.	San Francisco Department of Public Health	Available in Map	Not Available	Not Available	
Excessive Rent Burden	Percentage of households in each neighborhood and census tract who pay over 50% of their monthly income towards rent.	American Community Survey Estimate, 2008 - 2012	22.1%	30%	28%	
Employment Status	Percentage of residents over 16 in the labor force each neighbor-hood and census tract who are employed.	American Community Survey Estimate, 2008 - 2012	92%	89.1%	88.9%	

COMMUNITY VULNERABILITY FACTOR	DATA COLLECTED	SOURCE	SAN FRANCISCO	LOS ANGELES	CALIFORNIA	NOTES
Proximity to Cooling Centers and Shelters	Number of cooling centers and shelters within a walkable distance (.25 miles) / 1000 people, by census tract and neighborhood.	San Francisco Department of Public Health	Available in Map	Not Available	Not Available	
Access to Hospitals and Clinics	Data Forthcoming	San Francisco Department of Public Health	Not Available	Not Available	Not Available	
Proximity to Pharmacies	Percentage of residents in each neighborhood and census tract who live within a quarter-mile of a pharmacy.	California Department of Consumer Affairs Board of Pharmacy	Available in Map	Not Available	Not Available	
Disabilities	Percentage of residents in each neighborhood and census tract who are disabled.	American Community Survey Estimate, 2008 - 2012	10.5%	9.4%	10%	
Preventable Hospitalizations	Preventable hospitalizations, per 10,000 people, by zip code.	California Office of Statewide Health Planning and Development, 2009-2011	Available in Map	Not Available	Not Available	*Preventable hospitalizations include admission rates for diabetes short-term complications, diabetes long-term complications, chronic obstructive pulmonary disease, hypertension, heart failure, dehydration, bacterial pneumonia, urinary tract infection, angina without procedure, uncontrolled diabetes, asthma in younger adults, and rate of lower extremity amputation among patients with diabetes.*
Residents over 85	Percentage of residents in each neighborhood and census tract over 85-years-old.	American Community Survey Estimate, 2008 - 2012	2.2%	1.6%	1.6%	
Residents over 65	Percentage of residents in each neighborhood and census tract over 65-years-old.	American Community Survey Estimate, 2008 - 2012	13.7%	11.5%	12.1%	
Residents under 18	Percentage of residents in each neighborhood and census tract under 18 years old.	American Community Survey Estimate, 2008 - 2012	13.4%	23.7%	24.3%	

COMMUNITY VULNERABILITY FACTOR	DATA COLLECTED	SOURCE	SAN FRANCISCO	LOS ANGELES	CALIFORNIA	NOTES
Residents under 5	Percentage of residents in each neighborhood and census tract under 5 years old.	American Community Survey Estimate, 2008 - 2012	4.4%	6.6%	6.5%	
White Population	Percentage of residents in each neighborhood and census tract who racially self-identify as white.	American Community Survey Estimate, 2008 - 2012	50.0%	49.8%	73.5%	
Black Population	Percentage of residents in each neighborhood and census tract who racially self-identify as black.	American Community Survey Estimate, 2008 - 2012	5.8%	9.6%	6.6%	
Asian Population	Percentage of residents in each neighborhood and census tract who racially self-identify as Asian.	American Community Survey Estimate, 2008 - 2012	33.2%	11.3%	14.1%	
Latinio Population	Percentage of residents in each neighborhood and census tract who racially self-identify as Latino.	American Community Survey Estimate, 2008 - 2012	14.7%	48.5%	38.4%	
Low Income Families	Percentage of residents in each neighborhood and census tract who are below 200% of the poverty rate.	American Community Survey Estimate, 2008 - 2012	28%	39%	35.1%	
Population Density	People per square mile, in each neighborhood or census tract.	American Community Survey Estimate, 2008 - 2012	17,179.1 people per square mile	2419.6 people per square mile	239 people per square mile	
Daytime Population Density	The density of San Francisco neighborhoods and census tracts during a typical 9am-5pm workday.	American Community Survey Estimate, 2008 - 2012, Longitudinal Employer-Household Dynamics Survey, San Francisco Unified School District	23,280.9 people per square mile	Not Available	Not Available	*Residents (ACS Estimate) + Workers (LEHD 2011 CB Data) + Students (SFUSD + Private Schools)- (Total Employed (ACS Estimate) - Works From Home (ACS Estimate)) - Students Enrolled in School (ACS Estimate).*