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THE CENTER FOR STUDIES IN DEMOGRAPHY & ECOLOGY

Exploring Our Future: King County Forecasts to 2045

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Executive Summary

The 2020 Population Health Initiative's Applied Research Fellowship Program sought to produce small area population forecasts at the Census tract and Health Reporting Area (HRA) levels by sex, race, ethnicity and 5 year age groups for King County from 2020 to 2045 using a novel version of the Hamilton-Perry (HP) method with a multistage smoothing process. Our results are comparable to other, well-regarded forecasts and offer new and complementary information.

We also developed an interactive visualization tool, which allows users to conduct their own, targeted analyses of our projections by sex, age, race and ethnicity across small areas within King County. Our methodology and data products provide King County with new and critical insights about its potential future and has the flexibility to be applied to different contexts across the U.S. With three examples, we illustrate how our forecasting tool can be used for practical insight when considering policy and program planning.

Our projections indicate that King County's population will experience significant growth in the coming decades, from roughly 2.2 million people in 2020 to approximately 2.8 million by 2045. While King County's population growth will be steady, our projections indicate that growth will not be uniform across ages, races, ethnicities, or regions within the county. Specifically, Asian, Hispanic, and elderly populations will increase most rapidly during the forecast period, while White residents will increase most slowly. Our visualization tool allows users to explore these and other population changes from 2020-2045 by age, gender, race, and ethnicity across tract- and HRA-levels. The tool further allows individuals to examine the location of existing public health and educational facilities in relation to current and projected populations.

The results and visualization tool from this project can be used to inform local and extralocal decisions about where to locate resources in King County to meet the needs of a growing and diversifying population. Beyond this, the methodology and visualization tool we have developed can be adapted to project population growth across the United States. These tools therefore help fill a crucial information gap faced by policymakers and stakeholders who have little information about how local areas might change going forward, particularly in terms of the racial and ethnic composition of local areas. Given that decisions about locating resources often happen at neighborhood and administrative levels, our projection method and visualization tool offer a powerful means for local areas to meet the needs of diversifying populations.

Introduction

The U.S. population is becoming older and more racially and ethnically diverse (Frey, 2020). King County and its surrounding areas are no exception to these changes. Since 1990, King County has experienced 50% population growth, largely driven by migration to King County (King County Office of Economic and Financial Analysis, 2020). As the White population has remained stable, all other racial and ethnic groups have grown over this time period, leading to a more racially and ethnically diverse King County (King County Office of Economic and Financial Analysis, 2020). Unsurprisingly, these demographic shifts are not uniform across the county (King County Office of Economic and Financial Analysis, 2020), and being able to anticipate population changes is an important tool for policymakers who would like to know where to site healthcare facilities, childcare centers, bus routes, and other public resources. Demographic projections offer an opportunity to anticipate these changes by utilizing information on past population changes occurring within an area as a result of changes in fertility, mortality, and migration, and using that information to project or forecast possible future changes in that area. While demographic projections are relied upon for crucial planning decisions, such as setting growth targets, currently available products exist largely at the county, regional and state levels and are rarely disaggregated by race and ethnicity. They therefore lack detail about the heterogeneity of demographic profiles within the county and hamper the abilities of planners and policy makers to make crucial decisions about the placement of transportation routes or facility locations. Micro level spatial information is especially crucial for meeting the needs of a diverse and aging population.

However, because data are rarely available on the components of population change, such as fertility, mortality, and migration rates, for small, sub-county areas, small area projections are difficult to create. Creating reliable small area projections is especially difficult because small areas, such as Census tracts (which are often used to represent neighborhoods) frequently exhibit very different population compositions within a county, with, for example, populations tending to cluster by age and race and ethnicity. Further, Census tracts exhibit considerable change over time and are highly influenced by the populations and characteristics of nearby tracts. To produce reliable estimates, small area projection methods must therefore account for this lack of data, disparate population compositions, and the influence of nearby tracts.

The primary goal of the 2020 Population Health Initiative Applied Research Fellowship Program was to work with the Public Health Services Division of Seattle & King County to make small area population projections at the Census tract and HRA levels for King County for every five years up to 2045. Our projections utilized population data from the Washington State Office of Financial Management (OFM) in conjunction with population projections from OFM and the Puget Sound Regional Council (PSRC). Our small area projections (Exploring Our Future: King County Forecasts to 2045, 2020) were made by age, gender, race and ethnicity using statistical demography methodologies and are compared to existing OFM and PSRC population projection estimates for larger geographic levels. As such our projections fill a gap in current projections provided by either OFM or PSRC. Our projections provide nuanced insights into how King

County's neighborhoods and administrative areas are anticipated to change in the coming decades, allow us to identify potential population challenges, and inform recommendations for responses to these challenges, including how resources might be distributed to meet the needs of a changing population. Further, the method we develop here has the flexibility to be applied to other geographic areas across the U.S. to help fill a critical information need faced by many local policymakers who have little information about how their neighborhoods and administrative areas may change going forward.

Background

Existing Population Trends in King County

Introduction

Our overview of population trends in King County begins with a summary of trends in race and ethnic composition, as well as age composition. We then turn to examine trends in the component demographic factors that affect population growth, namely: fertility, life expectancy (and, by implication, mortality), and migration. These trends affect the assumptions we made when developing our forecast models.

Increasing Racial and Ethnic Diversity

To anticipate how King County's population may change in the coming years, it is important to understand population changes currently underway in King County. Since 1990, the overall population in King County has increased nearly 50% from approximately 1.5 million residents to over 2.26 million residents in 2020, significantly outpacing the overall United States population growth during the same time period (King County Office of Economic and Financial Analysis, 2020). Much of this increase results from the growth of the Asian and Hispanic populations in King County. Indeed, the Asian population has increased the most significantly among any racial or ethnic group in King County over the past 20 years, accounting for 18% of the population in 2018, up from 10.8% in 2000. While King County's White residents comprise the largest share of the county's total population, their population growth has stabilized and is consistently declining as a proportion of the population since 2000 (King County Office of Economic and Financial Analysis, 2020). These trends are similar to the United States, as a whole. Throughout the U.S. the White population has comprised a shrinking proportion of the United States population since 2000 (Johnson, 2011).

Although King County has become more racially and ethnically diverse, many of these changes predominantly occurred in particular areas within the county. For instance, Black, Hispanic and multiracial populations are largely concentrated in parts of south Seattle, while the eastern regions of the county remain predominantly White (King County Executive Equity & Social Justice Office, 2014). Given that the White population tends to be concentrated largely in eastern areas of King County and growth among this group has remained relatively stagnant over time, we can anticipate that these areas may grow less in the coming decades. In contrast, the Asian population tends to be concentrated in Sammamish, Issaquah, and along the eastern side of Lake Washington, as well as in the southern boundary of Seattle. Given that this

population is experiencing some of the most rapid growth in King County, we anticipate that these areas will experience particularly large growth in the future.

Shifts in Working Age and Older Adults

Additionally, King County's population is becoming progressively older, in line with the aging of the population throughout the U.S. (U.S. Census Bureau, 2018a). However, the growth of the Asian, Hispanic, and multiracial populations in King County, has partially offset this aging, because these populations tend to be younger populations on average (U.S. Census Bureau, 2018a). Consequently, King County has a larger working-age population than many comparable regions in the U.S. (U.S. Census Bureau, 2018a) As a result, residents aged 30-39 make up the largest share of King County's population followed closely by residents aged 20-29. The rapid rise of the Asian, mixed race, and Hispanic populations and their younger age profiles may suggest the need to target educational, childcare, and family health resources to these communities. In contrast, King County's White population tends to be older, on average (U.S. Census Bureau, 2018b). Areas in which the White population comprises a relatively larger share of the population may therefore exhibit especially large increases in the aging population and, as a result, experience increased demand for resources to support elder care and well-being.

Declining Fertility

The general fertility rate among nearly all racial and ethnic groups in the U.S. has declined since 2014, setting a record low birth rate for the nation (Martin et al., 2019). In King County, fertility rates have followed a similar trend. From 2016 to 2018, every racial and ethnic group exhibited declines in fertility among women aged 15-44 (Washington Department of Health, 2019). Pacific Islander women have exhibited the highest fertility rates and also some of the sharpest declines in recent years. The birth rates among multiracial, American Indian/Alaska Native and White women have remained the lowest of any racial and ethnic groups in King County since 2004 (Washington Department of Health, 2019). In recent years, women of all ages have exhibited declines in birth rates with the exception of residents aged 35- to 44-years-old (Washington Department of Health, 2019).

Variation in Life Expectancy

Life expectancy in King County ranks in the 95th percentile among all counties in the U.S. Still, substantial differences in life expectancy exist across King County neighborhoods. In 2014, a gap in life expectancy of nearly 18 years for men and 14 years for women was found between King County Census tracts with the lowest and highest life expectancies (Dwyer-Lindgren et al., 2017). Sub-county estimates suggest that life expectancy in some regions within King County is much lower than the national average, and in some cases close to the lowest levels observed anywhere in the U.S. (Dwyer-Lindgren et al., 2017). For example, in 2014 life expectancy among men within King County ranged from a low of 68.4 years in Auburn, located in the southern region of the county (Census tract 308.01), to a high of 86.7 years in Clyde Hill (Census tract 241) located in the eastside of the county. Life expectancy among women ranged from a low of 73.6 years in Auburn (Census tract 308.01) to a high of 88.4 years (86·9–89·9) in the Bryant neighborhood of northeast Seattle (Census tract 42) (Dwyer-Lindgren et al., 2017).

In addition to geographic variation, life expectancy within King County varies by race and ethnicity. For example, between 2013 and 2017, the life expectancies of Asian and Hispanic populations were, on average, nearly 10 years higher than that of Native Hawaiian/Pacific Islander and American Indian/Alaska Native groups (Washington Department of Health, 2019).

Increasing Migration

Migration is a significant driver of Washington's population growth. In 2018, net migration accounted for approximately 70 percent of the state's population growth, while natural increase (births exceeding deaths) was responsible for the other 30 percent (Washington State Office of Financial Management, 2019). Almost half of this growth is the result of migration to King County among foreign-born residents, and the other half consists of residents migrating internally within the U.S. Further, from 2010 to 2017 King County experienced the third largest increase in foreign-born residents among all U.S. counties (King County Office of the Executive Performance, Strategy and Budget, 2017). Evidence suggests immigrants to King County disproportionately settle in the county's suburban areas, leading to substantial growth in these areas (King County Office of the Executive Performance, Strategy and Budget, 2017).

While economic conditions within King County are a major pull factor for increasing migration, King County's migration patterns are also shaped by the economic conditions of economically comparable areas that might push migrants out. For example, King County tends to experience increased migration from California when economic conditions in California are relatively unfavorable, which may prompt individuals to move if they lose their jobs or perceive opportunities to be more plentiful in the Seattle area (Washington State Office of Financial Management, 2019). Additionally, ongoing climate change may be associated with increased migration to places like King County from places where temperatures are increasingly too hot or climate-related disasters disruptive of livelihoods (McLeman and Smit, 2006). Despite the current trend of increasing migration, experts predict a slowing of migration into the state and King County (Washington State Office of Financial Management, 2018). Pending policy changes and the future economic conditions of King County, as well as those insending areas, may lead migration to become a smaller component of King County's growth over time (Washington State Office of Financial Management, 2018).

King County's population is growing and diversifying rapidly, largely as a result of internal and international migration. In contrast, fertility is contributing far less to King County's growth. These declining fertility rates combined with increases in life expectancy have meant that King County's population is likely to become progressively older, though that process is partially offset by the younger age profile of migrants. All of these changes, however, exhibit considerable variability across racial and ethnic groups. These past trends are crucial to keep in mind and provide the basic inputs to our forecast models.

Significance of Small Area Projections

The complexity of population change and growth highlights the value of projecting population change at geographic levels and demographic categories that help reflect that nuance and complexity. Small area population projections provide more detailed estimates of future

community needs than do projections made at larger geographic levels (i.e., national, state, county) (Klosterman, 1990). As such, small area projections allow policymakers and stakeholders to target resources to particular areas that may be changing especially rapidly, that exhibit unique population compositions, or that are geographically isolated. Historically, public and private sectors have used small area projections in a number of applications, including identifying housing demand (Mason, 1996; Siegel, 2002) and changing consumer profiles and preferences (Murdock and Hamm, 1994; Thomas, 1994), planning for economic development (Swanson et al., 2010), targeting business development (Johnson, 1994), and assessing the short and long term effects of major events (Swanson and Pol, 2008).

In the context of this project, small area projections are particularly valuable for unmasking trends that are often overlooked at a larger level of analysis and then equitably targeting resources within King County. High resolution demographic projections allow us to think about sub-county variation in terms of population distribution and needs, clearly link the location of existing facilities with population growth and demands, and leverage existing, tract-level measures of well-being to better understand how population dynamics may change over time. Without these projections, we may have an incomplete understanding of where populations are growing and shrinking and which areas might be in particular need of investment.

Currently, King County relies on population projections created by the Office of Financial Management (OFM) and the Puget Sound Regional Council (PSRC). OFM produces projections of the state population through 2040 by age, sex, race and ethnicity using a cohort component method, as well as producing county-level projections by age and sex. The PSRC produces a macroeconomic forecast that captures regional population changes by employment, wages, household size, income and age through 2050. The Macroeconomic Forecast is an input to PSRC's land use and travel forecasting, and provides the growth assumptions used in their regional growth strategy. The PSRC and OFM forecasts are within close range of one another.

However, neither entity produces small area forecasts of King County by age, sex, race and ethnicity at the Census tract or HRA levels. As such, our understanding of how King County's demographic composition might change and how that change may vary within the County is limited. Our project helps fill that gap by producing Census tract and HRA population projections for King County by 5-year intervals to 2045, disaggregated by sex, race, ethnicity, and 5-year age groups (Exploring Our Future: King County Forecasts to 2045, 2020). Our projections complement existing information tools and coincide with existing forecasts to fill a crucial data need for county planners and policymakers.

Objectives

The Population Health Initiative's Applied Research Fellowship team aimed to achieve the following objectives:

1. Develop a method for producing small area projections that is reasonably robust and can be used to produce projections by age, race, ethnicity, and sex.
2. Produce Census tract- and HRA-level population projections by sex, race, ethnicity and 5 year age groups for King County, in 5 year intervals from 2020 to 2045.

3. Develop a visualization tool that showcases a graphical representation of the UW projections that allows users to explore the changing dynamics of King County's population over time by sex, age, race and ethnicity, within Census tracts and HRAs.
4. Utilize these projections to provide policy-relevant insights into how King County neighborhoods and small areas are changing in the coming decades by identifying potential population challenges and responses and informing future resource distribution.

These aims helped us provide insights into following research questions:

1. What do we expect the distribution of King County's population to be at the tract and health-reporting area level by sex, race, ethnicity, and age between 2020-2045?
2. Where are people expected to be living in King County (at the tract and health-reporting area unit level) and how does that vary across sex, race, ethnicity, and age?
3. How do these projections inform policy-relevant questions such as the effectiveness of current facility locations, future facility locations, and potential resource challenges King County might face in the future?

Data and Methods

Data

Our projections were created using OFM's annual estimates of the population by 5-year age groups, sex, and race and ethnicity at the tract level (Washington State Office of Financial Management Forecasting Division, 2019). We use data from 2010 and 2015 to inform our projections.

Race and Ethnicity

In our projections, we utilize the racial and ethnic group categories employed by OFM in their population projections. We combine individuals of Hispanic origin, regardless of race and ethnicity, into a singular Hispanic category. This results in seven mutually exclusive race and ethnic groups: Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Non-Hispanic American Indian and Alaskan Native (AIAN), Non-Hispanic Native Hawaiian and Other Pacific Islander (NHOPI), Non-Hispanic Multirace (Two or more races), and Hispanic. We drop the Non-Hispanic modifier for the first 6 groups in presenting our results and figures. More information about how OFM produces their small area population estimates can be found on their website.

Projections

At the core of population projections is the demographic balancing equation:

Ending Population = Starting Population + (Births - Deaths) + (In-Migration - Out-Migration)

The demographic balancing equation indicates that for a given geographic area of interest, the population at a given time point is equal to the size of the population at the starting time point,

plus the number of births and in-migrants to the area of interest over the time period, net of the number of deaths and out-migrants during the same time period.

Most population projections are produced using the cohort component method, which accounts for changes in the population size of age- and sex-specific groups due to births, deaths, and migration. In other words, data on the number of expected births, deaths, and in- and out-migrants for the area of interest are needed to produce projected population counts into the future.

Hamilton-Perry Method

Our projections utilize the Hamilton-Perry (HP) method to create the Census tract-level projections, which we aggregate to HRA and county-level projections. The HP method is a variant of the cohort component method. It makes several simplifying assumptions about the components of population change, namely, that observed changes in population size capture the effects of fertility, mortality, and net migration. More specifically, the HP method estimates population change using only data on population counts of different age- and sex-specific groups from two time points for the geographic area of interest. Because data on fertility, mortality, and migration rates are often unavailable for small areas, the HP method is an ideal way for measuring and projecting population change at the Census tract level.

The HP method projects population change using two primary measures--the Cohort Change Ratio (CCR) and the Child Woman Ratio (CWR).

Cohort Change Ratio

The CCR captures the change in the size of a given population from one period to the next and thereby proxies for age-specific population change arising from survival and in-migration, net of mortality and out-migration. For example, if we are interested in the change in the size of the cohort of 20-24-year-olds from 2015 to 2020, we would represent that with the following equation:

$$ {}_5CCR_{20} = {}_5P_{25,2020} / {}_5P_{20,2015} $$

Here, ${}_5CCR_{20}$ would represent the change in the size of the cohort of 20-24-year-olds in 2015 when they have aged to 25-29-years-old in 2020. ${}_5P_{25,2020}$ represents the population of 25-29-year-olds in 2020 and ${}_5P_{20,2015}$ represents the population of 20-24-year-olds in 2015. A CCR value less than 1 indicates that the population in question has shrunk across the time period through mortality and/or out-migration, while a value greater than 1 indicates that it has grown through in-migration.

The CCR can be calculated for various geographic levels, including Census tracts, counties, or regions, and can be calculated separately by sex, race and ethnicity, and other demographic characteristics. Here, we calculate a CCR for each age-, sex-, and racial and ethnic-specific combination.

Child Woman Ratio

The CWR, in contrast, proxies for fertility by measuring the ratio of the child population to the population of women of childbearing age. The CWR is calculated separately for male and female children aged 0-4. If we are interested in the projected size of the male population of 0-4-year-olds in 2020, we could measure it with the following equation for the CWR:

$$CWR_{MP} = {}_5MP_{0,2015} / {}_{30}FP_{15,2015}$$

$${}_5MP_{0,2020} = CWR_{MP} * {}_{30}FP_{15,2020}$$

Here, ${}_5MP_{0,2020}$ represents the estimated size of the male population aged 0-4 in 2020, which is calculated from the size of the 0-4-year-old male population (${}_5MP_{0,2015}$) over the size of the population of childbearing women aged 15-45 in 2015 (${}_{30}FP_{15,2015}$). This creates a proxy for the fertility rate for infant males, which is presumed to persist into the next period and so apply to women of childbearing age in 2020. As such, the 2015 pseudo-infant male fertility rate is multiplied by the childbearing woman population in 2020 (${}_{30}FP_{15,2020}$) to yield the expected infant male population in 2020. This process is then repeated to produce an estimate for the female population aged 0-4 in 2020. Here, we calculate a CWR for each race and ethnic group, as fertility patterns have been observed to differ by race and ethnicity (Washington Department of Health, 2019).

Smoothing

Because the HP method presumes that past population change will continue into the future, it can create unrealistic population change scenarios in areas where rapid population growth or decline has taken place. For instance, areas with small, rapidly growing populations may be projected to see continued, exponential growth into the future. Similarly, the time period being examined in constructing the CCRs and CWRs can also have an effect on the magnitude of the projected population numbers. Areas that see a sudden increase or decrease in population would be projected to see sustained growth or decline, when in actuality the change in population size was a unique event, and average population change may in fact be quite stable.

To mitigate issues of unreasonable growth in geographies with small, rapidly growing populations, we implement a variant of a smoothing method originally applied to small area forecasts in Japanese prefectures (Inoue, 2017) and Washington State (Inoue, 2017). We created a multi-stage smoothing process that allowed us to produce our tract level population forecasts incrementally, first computing county level projections, then creating county-level projections by race smoothed to the overall county projections, and then utilizing this information to inform our tract level projections which themselves go through a two-step smoothing process. This approach allows us to account for differential age, sex, and race and ethnicity distribution patterns that exist in King County. In other words, smoothing allows us to produce projected population numbers that are not heavily skewed by differential population growth patterns and changes in different parts of the county. A more detailed explanation of how the smoothing works is available in the Technical Appendix.

Further Modifications

Even though employing a smoothing method yields reasonable projected population numbers for most Census tracts, it does and can lead to unrealistic estimates in tracts with substantially different population dynamics. Specifically, group quarter populations, or populations that reside long-term in housing or facilities that are organized by a third party and provided to individuals or households (U.S. Census Bureau, 2020), tend to exhibit unique population dynamics. Group quarters can include college dormitories, nursing homes, and prison and correctional facilities. These populations tend to exhibit unique age profiles and their growth may be influenced by the policies and size restrictions of facilities.

In King County, the University of Washington area contains a high percentage of residents residing in group quarters, specifically in college dormitories. Due to the university's administrative and admission policies and the proximity of the area to the campus, over time the total population in this area is expected to largely remain around the same size, in the same age range, and with many continuing to reside in student housing. Even though the smoothing method can capture differential growth patterns across King County, it does not capture the population dynamics and growth patterns in the University of Washington area well. In our projections, we assume there will be no growth in the two Census tracts that make up the University of Washington area. In other words, we will be holding the population of these two tracts constant in our projections going forward.

Results

County-Level Projections

Total Population

We first present the results from our county-level projections. These projections are aggregated from our tract-level projections. As illustrated in Figure 1, our UW projections anticipate that King County will grow by almost 600,000 between 2020 and 2045, with that growth being quite linear over time.

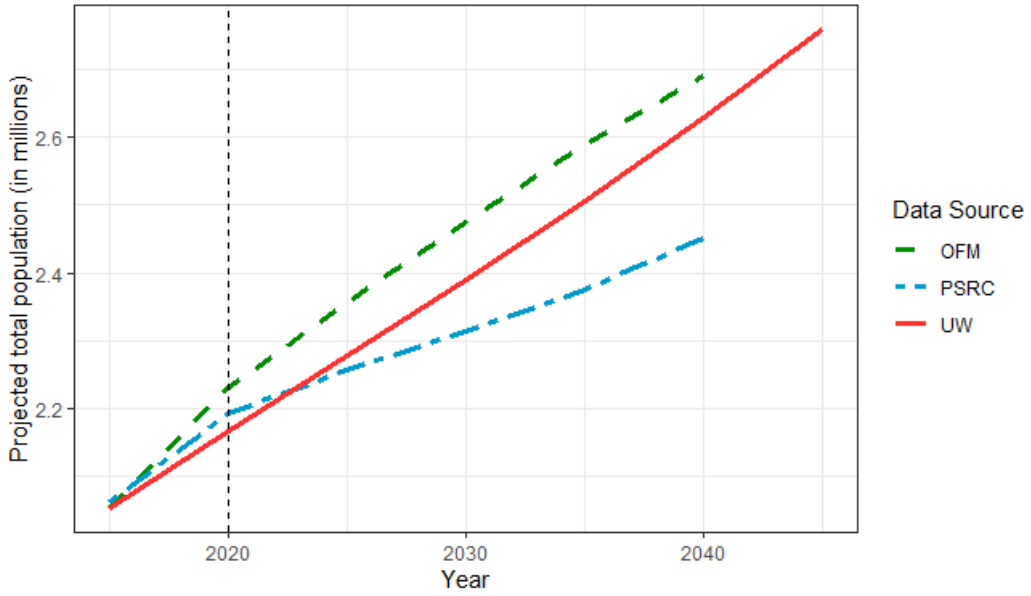

Figure 1: The projected population of King County from 2020-2045 as estimated by UW, PSRC, and OFM estimates.

Comparing our results to those produced by OFM and PSRC, we see that our projections fall between those calculated by OFM and PSRC, and that we project comparable levels and trajectories of population growth. While we utilize different methods and focus on different demographic groupings than do the OFM and the PSRC, the comparability of our results to their projections lends credibility to our results. The PSRC projections are by total population counts for all Census tracts in King County, while the OFM projections are by age, sex, and race and ethnicity at the state level, and by age and sex at the county level.

Race and Ethnicity

Figure 2 disaggregates our population projections by race and ethnicity. Each colored band in Figure 2 represents the percentage of the total population in King County that is comprised of a particular racial and ethnic group. The y-axis represents the cumulative percentage of the total population that is made up of the racial and ethnic groups present in King County. In this figure, we observe that by 2045, Whites will comprise approximately 50% of King County's population, which represents a substantial decline from 2000 when Whites represented 75% of King County's population (Figure 2). This echoes national statistical projections produced by the Census Bureau, which forecasts that the nation will become "minority white" in 2045 (Colby and Ortman 2015). In contrast, the fastest growing racial and ethnic groups in King County are projected to be Asians, Hispanics and those who identify as Two or More Races (multiracial). This is represented by the thickening color bands for each of these groups over time. We notice that the Black and American Indian and Alaskan Native (AIAN) populations remain fairly stagnant in terms of growth throughout the projected 25 years.

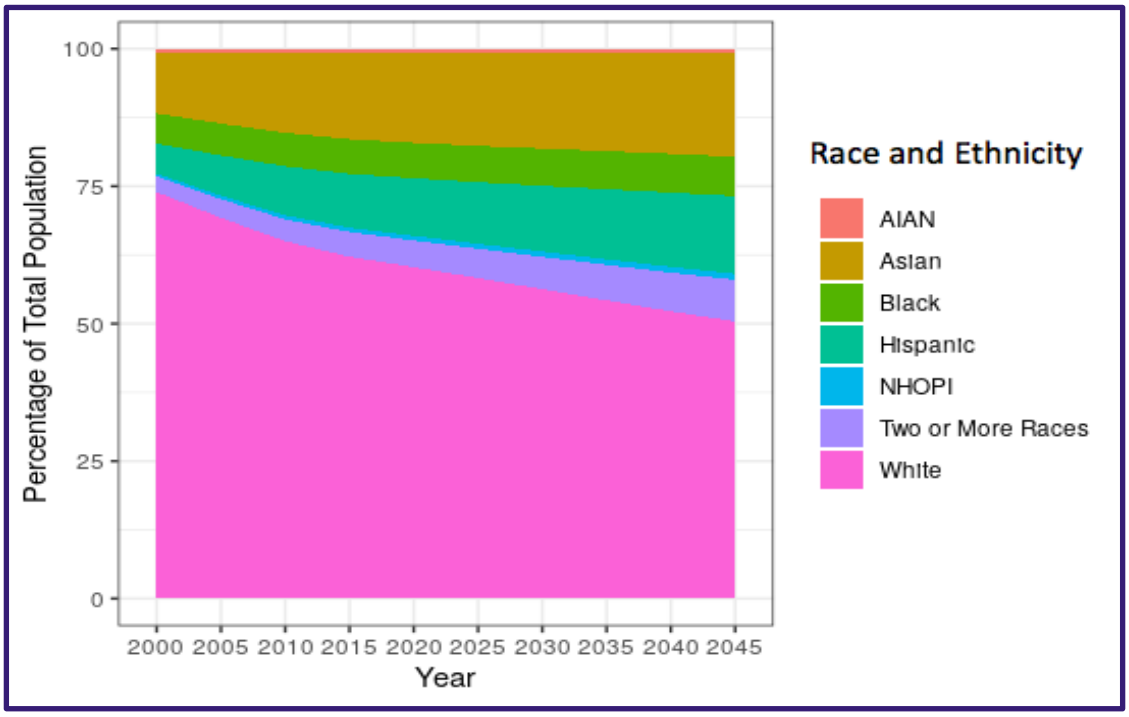

Figure 2: The estimated population composition of King County from 2000-2015 and the projected population composition of King County from 2020-2045 by race and ethnicity; produced from UW's population projection estimates.

Age

Figure 3 illustrates the projected county-level population disaggregated by age groups. Each color band represents the projected size of a given age group in millions. The total size of the stacked bars for a particular year represents the projected size of the total King County population in millions. As can be seen in Figure 3, all age groups are growing in size. However, the 15-44 age group is projected to be the largest age group in the coming 25 years, consistent with past trends. The 0-14 and 45-64 age groups remain fairly constant as they are growing proportionally to the overall county growth.

Figure 3 also highlights that King County's older population is becoming larger over time and its rate of growth is fastest among all age groups. The growth of the aging population points to the importance of investing in resources for aging and elderly populations. Investment opportunities could include offering more programs at senior centers or expanding outreach to isolated seniors.

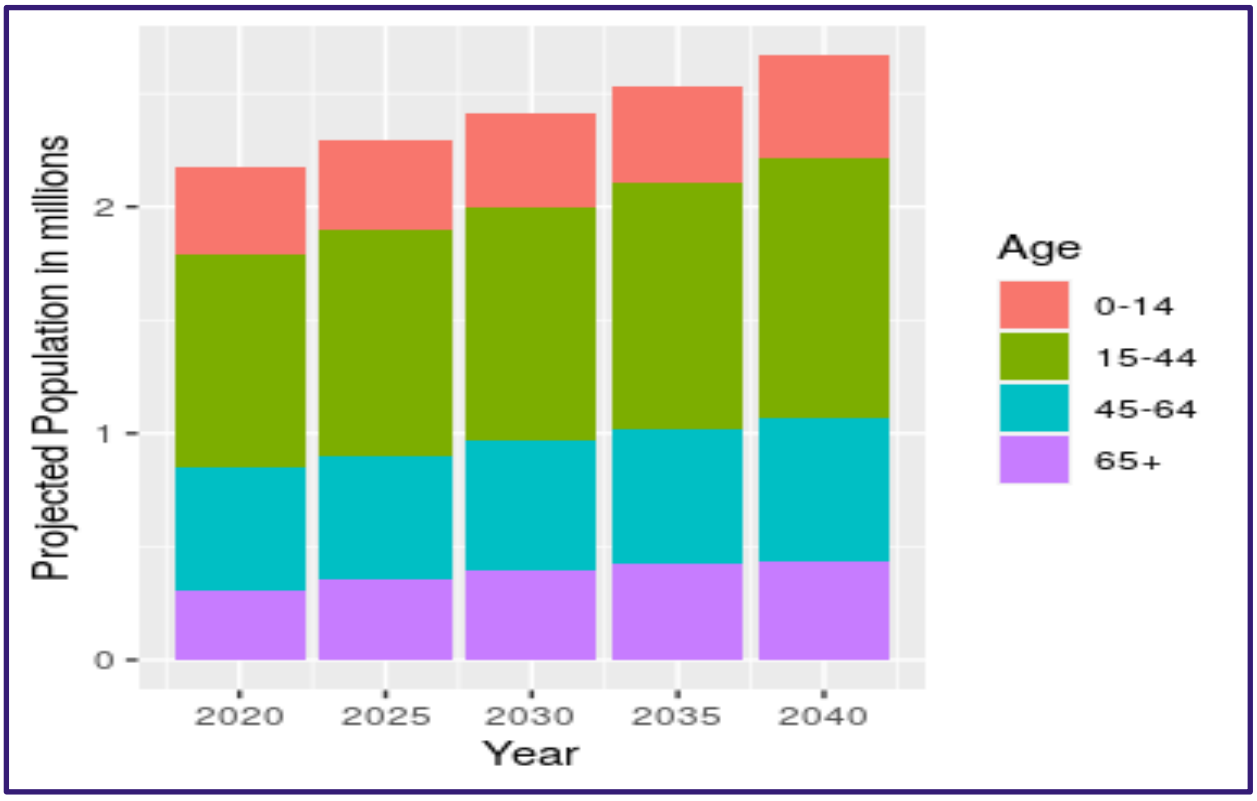

Figure 3: The projected population of King County from 2020-2045 by age group; produced from UW's population projection estimates.

Figure 4 disaggregates the county-level projections by age, race, and ethnicity, focusing on the three racial and ethnic groups that comprise the largest share of King County's population now and likely going forward--Asians, Hispanics, and Whites. In Figure 4, each panel represents a

particular age group, including 0-14-year-olds, 15-44-year-olds, 45-65-year-olds, and those who are 65+. Each line in the panels represents the estimated size of the Asian, Hispanic, or White population in that age group from 2000-2015 and the projected size of the Asian, Hispanic, or White population in that age range from 2020-2045 in 100,000s. For example, the red line for 15-44-year-olds shows that the 15-44-year-old Asian population has been growing quite rapidly and is projected to grow to over 200,000, from a population of about 100,000 in 2000. Figure 4 illustrates that changes in the age distribution of the County are not occurring uniformly across racial and ethnic groups.

Indeed, the Asian and Hispanic population are growing the fastest in the 15-44 age group. This age range comprises the largest portion of the labor force, and has also been classified as the Childbearing Age Group in our projections. When looking at Childbearing Age Projections for Women, we observe similar patterns to those observed here, with higher growth rates for Asians and Hispanics, resulting in these groups comprising a larger portion of women of childbearing age over time.

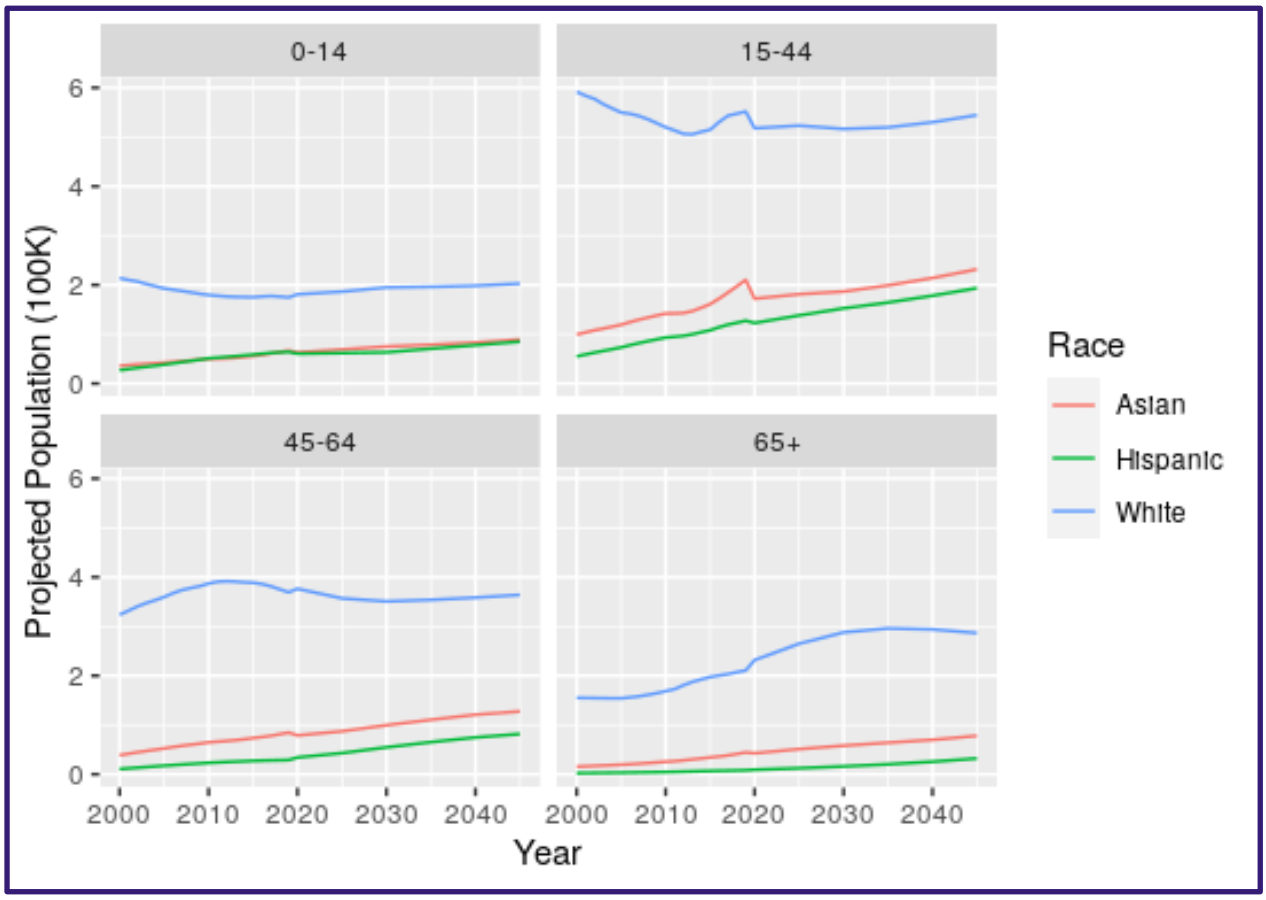

Figure 4: The projected population of King County from 2020-2045 by age group for Asians, Hispanics, and Whites; produced from UW's population projection estimates.

In the 0-14 age group we see that the Asian and Hispanic growth is fairly convergent throughout the projected twenty five years. When taking a look at the 45-64 age group, we notice that there is slower growth for both the Asian and Hispanic population in that cohort in comparison to the other age groups.

Another important trend to observe is that the White 65+ age group is expected to grow in the next decade and that there is anticipated to be a plateau in growth for the White population from 2030 onwards for all age groups, contributing to the recurrent trend of a shrinking White proportion of the population that we observe throughout our projections.

Small Area Projections

The preceding results are important for understanding and anticipating changes in the County's demographic composition over time. However, our projections can also be examined at the tract- and HRA-level to provide greater insights into the geographic variability of these changes within the county. These projections are high resolution and have high levels of granularity because small geographic areas and multiple population characteristics can be assessed and compared. In order to thoroughly present our projection results, we developed an interactive visualization tool using the R language. The UW projection tool visualizes our population projection results on a map of King County, which shows our projections by sex, age, race and ethnicity. As such these projections can help unmask population dynamics and geographic distributions that differ across demographic groups. Consequently, our tool can help identify areas at risk of being underserved and assist with evaluating impacts of proposed policies.

Additionally, our small area projection tool includes additional layers of information about the location of infrastructures such as public health and community clinics, services for women, infants and children, or current and planned public transportation. In viewing the projection of a subpopulation of interest overlaid with current resources, city and county officials can identify areas of future high and low need, consider where to site new facilities, and think about re-allocation of resources or co-location of services. We encourage those who are interested in exploring these projections in more detail to visit the interactive map and explore these projections in more detail.

Applying UW's Small Area Projections: Three Example

Because our small-area projections can be used to assess a wide variety of research questions, we highlight their power and flexibility by focusing on three specific, policy-relevant questions our small area projections can provide insight on:

1) How will the aging population be distributed throughout King County going forward?
2) What geographic and demographic changes do we expect to see in the population of childbearing women?
3) How will racial and ethnic segregation change across King County?

Aging Population

Due to increases in life expectancy and the tendency for individuals to age in place (Medina et al., 2020), King County's population is becoming progressively older, on average. The UW

projections predict that the oldest age cohorts will experience the largest growth over the forecast period, with a more than doubling (115%) of the 85+ population and near doubling (94%) of the 75+ population. Figure 5 below shows mean age disaggregated by sex and race and ethnicity, and demonstrates that all racial and ethnic groups in King County are expected to become older, on average, between 2020 and 2045. The White population has been and is projected to remain the oldest on average. The multiracial category has been and is projected to remain the youngest, on average, though it is important to note that this racial category is highly heterogeneous and remains quite small relative to other racial and ethnic groups in King County. In addition, the smoothing method may produce artificially inflated projection of mean age due to the relative size and age of the White population, which acts to increase mean age especially for small groups with younger mean age.

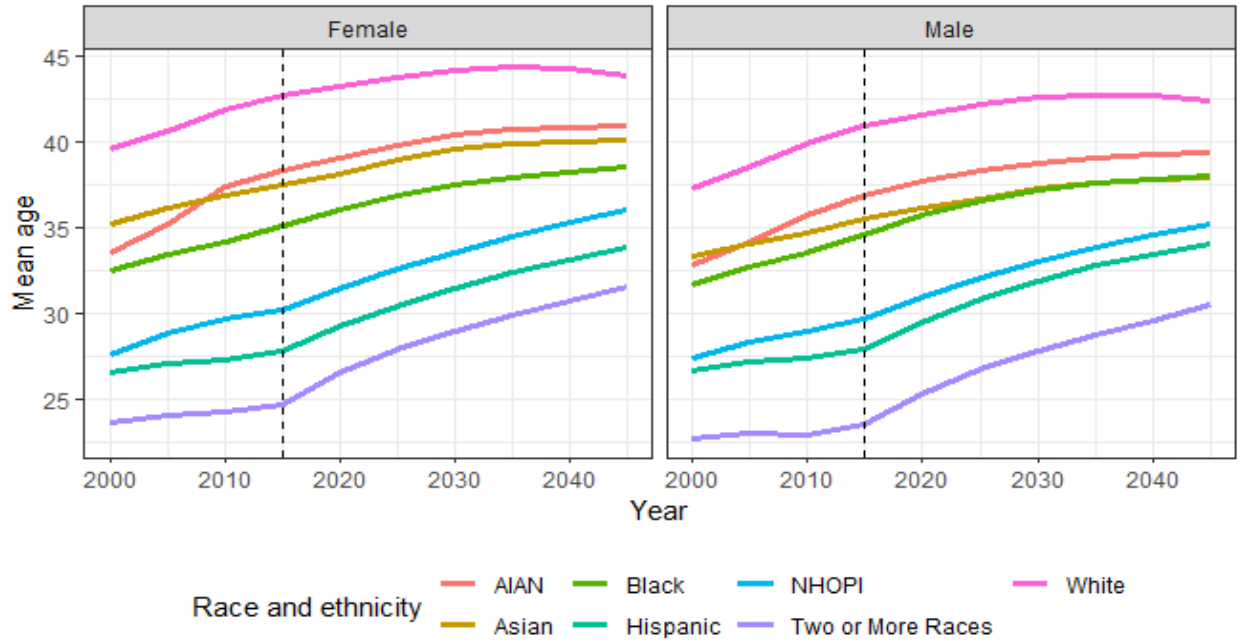

Figure 5: The projected mean (average) age of King County's population from 2000-2045 by sex, race, and ethnicity; produced from UW's population projection estimates.

This projection alone is not surprising, and conforms to recent trends in King County and the United States at large. Nevertheless, there are numerous policy and planning implications associated with this finding, including the need to expand public transport services, increase senior services such as long term care facilities and senior centers, and increase education and jobs for eldercare.

Additionally, the UW projections enable a detailed look at the geographic distribution of the aging population. In examining the tract-level 2045 projections for the 65+ population for Whites and Asians in Figure 6 below, we can see that these racial and ethnic groups are expected to be geographically segregated, with the 65+ White population largely located in the eastern portion of the County and the Asian population largely located in the western and southern portions of the County. We observe similar patterns for the Hispanic and Black populations as

we do for the Asian populations, with even greater clustering observed for Hispanics and Blacks than for Asians. These geographic variations in where populations are expected to age has important impacts on resource allocation and service provision. Disaggregation by race and ethnicity unmasks these differential geographic distributions and allows for services and resources to be targeted to racial and ethnic populations who have been traditionally underserved.

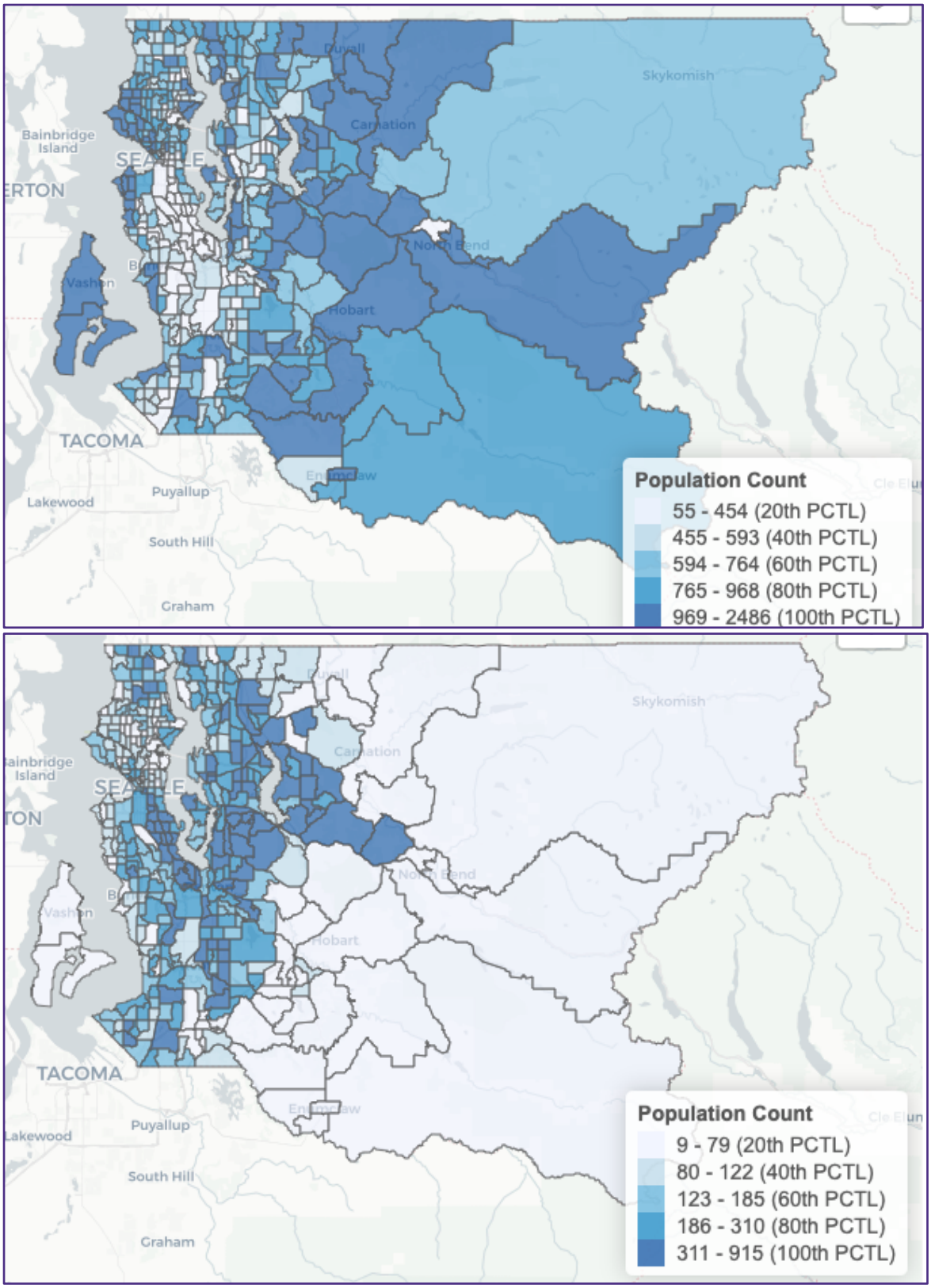

Figure 6: The projected population of 65+-year-old Whites (top) and Asians (bottom) in King County in 2045; produced from UW's population projection estimates.

Women of Childbearing Age

As discussed above, we project a rapidly diversifying King County, and women between the ages of 15 - 44 are no exception. This subgroup is targeted for reproductive health services including contraception and federal, state and local programs for women, infants and children, including King County's own Best Start for Kids. Over the course of the forecast period, women of childbearing age consistently account for approximately 21% of the total population of King County. However, we project this population to become more racially and ethnically diverse, as illustrated by Figure 7. This figure shows the projected percentage of King County's total population that is expected to be made up of women of childbearing age of each race and ethnicity. For example, the orange line shows that, in 2020, just under 12 percent of King County's total population is projected to be White women of childbearing age, and this percentage is expected to decline to under 10 percent by 2045.

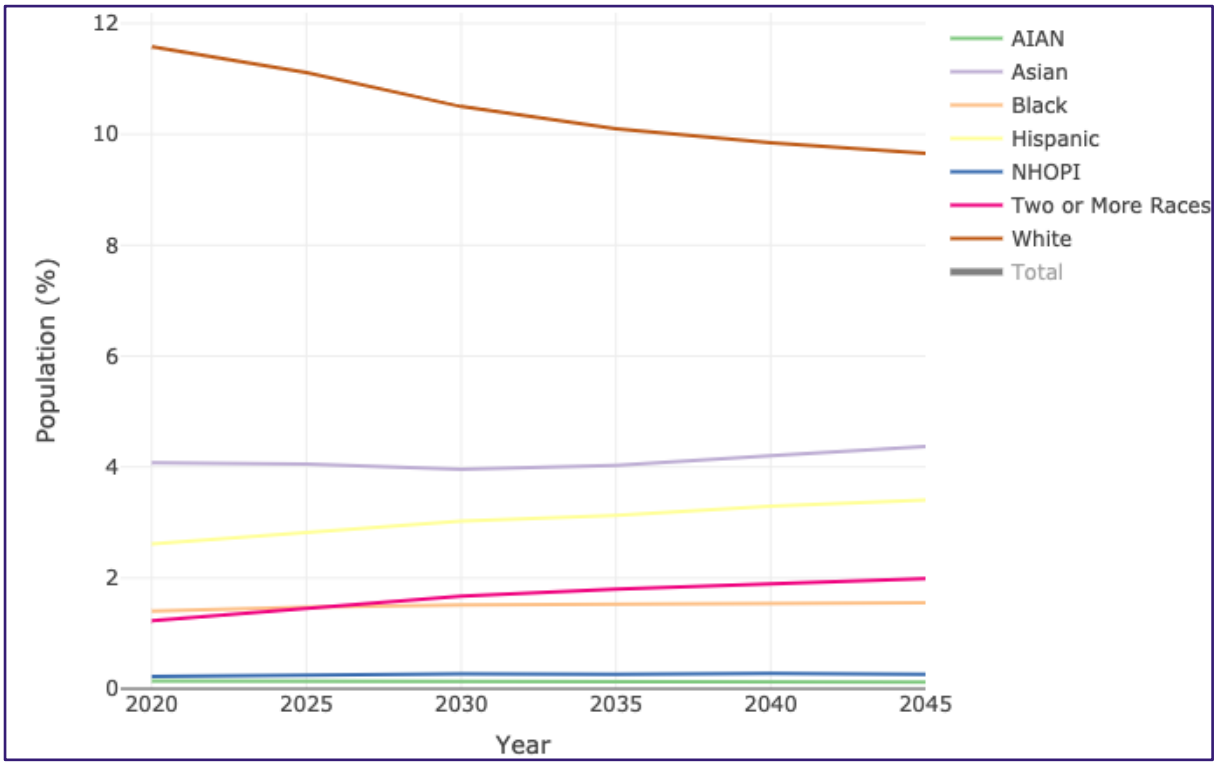

Figure 7: The projected proportion of King County's population comprised of women of childbearing age for each race and ethnicity; produced from UW's population projection estimates.

From 2020 to 2045, the racial and ethnic composition of this subpopulation is anticipated to shift, with steady gains in the share of Asian, Hispanic and Two or More Races populations and, as mentioned, decreases in the proportion of the White population. This diversifying population of women of childbearing age suggests the need for services and programs that are attuned to racial and ethnic backgrounds, as well as the needs of individuals who may have migrated recently from elsewhere in the U.S. or from abroad.

Moreover, as discussed for the 65+ population, we observe racial and ethnic clustering of populations in particular geographic areas. As such, the UW forecasts at the tract- and HRA-levels are useful for identifying potential locations for clinic and program sites, among other planning activities.

Another trend seen in the UW projections for women of childbearing age is a geographic diffusion of this population from central Seattle to south and east King County. Figure 8 provides insight into this projected shift.

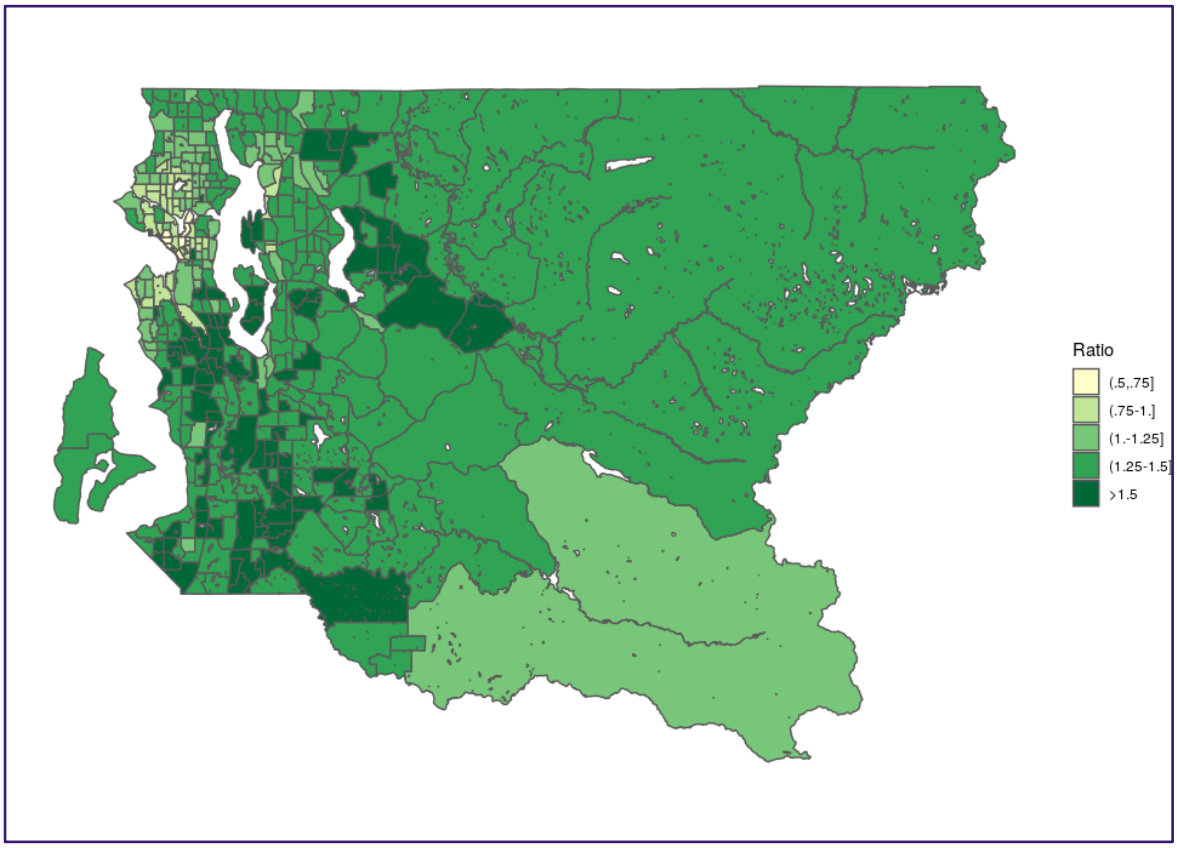

Figure 8: The projected ratio of women of childbearing age in 2045 (projected) to women of childbearing age in 2015 (estimated) by tract; produced from UW's population projection estimates.

Figure 8 presents the ratio of the population of women of childbearing age in 2045 as estimated from our projections to the population of women of childbearing age in 2015 as estimated from existing data. Lighter areas represent tracts that are expected to experience declines in their populations of women of childbearing age, while darker areas are expected to experience gains. Tracts projected to experience decreases in their populations of women of childbearing age are highly concentrated in the area from central Seattle to Green Lake, whereas tracts that are projected to experience gains in this subpopulation are spread over a much larger geographic area in south, east and even in north King County. Furthermore, noting that we project an average 26% growth for this population between 2020 and 2045, we can see that many tracts

are outpacing average growth (the two darkest colors in Figure 8), while a relatively small number account for the major losses in this subpopulation (the two lightest colors in Figure 8). This indicates a future need for services to be made available in a larger geographic area than previously, with focuses on growing hubs in south and east King County.

Segregation Measures

As illustrated above, our projections can help us understand how subpopulations of interest may be spatially distributed throughout King County. An important issue associated with the spatial distribution of the population is racial and ethnic residential segregation. Residential segregation can shape lives in important and myriad ways, influencing individuals' and families' access to resources and racial and ethnic inequity (Charles, 2003; Massey & Denton, 1993; Quillian, 2012; Sharkey, 2013; Williams & Collins, 2001). Our projections provide us with the valuable opportunity to examine how segregation within King County might change in the coming decades.

We examined the segregation patterns in King County by applying the Multi-Group Entropy Index to our projections (White, 1986). The Multi-Group Entropy Index is a measure of the evenness of the spatial distribution of different groups (White, 1986). In other words, the index measures whether racial and ethnic groups are spread evenly across a geographic area such as a county. In this case, low segregation or low entropy would indicate that all racial and ethnic groups are represented in similar proportions across the neighborhoods within a county, whereas high segregation or high entropy would indicate that racial and ethnic groups are highly clustered such that some groups are highly represented in particular neighborhoods and not represented in others. The Entropy Index varies between 0 and 1, with 0 representing minimum segregation, where "all areas have the same composition as the entire metropolitan area," and 1 representing maximum segregation where all areas contain only one group (Iceland, 2004). In the Multi-Group Entropy Index, segregation can be further decomposed to examine how subgroups contribute to the total segregation measure.

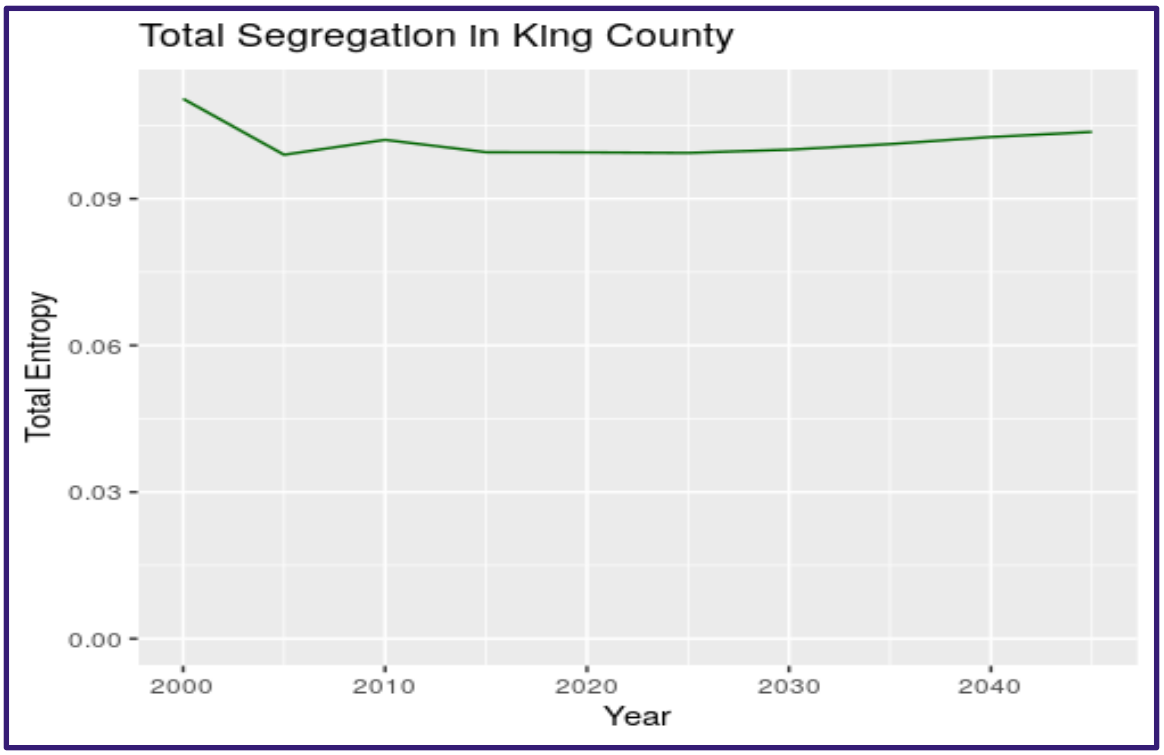

Figure 9: The projected level of segregation (entropy) from 2020-2045 in King County; produced from UW's population projection estimates.

Figure 9 highlights King County's total segregation. The total segregation is slightly less than 0.10 from 2005 onward. Due to high variance in the data between 2000-2010, we are unable to assert that segregation is increasing by solely looking at the overall index.

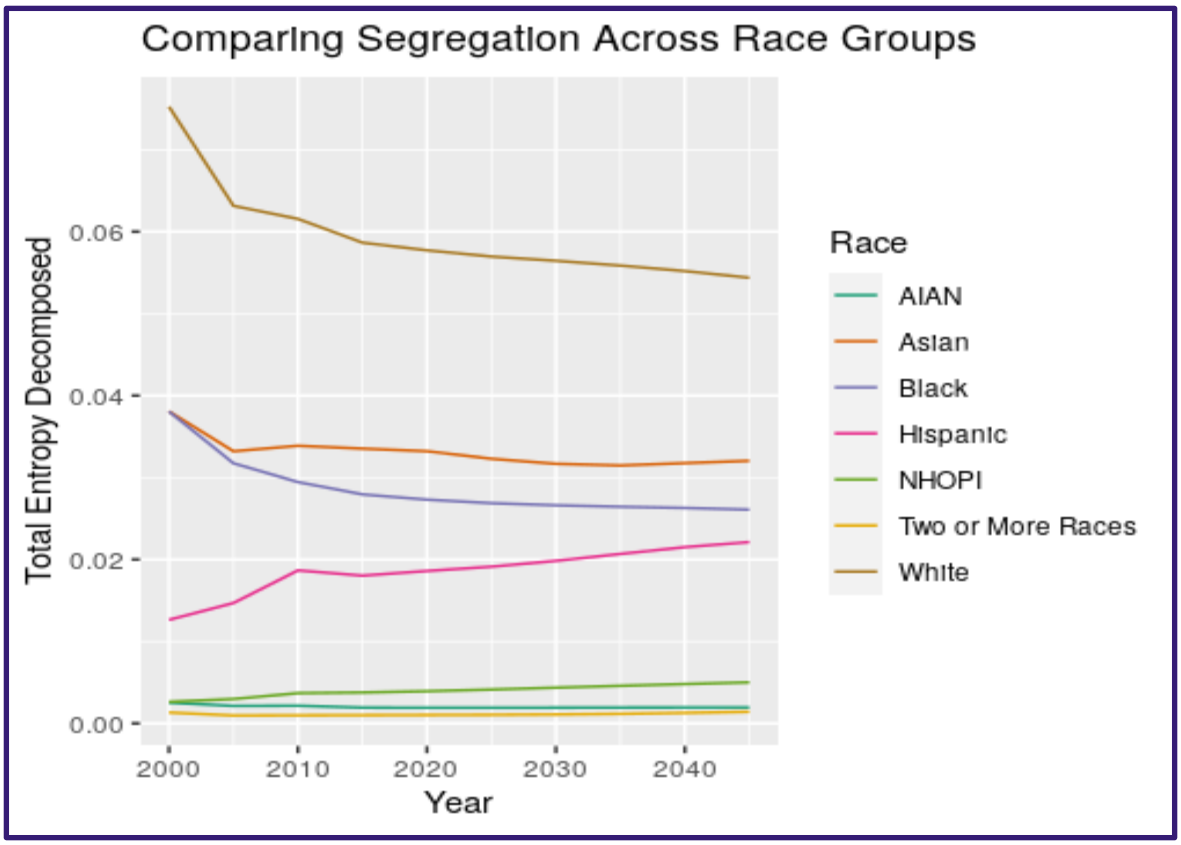

Figure 10: The projected level of segregation (H = entropy) from 2020-2045 by race and ethnicity in King County; produced from UW's population projection estimates.

However, when decomposed by race and ethnic group, Figure 10 highlights that segregation is increasing for the Hispanic group. The lines in Figure 10 represent how much each group is contributing to total segregation. Therefore, it is possible that the slight increase observed in total segregation in King County could be attributed to the increase in Hispanic segregation.

Conclusion

Overview

In light of increasing demands for small area population projections for King County and many other jurisdictions across the U.S., the 2020 Population Health Initiative Applied Research Fellowship Program sought to create sub county population forecasts at the Census tract and HRA levels by sex, race, ethnicity and 5-year age groups for King County from 2020 to 2045. The Fellowship Program also aimed to validate these results against the projections produced by OFM and the PSRC and to develop an interactive tool that allows users to flexibly explore these projections based on their own interests. More broadly, this project aimed to develop a reasonably robust small area projection method and interactive mapping resource that could be adapted for other contexts across the U.S. In doing so, we hope our projection method can help fill a critical need and allow local stakeholders to better anticipate potential population

challenges and consider how resources might be distributed to meet the needs of their changing populations.

The Hamilton Perry method with a multistage smoothing process that we developed to create small area, race and ethnicity specific projections is adapted from methods created by Inoue for Japan and Washington State (2017) and Swanson et al. (2010). This method helps address the limitations faced by small area projections, namely the lack of data on components of population change for small areas; the small size of small area populations, particularly when broken down by race and ethnicity; the tendency for racial, ethnic, and age groups to be clustered within particular neighborhoods and administrative areas, and the fact that population changes within small areas are often highly influenced by the population changes occurring in adjacent areas. To showcase our projections, we developed an interactive, online mapping tool that allows users to explore King County's changing demographics over time at the tract- and HRA-level. This tool provided us with the ability to explore projected subcounty population trends, examine variations in King County's population dynamics and geographic distributions across demographic groups, identify areas with emerging needs, and provide insight into various policy-related questions.

Limitations

Although our projections provide important information about King County's changing subpopulation dynamics and spatial heterogeneity, several limitations exist. First, no projections, including ours, are determinative of the future. Rather, they are reflective of past and present trends in population dynamics, and how they may shape future population trajectories should these trends continue to hold. Also, projections are inevitably limited by the data available to create them. Indeed, because we do not have data on fertility, mortality, and migration rates at the tract-level, we instead rely on changes in the population sizes of racial, ethnic, sex, and age groups as a proxy for these processes.

Furthermore, projections cannot encompass the full range of social processes that may impact the future. Perhaps most notably as we consider the possible impacts of the COVID-19 pandemic, our model does not incorporate economic shocks but rather assumes sustained recent growth patterns. Because economic downturns are known to have impacts on migration and fertility (Cherlin et al., 2013; Johnson, 2014; Sobotka et al., 2011), we expect our projection results to differ should the economic calculus shift. In addition, because a sizable proportion of the recent growth in King County has been due to immigration, we may anticipate population growth to slow under a different immigration policy regime. Our model also assumes that there will not be significant changes to fertility and mortality for particular racial, ethnic or age groups. Nevertheless, shocks or changes to these recent trends can be incorporated by changing the specifications of the model.

Additionally, our projections lack detail on native born versus foreign born status among King County residents. This distinction is important as immigration has been a major driver of King County's growth, with 23.6% of King County residents identifying as foreign-born (King County Office of Economic and Financial Analysis, 2020). Given the important role immigration has

played in King County's growth over time, including as our projections suggest the rapid growth of the Asian and Hispanic populations which much of the foreign-born population resides within, understanding these demographic characteristics may be critical for shaping policy and targeting resources in the coming decades.

A similar issue is that the data used in our projections lack detailed racial categories which belies the heterogeneity of opportunity, socioeconomic status and epidemiologic profiles within each of the seven racial and ethnic categories we forecast. The Black population, for example, is comprised of African-Americans and recent African immigrants from various countries, groups which have different norms of household creation, public service utilization and access to community resources, and socio-economic and epidemiologic profiles. This is true for every racial and ethnic group included in our forecast. Although such racial and ethnic details are not available to us, these nuances highlight the importance of not collapsing racial categories of diverse populations, as well as the importance of incorporating on-the-ground knowledge when interpreting our projections and the implications they may have for resource distribution.

A related issue is that, as the multiracial category makes distinct, race is socially constructed, and the existence and recent growth of this catch-all category indicates social processes as much as it does hereditary background or skin color. No doubt, this group is composed of individuals with highly variable racial and ethnic backgrounds, as the category name implies. However, we recognize that another dimension of the growth of the multiracial group stems from the social process of self-identification. How a person chooses to identify their race and ethnicity can and does shift over time due to a myriad of factors which are impossible to reflect in any demographic forecast (Pew Research Center, 2015). Our inability to reflect these processes is further exacerbated by the calculation of the Child Woman Ratio, which assumes that the child shares a race or ethnicity with their mother. However, children's racial and ethnic identities will likely be shaped by the races and ethnicities of both parents. As such, the multiracial category may grow over time as individuals increasingly identify with this category. While this is an important process, we are unable to fully capture it in our projections. Similarly, we treat sex as binary and unchanging due to data limitations in our ability to project individuals who do not identify as male or female or who change their gender identities over time. These are important limitations to consider when interpreting our results and further point to the importance of grounded knowledge of people and populations.

Finally, geographic areas are shaped in important ways by neighboring areas. While these spatial relationships are present at larger geographic levels, they will be especially important for understanding populations at the sub-county level, such as at the neighborhood- or tract-level. This is because these areas will exhibit frequent overlap in demographic profiles and will experience more exchanges of residents than larger geographic areas. Small area projections therefore require an assessment of population change for a given geographic area and for the area's neighbors. Despite their inherent imperfections, population projections--and small area projections, in particular--are an important source of information in community stakeholders' and policy makers' toolkits.

Future Considerations

The UW projections offer a glimpse into a possible future of neighborhoods, cities and King County at large, making them a valuable tool for policymaking and planning activities for a variety of contexts. Because of our ability to provide projections at the Census tract and HRA level, not just for age cohorts but for the seven normative racial and ethnic groups, the UW projections hold value as a tool for increasing equity in access to public services and resources across the county. Although our projections cannot predict the future, they suggest that King County is growing, aging, and diversifying rapidly, which has important implications for resource planning going forward.

While we are unable to explore the full range of possibilities for applying our projections to contemporary issues, we believe that the flexibility of our forecasting model and its output will provide policymakers and stakeholders opportunities to explore a number of questions concerning population growth going forward. For example, future simulations may consider changes in fertility rates in response to fluctuating economic conditions, declines in migration in response to federal immigration policy and sociopolitical contexts, or changes in mortality rates as a result of events like COVID-19, health care availability and innovation, or technological advances. Ultimately, our projections are ripe for future analyses to examine policy or population growth changes and explore nuanced scenarios that vary across age, race and ethnicity.

The changes we outline above are not unique to King County and are faced by many counties and jurisdictions across the U.S. By developing the methodology used here, we hope that our findings and tools can be adapted and used by policymakers and planners in other regions to better understand potential population changes and to plan for the resource needs that could be created by those changes. Indeed, our findings from these analyses highlight the importance of attending to the variability of populations of large and small geographic areas and suggest that to achieve equity, we must understand the diversity of people and places.

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Technical Appendix

In the following example, we illustrate how a CCR was calculated for each age-, sex-, and race and ethnic group combination for each Census tract in King County. In our forecasts, this multi-stage smoothing technique is also applied to compute a CWR for each sex- and race and ethnic group combination for all tracts in King County.

First, we compute a cohort change ratio for each 5-year age group at the county level, and do so separately by sex, temporarily ignoring race and ethnicity. Neither race and ethnicity nor tract information are utilized here. Note also that we do this, and all subsequent calculations of the CCR and CWR separately for the male and female populations.

We use this information to compute a county level smoothed CCR for each 5-year age and race and ethnic group combination. We do this by first calculating the raw CCR for each 5-year age and race and ethnic group combination. Next, we re-weight this estimate by the proportion of individuals in the county that fall into the given age range and race and ethnic group. We then further smooth our estimate by including the county level CCR calculated in the previous step, itself weighted by the proportion of individuals in the county that fall in the specified age range. This produces a smoothed county level CCR for each 5-year age and race and ethnic group. When the size of the race and ethnic group in question is sufficiently large, the degree of smoothing is minimal. Conversely, when the size of the race and ethnic group is small, its CCR will be inflated to be closer to the county average compared to its raw value.

We then extend this technique to compute a CCR for each 5-year age and racial and ethnic group combination for each tract. Here, we weigh the raw CCR for each 5-year age and racial ethnic group combination in each tract using the proportion of individuals in the tract that fall into the given age range and race and ethnic group. We then add the smoothed county level racial and ethnic group-specific CCR, which is weighted by the proportion of individuals in the county that are in the specified age range and race and ethnic group. This produces a smoothed tract level CCR for each 5-year age and racial and ethnic group. As before, when the racial and ethnic group in question is present in sufficiently large numbers in a given tract, the smoothed and unsmoothed estimates do not differ much. However, when the size of the racial and ethnic group in a given tract is small, the smoothed CCR will be closer in value to the smoothed county level CCR for the specified racial and ethnic group than to its raw value.

Performing this smoothing method is necessary in constructing tract-level projections as the population sizes of different census tracts can vary greatly; moreover, the age, sex, and race and ethnicity distribution can be drastically different in one tract compared to another. This is further compounded by many racial and ethnic subpopulations in King county tending to reside in clusters in certain areas of the county.