Special Report

THE IMPACT OF POPULATION STRUCTURE ON HEALTH DISPARITIES

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The Impact of Population Structure on Health Disparities

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This report highlights the use of population pyramids for illustrating health disparities between different racial/ethnic groups and length of time for changes in health to affect population structure. In addition, the current population structures for the major racial/ethnic groups in Chicago are presented. Projections are made to compare population pyramids in the year 2040 based on current disparate birth and death trends among Chicago racial/ethnic groups and those based on equalized death rates for all groups that would exist if racial and ethnic disparities in health were eliminated.

1 Why does population structure matter when comparing health disparities between different racial/ethnic groups?

Population pyramids are graphical representations of a country's fertility and death rates and can provide valuable information on the health of a population. There are three major shapes of population pyramids:

- Triangular
- Rectangular
- Inverted

The triangular pyramid has a wide base, indicating high birth and death rates (Figure 1a). The rectangular pyramid has an approximately equal base and tip, indicating equal birth and death rates (Figure 1b). The inverted pyramid has a narrower base than tip, indicating a falling birth rate compared to the death rate (Figure 1c). Each shape of population pyramid is a reflection of the health of the population it represents especially your chances of surviving at different age intervals (1). By examining the shape of a population pyramid, we can better understand the health conditions/outcomes of a population. Therefore, the shape of a population pyramid should be determined before making any plans to reduce health disparities between different racial/ethnic groups. For example, targeting a chronic disease of the elderly in a population that is predominately young, would have little impact on the mortality disparities of that population.

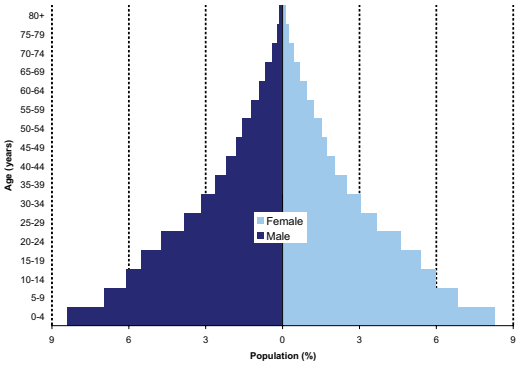


Figure 1a. An example of a triangular population pyramid (Both birth and death rates are high).This pyramid represents the 2000 population structure of Nigeria (2).

Birth rate = 40.2 births per 1000 population
Fertility rate = 5.7 children born per woman
Death rate = 13.7 deaths per 1000 population

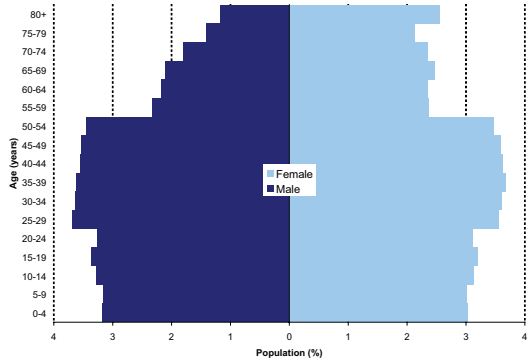


Figure 1b. An example of a rectangular population pyramid (Birth and death rates are approximately equal).This pyramid represents the 2000 population structure of France (3).

Birth rate = 12.3 births per 1000 population
Fertility rate = 1.9 children born per woman
Death rate = 9.1 deaths per 1000 population

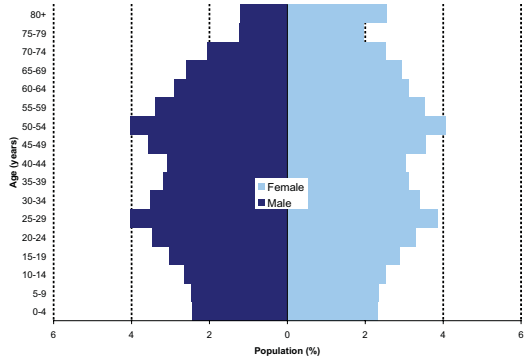


Figure 1c. An example of an inverted population pyramid (Birth rate is falling compared to death rate).This pyramid represents the 2000 population structure of Japan (4).

Birth rate = 10.0 births per 1000 population
Fertility rate = 1.4 children born per woman
Death rate = 8.2 deaths per 1000 population

2 How long does it take for health outcomes (i.e. prenatal care, better access to health care and insurance) to change the population structure?

The shape of a pyramid changes slower than health outcomes for individuals in the population. Individual changes need to accumulate to affect population outcome. In general, several decades are required to change a population pyramid from one shape to another. Figure 2 depicts a time series of U.S. population pyramids from 1950 to 2050. Table 1 details the birth and death rates associated with the population pyramids from 1950 to 2000. The birth rate decreased from 24.1 per 1000 to 16.7 per 1000 from 1950 to 1990, less than a 0.2 per 1000 decrease per year. The death rate also decreased slowly from 9.6 per 1000 to 8.6 per 1000, an average decrease of 0.025 per 1000 per year (5). Therefore, given that the basic determinants of pyramid's shape, birth and death rates, change slowly over several decades, the shape of a population pyramid will take a long time to change as well.

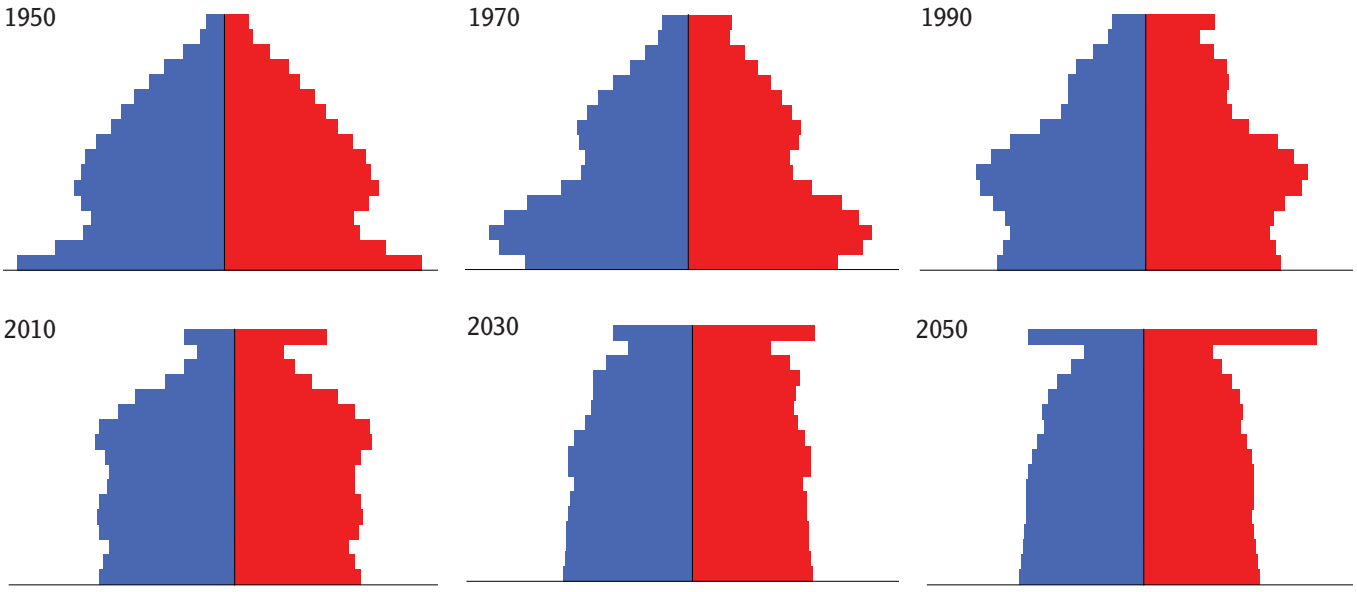


Figure 2. Time Series of US Population from 1950-2050 (projected for 2010, 2030, and 2050).

Table 1. Birth and Death Rates for the U.S. Over Time.

YEAR	BIRTH RATE	DEATH RATE
1950	24.1	9.6
1970	18.4	9.5
1990	16.7	8.6
2000	14.7	8.7

3 What are the current population structures for the major racial/ethnic groups in Chicago?

The population pyramids for Chicago and the 4 major racial/ethnic groups are shown in Figures 3a-e. The pyramid for the total population has a rectangular distribution (3a). The Non-Hispanic White (3b) and Asian (3e) populations in Chicago have inverted distributions. The Non-Hispanic Black (3c) population is represented by rectangular distribution, and the Hispanic (3d) by triangular distribution. The fertility rate plays a critical role in determining the shape of a population pyramid. The fertility rates for Chicago in 2002 were 49 per 1000 for Non-Hispanic Whites, 69 per 1000 for Non-Hispanic Blacks, 97 per 1000 for Hispanics, and 40 per 1000 for Non-Hispanic Asians (6). Given the higher fertility rates, the population pyramids for Hispanics and Non-Hispanic Blacks have broader bases than the population pyramids of Non-Hispanic Whites and Asians. Unusual bites or bulges appear in population pyramids, reflecting immigration and emigration, particularly among working age groups (5). The population pyramids for all Chicago, Non-Hispanic Whites, Hispanics, and Non-Hispanic Asians have bulges in the working age groups, most likely due to immigration.

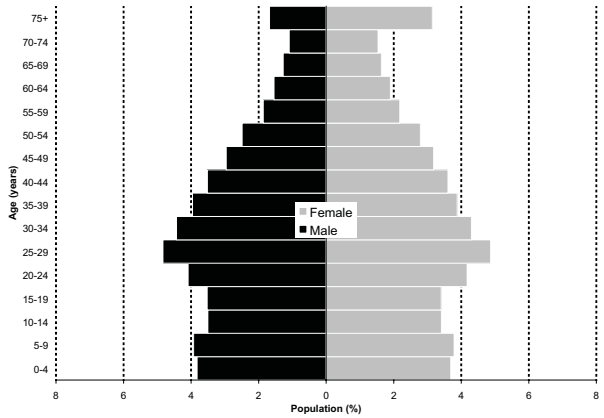


Figure 3a. 2000 Chicago Population

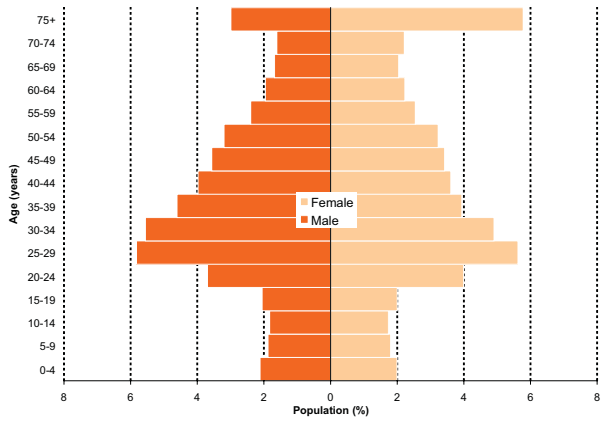


Figure 3b. 2000 NH-White Population

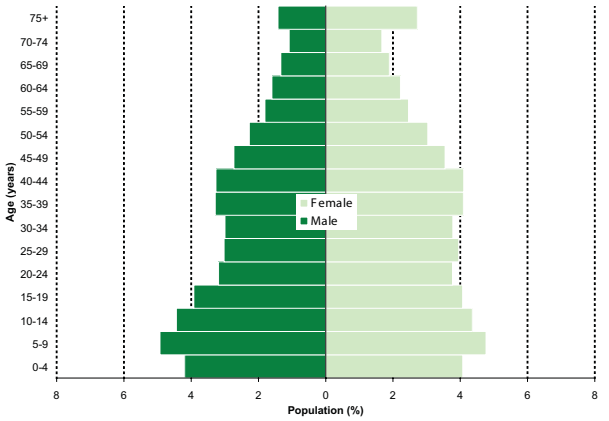


Figure 3c. 2000 NH-Black Population

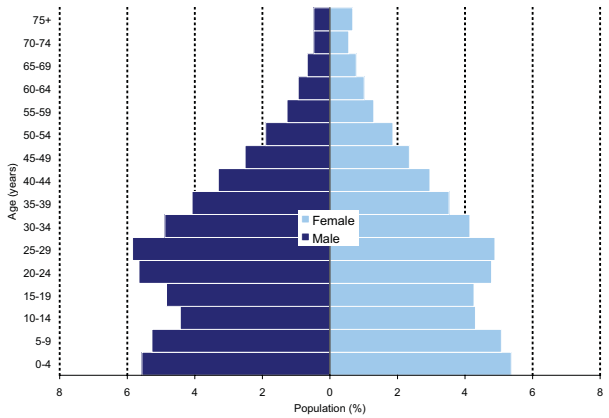


Figure 3d. 2000 Hispanic Population

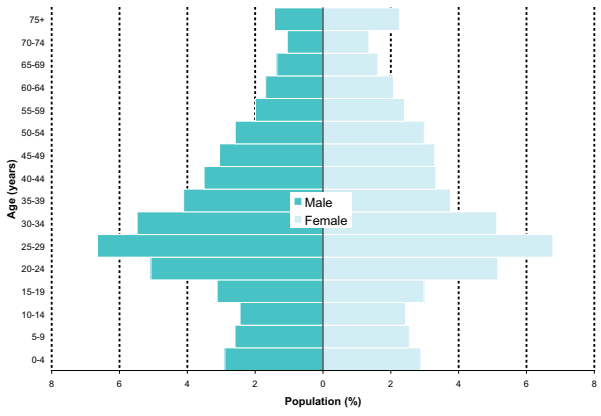


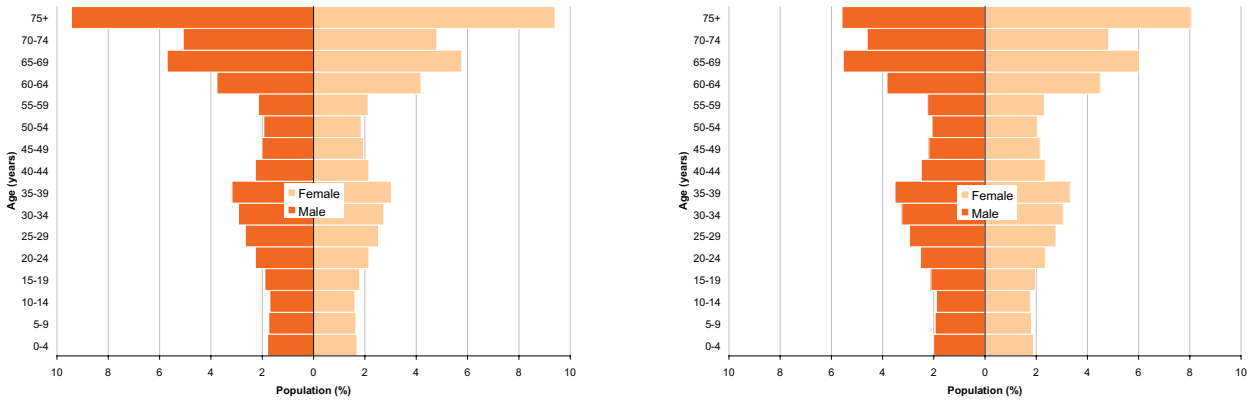
Figure 3e. 2000 NH-Asian Population

4 What are the implications of the population structures on time to eliminate health disparities?

The shapes of the population pyramids for the different racial/ethnic groups in Chicago reflect variation in the health in these communities, signifying disparities in the burden of illness and death experienced by the groups. Most health disparities efforts are aimed at ultimately reducing differences in mortality.

In the last section, we saw that a long time is needed for health outcomes, such as birth and death rates, to change the population pyramid of the United States. In this section, we will show the implication of this slow change in health outcomes on the time it takes to eliminate disparities among the racial/ethnic groups in Chicago. The 2000 U.S. death rate of the Asian/Pacific Islander population, the lowest of all racial/ethnic groups, was applied to the 2000 population of each of the 4 major racial/ethnic groups in Chicago. The birth rate and other factors that can influence the population structure were allowed to continue with present trends. Each population was then projected to 2040 in order to determine if there would be a noticeable change in the shape of the population pyramids if there was no disparity in death rate (See Methods for details). When the shapes of the projected 2040 population pyramids with equal low death rates applied (adjusted) are compared to the pyramids of the projected populations with no equalization of death rate (unadjusted), no difference was observed for any of the 4 racial/ethnic groups (see Figure 4a-d). There are inherent limitations in this analysis due to the assumptions made:

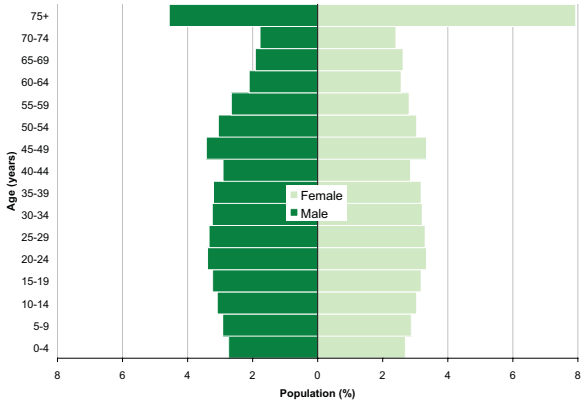
1. A proportional increase or decrease in birth and death rates for a given time interval.
2. Social, economic, cultural, and environmental factors capable of affecting outcomes in birth and death rates remain stable for long periods of time.
3. Changes to factors that influrence birth and death rates affect populations equally.



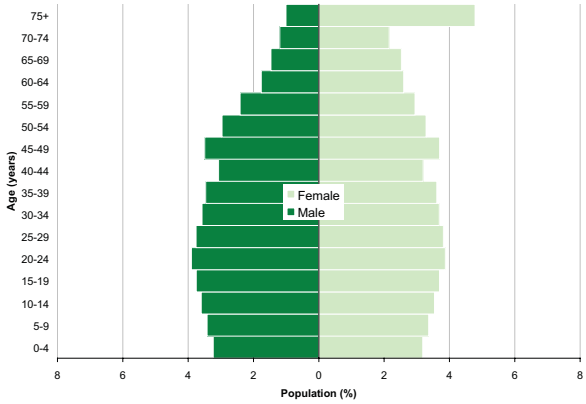
2040 NH-White Population (adjusted)

2040 NH-White Population (unadjusted)

Figure 4a. A large increase in the size of the adjusted 75+ population is observed beause 2000 population was experiencing a greater death rate than the 2000 Asian/Pacific Islander population.

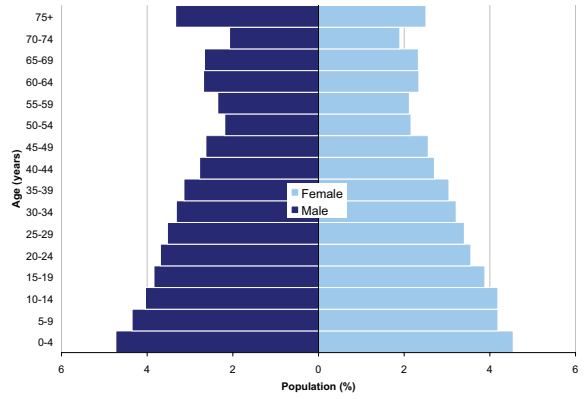


2040 NH-Black Population (adjusted)

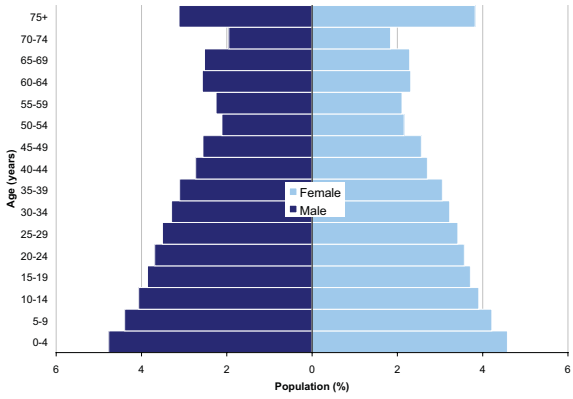


2040 NH-Black Population (unadjusted)

Figure 4b. There is a notable upward shift (relatively larger percent of the population in older age groups) for the NH-Black population in the adjusted pyramid compared to the unadjusted pyramid. The adjusted pyramid does not become inverted, however. There is also greater equity in the male/female ratio in older age groups in the adjusted pyramid.

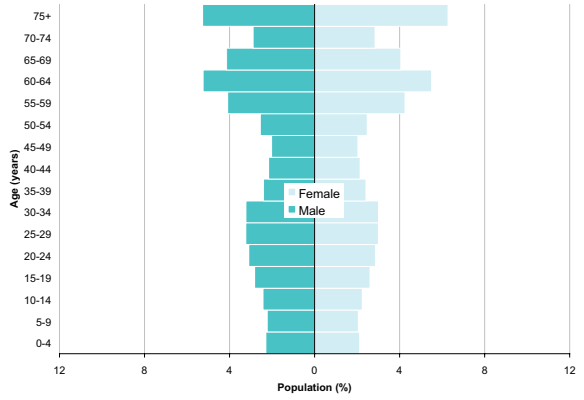


2040 Hispanic Population (adjusted)

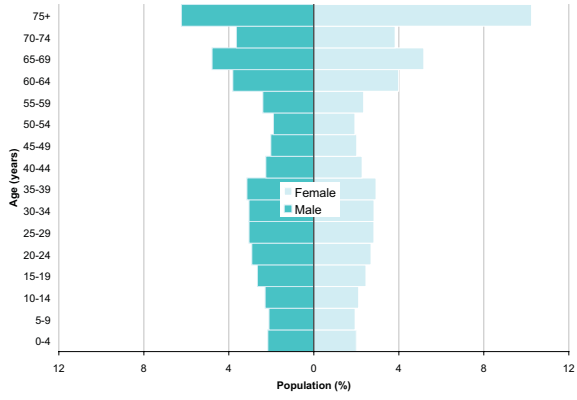


2040 Hispanic Population (unadjusted)

Figure 4c. The percentage of female 75+ is smaller in the adjusted popualtion than in the unadjusted. The 2000 Hispanic population was already experiencing a low death rate, and the impact of applying low death rate to the popualtion minimized differences between the adjusted and unadjusted pyramids compared to the other racial/ethnic groups.



2040 NH-Asian Population (adjusted)



2040 NH-Asian Population (unadjusted)

Figure 4d. The percentage of 75+ was smaller in the adjusted population compared to the unadjusted. The unadjusted population was already experiencing low death rate and the impact of applying low death rate to this population was minimal.

This report demonstrated:

1. Eliminating population level health disparities can be a slow process, possibly taking decades to accomplish.
2. Changing mortality rates alone will not change the shape of the population pyramids presented here, i.e. triangular to rectangular.
3. The largest impact of disparities reduction will be for age ranges where there are large between-group differences. For example, the 70 and older population is a much smaller percentage of the total population for Non-Hispanic Blacks and Hispanics compared to Non-Hispanic Whites.
4. The greatest effect of disparities reduction will be seen in age groups that are most populous in the disadvantaged populations. For example, the 10 and under Hispanic population and the 25-29 age group in the Non-Hispanic Black population are the largest percentage of the the total population for each ethnic group.

Methods

Data Sources

Data on sex and age for the 4 major racial and ethnic groups (Hispanic, NH-Asian, NH-Black, NH-White) in Chicago for 2000 were obtained from the 2000 U.S. Census. Birth, fertility, and death rates were obtained from the 2002 U.S. Statistical Abstracts, Birth Outcomes and Infant Mortality, 1993-2002 (Chicago Department of Public Health), and unpublished data from the Chicago Department of Public Health.

Analysis

To assess the impact of changes in the 2000 death rate on the shape of population pyramids in 2040, an equal low death rate was applied to each racial/ethnic population while keeping existing birth rates and other factors unchanged. The year 2040 was selected to minimize errors in population projection because it was closer to the baseline year of 2000. The age-adjusted death rate of the Asian/Pacific Islander population, 507.4 per 100,000 in 2000, was the lowest among all U.S. racial/ethnic groups. Therefore, the age-specific death rates were applied to each racial/ethnic group in Chicago. Each racial/ethnic group in 2000 was categorized by sex and 5-year age groups. The number of deaths for each racial/ethnic group was determined using the death rates of the U.S. Asian/Pacific Islander population, distributed by the proportion of deaths occurring in each age group among the U.S. Asian/Pacific Islander population. In addition, populations for each year by sex and age for the major racial/ethnic groups without changes to the death rate were also projected to 2040. The algorithms followed in preparing the population data for projection are outlined in Appendix A for populations with changes to the death rate, and in Appendix B for populations with no changes to the death rate. Using the populations projected for each racial/ethnic, population pyramids were constructed for the year 2040. The shape and pattern of the projected populations pyramid in 2040 with changes to the death rate were compared to the pyramids without changes.

Appendix A. Death rate of 2000 U.S. Asian/Pacific Islander population applied.

1. Categorize the population by sex and age groups (0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-44, 45-54, 55-64, 65-74, and 75+).

2. Multiply published racial/ethnic-specific fertility rates to the appropriate racial/ethnic female population for each age group. This gives the number of expected births per year per age group. The number of expected births is classified into sex groups (male/ female) using the sex ratio.

3. Multiply male and female births by five.

4. Calculate age-specific deaths using the age-specific death rate of the 2000 U.S. Asian/Pacific Islander population.

5. Multiply the age-specific deaths for each sex by five.

6. Subtract the number of deaths from each age group.

7. At this step, a new population cohort is formed for 2005 with the new births becoming the 0-4 age group. Move the populations in each 5-year age group to the next higher age group e.g., 70-74 becomes 75+.

8. Steps 1-7 are repeated every five years until 2040 for each racial/ethnic group.

Appendix B. No change in death rate was applied.

1. Categorize the population by sex and age groups (0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-44, 45-54, 55-64, 65-74, and 75+).

2. Multiply published racial/ethnic-specific fertility rates to the appropriate racial/ethnic female population for each age group. This gives the number of expected births per year per age group. The number of expected births is classified into sex groups (male/ female) using the sex ratio.

3. Multiply male and female births by five.

4. Calculate age-specific deaths using the age-specific death rate for each racial/ethnic group in 2000.

5. Multiply the age-specific deaths for each sex by five.

6. Subtract the number of deaths from each age group.

7. At this step, a new population cohort is formed for 2005 with the new births becoming the 0-4 age group. Move the populations in each 5-year age group to the next higher age group e.g., 70-74 becomes 75+.

8. Steps 1-7 are repeated every five years until 2040 for each racial/ethnic group.

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