

## Chapter 2

# A Comparative Study of the Demography of Human Populations

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## Introduction

This section provides instructors with a description of the target audience, thoughts on how the exercise might be modified for more advanced students, estimates of the amounts of time needed for preparation and instruction, and a discussion of the conceptual development of the exercise.

### Student Level

We use the following exercise in our freshman-level Human Biology course. This course uses an issues-based approach to introduce general biology concepts to non-science majors. The exercise could be adapted to advanced courses by including a more detailed consideration of the underlying demographic models. Appendix B of a report from the U.S. Bureau of the Census (1998) provides a discussion of some of the assumptions made, and methods used, to make the population projections presented in the Census Bureau’s International Database. Also, upper-division students could identify the variables and data they need to evaluate a country’s demography, and they could be directed to the web site databases without the explicit instructions telling them how to extract information from these sites.

### Time considerations

Two hours is sufficient preparation time if you do not have computer problems; it takes students from 2.5 hours to 3 hours to complete the exercise. Prior to teaching this exercise, work through the exercise to make sure the format of the databases has not been changed, and to insure that the age pyramid graph works in your version of Excel. It works in Office 97 through XP Professional, if you have an earlier version of Excel, see Stauffer (1999).

### Conceptual Goals and Strategies

Each group of students will use web resources to investigate factors that influence the demographic characteristics of a country of their choice; they will compare characteristics among

different group's countries in a poster session; and they will write a discussion of the socioeconomic implications of their country's demography. These activities challenge students to develop a working knowledge of the tenets of population ecology. The poster session and discussion also exercise students' ability to apply quantitative biological information to societal issues.

In order to develop a well-balanced discussion of a country's demography, students must become familiar with a variety of demographic concepts. The introduction to the student exercise assumes students are starting the exercise with very little exposure to demographic principles. These concepts are introduced in a carefully planned sequence so that the introduction to, and definition of, each concept builds on previous concepts, but does not assume an understanding of subsequent concepts.

In the exercise, students first collect data describing individual statistics, such as life expectancy and fecundity, because these are easier for students to imagine than the population-level statistics. The separation of these two types of related statistics also enables students to understand the role of age structure as it influences the conversion of individual- to population-level statistics. Students work from life expectancy and fertility, through age structure, to population birth, death, and growth rates. The introduction to age structure emphasizes the consequences of a population's age structure on its future growth more than the role of previous growth in determining age structure, as the circular nature of demographic momentum, and stable age structures, may be more than many of our students can grasp in their first demography exercise. Instructors who are modifying this exercise for more advanced courses might include these additional demographic principles.

## **Materials**

- Computers with connections to the web. Ideally students are working in groups of 2 - 3 on each computer with one person reading the instructions, one typing, and possibly a third proofing.
- Microsoft Excel in each computer. Alternatively, the 2 graphs could be done by hand on graph paper.
- Printer networked to computers, or 2 computers for each group so that graphs can be displayed on screen rather than printed.
- White boards (at least 2 feet by 3 feet) with pens and an eraser for each group.
- Binder clips for each group to attach their graphs to their white board.

## **Procedural Notes for the Instructor**

The exercise relies on websites produced by the Central Intelligence Agency, the Population Reference Bureau, and by the US Census Bureau. Before running students through the exercise, conduct a trial run to make sure that the arrangement of the links connecting pages and databases within each of these websites has not changed since this chapter was last updated. It is tedious, and a source of potential errors, to have each pair of students type in the URL of each website. I recommend that you add links to the three websites on your course website, or add the three sites to the favorites list in the web browser of each computer.

Students first explore the CIA World Factbook (2002) as they choose their country. I like to let each group of students pick a country of their choice -- sometimes these choices are based on interesting personal experiences -- with the one limitation that each group chooses a different

country. I keep track of the chosen countries by writing the country names on a white board as groups make their choices. Some instructors control student choices, and shape subsequent comparisons, with more structured geographic or economic rules that insure that groups choose very different countries. It is possible that a group could pick a country in the CIA World Factbook that is not present in the Population Reference Bureau or U.S. Census Bureau's International Database. I haven't yet run into this problem, but if it occurs, the group would need to choose a new country and start over. They would have only lost 10 to 15 minutes.

In the third activity, students collect age-specific data at the Census Bureau's International Database, and then graph their results using Excel. Age pyramids are an obscure type of graph to make in Excel; and unfortunately, the instructions need to be precisely followed. Two common errors that occur as students make these graphs are forgetting to select percent at Step 4b while at the database, and forgetting to add negative signs to the data for males in Step 3b of the graphing exercise. If students hurry through this activity assuming they know how to make a graph, they will probably miss a critical step. If a printer is not available, or is not working, and if each group has two computers, they can display their graphs in the poster session by making one graph in each of their two computers and setting them to print preview.

In the last section of computer work, students return to the Census Bureau's IDB to obtain birth rates, death rates, growth rates and projections of population growth through 2050. Appendix B of a report from the U.S. Bureau of the Census (1998) provides a discussion of some of the assumptions made, and methods used, to make these projections. It is worthwhile reading for instructors and advanced students.

The graphing instructions in the population growth section of the student exercise are not as detailed as those for the age pyramid graph. This is because they have already made one graph, and this second graph is a more standard design. In this section, I suggest students record population sizes in thousands and indicate this unit on their subsequent graph. Some students may need help with this change in units.

The structure of the poster session may be limited by the format of your room and the nature of your equipment. You want to create a situation in which students can look from one poster, or computer display, to the next, in order to contrast and compare the patterns. Stand back, and let the students be the experts about their particular country. Ask questions to express your interest, rather than to make them feel they are being evaluated.

## Student Outline

The field of population ecology has far-ranging implications that engage the attention of political and religious leaders and which influence some of the most central questions in our personal lives. How will the number of children that you have influence the quality of their life and of your life? How many children do you plan to have? Should government policy or religious doctrine attempt to influence your answers to these questions?

In addition to studying the complex issues of human populations, the study of population ecology extends beyond human populations to the dynamics (the nature of change) of other species. The population size of some species affects humans in direct and obvious ways, such as the effects of pathogen populations on human health, and the effects of insect herbivores on agricultural production. The population ecology of other species has a subtler, and less pragmatic, influence on the quality of our lives. The population size of the breathtakingly beautiful Golden Toad of the Costa Rican cloud forest has recently disappeared into extinction. In this last example, what have we lost? Would a better understanding of population ecology have provided us with the knowledge, or the motivation, to save this species?

While the implications of population ecology are complex, the central problems are easily focused into the following two basic questions:

- What determines the number of individuals in a population?
- What are the consequences of variation in population size?

Your laboratory group will address these questions as you study the characteristics of individual's lives and of a population of humans in one country and compare your findings to those of groups working on other countries. Some of these population characteristics are the same that are used to study the characteristics and dynamics of populations of other species; other issues that your group will uncover are uniquely human.

### Population Growth

A variety of models, from simple to very complex, are used by **demographers** (people who study population dynamics) to predict and explain changes in the characteristics of populations, particularly changes in the size of populations. A **population** is a group of individuals of the same species living in an area. In your study, your group will choose a population of humans to study. Your population will be defined as the people living in the country that your group chooses to investigate.

The current size of the population is typically represented by  $N$ . **Density** is the number of individuals in a given area. Counting all the individuals of a population is seldom possible. For example, in a recent U.S. census, Democrats generally wanted to estimate population size based on samples. **Samples** are partial counts of the population, which if carefully and impartially designed, can be used to estimate the total population size. On the other hand, Republicans wanted to attempt to count every individual in the U.S. Why would the two parties have different demographic philosophies? What are their motives, and how do these motives bias their methods and results?

While it is challenging to accurately determine  $N$  (population size), it is even more difficult to accurately estimate **population growth** ( $dN/dt$ ), the change in a population's size through time. Population growth is a result of the size of the population multiplied by its per capita (per person) growth rate ( $r$ ). This simple equation describing population growth  $dN/dt=rN$  illustrates a very important concept. Notice the population's growth rate is influenced not only by the per capita rate, but also by the size of the population. This means that if  $r$  is greater than zero, and if it does not

change through time, not only will the size of the population increase, but the population's size will increase **exponentially**, at a faster and faster population growth rate. This exponential growth occurs because at each generation,  $r$  is multiplied by a larger  $N$ .

The size of the human population over the entire world has been growing exponentially since the beginning of the industrial revolution. The recent increase in the global population is due to improvements in diet, sanitation, and health care. At an individual level, the positive effects of these improvements in the quality of life are reflected in an increase in **life expectancy**, the average number of years in an individual's life. In the worldwide population, this increase in life expectancy has had a stronger effect on population growth than any decreases in **fecundity**, the average number of offspring produced per female.

In order to calculate the effects of life expectancy and fecundity on population growth rate, demographers determine the population's **birth rate** and **death rate**. Both of these variables are often reported as the number of individuals who have been born or have died, out of 1000 individuals of the population in a single year. Fecundity and life expectancy are descriptions of the life of average individuals; birth and death rates are descriptions of the entire population.

One important characteristic of a population that influences the conversion of life expectancy and fecundity into birth and death rates is age structure. Consider two populations with the same life expectancy and fecundity; due to differences in demographic history, the first population has many young people and few older people and the second population has many elderly people and few young people. In spite of having the same fecundity, which population will have a higher birth rate? In spite of having the same life expectancy, which population will have a higher death rate? In addition to investigating your population's life expectancy, fecundity, and age structure, your group will describe how the combination of these factors has influenced the population's birth, death, and growth rates.

Population growth rate, at a global scale, is a result of birth rate ( $b$ ) minus death rate ( $d$ ). If we consider populations at a scale smaller than the entire earth, we also need to consider the effects of migration on population growth. **Immigration** ( $i$  as in moving in) and **emigration** ( $e$  as in exit) are added to the equation used to calculate per capita growth rate to produce the following equation:

$$r = (b - d) + (i - e); \text{ per capita growth} = (\text{birth} - \text{death rates}) + (\text{immigration} - \text{emigration}).$$

For many populations, it is not realistic to assume that all the factors that influence population growth will stay the same over a long period of time. The concept of carrying capacity considers the impact of population size on the population's growth rate. **Carrying capacity** is the maximum number of individuals of a population that can be sustained by that population's environment. As the density of a population approaches its carrying capacity, it begins to run out of resources and suffers from overcrowding. This causes an increase in mortality and emigration, and a decrease in fertility and immigration. These effects of population density on the availability of resources, and other density-dependent factors such as the spread of infectious disease and the accumulation of waste, eventually slow and then stop population growth at carrying capacity. The amount of mortality necessary to stop exponential growth is staggering. Major world wars did not significantly slow human population growth. Fortunately, humans have an alternative to waiting for the unbelievably high mortality rate associated with reaching carrying capacity; many human populations have slowed, or even stopped population growth before carrying capacity by reducing birth rate.

### Investigating a Human Population

Your laboratory group will collect information about the demographic status of a country of your choice from various web sites. You will first find statistics that describe the average individual's life (life expectancy & fecundity); secondly, you will investigate the population's age structure; and in the last activity on the web, you will describe your population's birth, death, and growth rates. The class will then have a poster session to compare the demographic status of the different human populations.

After developing an understanding of your population, and after comparing the countries in the poster session, in your laboratory report you will develop an explanation of what is unique about your country and why your population has these particular characteristics. What social and economic factors have influenced the dynamics of the population?

#### *Choosing a Country*

Your group's first task is to choose a country to investigate. The C.I.A. World Factbook provides a wealth of socioeconomic data about 268 geographic listings (as of October 2002). It also provides maps and links to related websites. You can browse through this information as your group decides which country to investigate.

1. Use the web browser to go to the C.I.A. World Factbook (<http://www.cia.gov/cia/publications/factbook/index.html>). This site may be bookmarked in your computer's favorites list, or it may be linked to your course website.
2. A window near the top of the web page allows you to select a country as you consider potential countries for your investigation. Notice that the World Factbook homepage also has a link to reference maps which may help you choose a country.
3. Once your group has chosen a country, check with your instructor to insure that your country has not already been chosen by another group.

#### *Individual Statistics: Life Expectancy & Fecundity*

The Population Reference Bureau is an excellent source of information about human populations throughout the world. We will use it to find estimates of the life expectancy and fecundity of individuals in your group's population.

1. Use the web browser to go to the Population Reference Bureau (<http://www.prb.org/>). This site may be bookmarked in your computer's favorites list, or it may be linked to your course website.
2. In the center of the top bar select *Datafinder*.
3. Scroll down to the Country Data window. Select your country in the data window.
4. The next window allows you to choose your variables. Select *Life Expectancy at Birth, Both Sexes* and then click the *Submit Query* button. Record the **life expectancy** of an average individual in your country\_\_\_\_\_.
5. Click *Back* to return to the previous page, select *Total Fertility Rate*, and *Submit*. Record **fecundity**, the average # of children per female during her life\_\_\_\_\_.

Notice that this online database allows you to obtain information about a number of characteristics of a population. You may want to return to this site to obtain information about child

health care policies, contraception, literacy, and the role of women in society as you write your report developing an explanation of the demographic characteristics of your population.

*Age Structure: The Census Bureau Data Base*

In this section you will collect information about the age structure of your populations at the U.S. Census Bureau’s International Data Base.

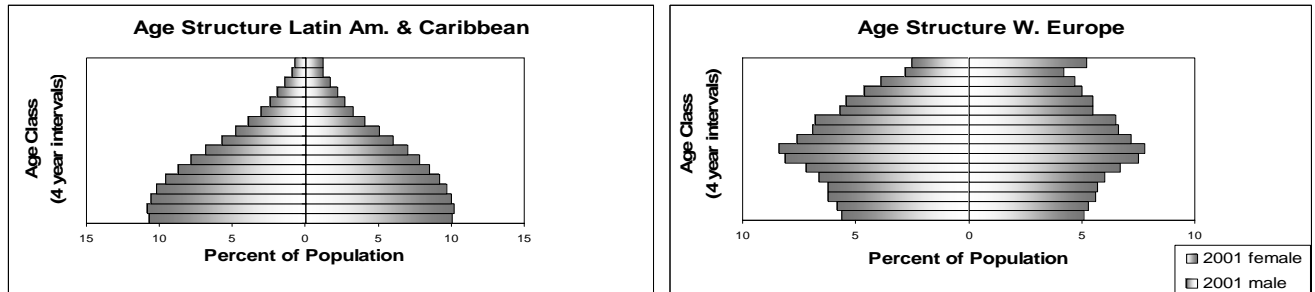
1. Use the web browser to go to the U.S. Census Bureau’s International Data Base (<http://www.census.gov/ipc/www/idbnew.html>). This site may be bookmarked in your computer’s favorites list, or it may be linked to your course website.
2. In order to obtain age specific data, select *Online Demographic Aggregation*.
3. You should now be in the U.S. Census Bureau: IDB Aggregations -- Access Options window. Select *Population by Age and Sex*, and under Output Type *Display Mode* should already be selected; if not, select it. Click *Submit Query*.
4. You should now see the U.S. Census Bureau: IDB Aggregations -- Table 094.
  - a. In predefined groups, select *5-year ages option*.
  - b. Scroll down to Variable Groups and check to make sure that *Population and Sex Ratio* is pre-selected and also select *percent*.
  - c. Scroll down to the Countries window; select your group’s country.
  - d. In the One or More Years window, select *latest available year*, and then *Submit Query*.
5. You should now see age and sex specific data showing both numbers of individuals and percents. Record, at the top of Table 1, the number of individuals of all ages in both sexes, males, and females. For the age-specific data that you will use to construct a graph of the age structure, it will be easier to compare results between countries if we focus on the percent of each sex, in each age class. Record these percents in the following table.

**Table 1.** Age Structure

Year			Age Class	% Male	% Female
Total both			35-39		
Total male			40-44		
Total female			45-49		
Age Class	% Male	% Female	50-54		
0-4			55-59		
5-9			60-64		
10-14			65-69		
15-19			70-74		
20-24			75-79		
25-29			80+		
30-34					

### Graphing Age Structure

In this section you will use your data from Table 1 to create a graph that illustrates the age structure of your country. Age structure is typically illustrated with centered bar graphs as shown in Figure 1.



**Figure 1.** Age Structure Charts

Age structure is a result of the population’s recent demographic history. Notice in Figure 1 that Latin America and the Caribbean shows a “bottom heavy” pyramid reflecting rapid growth and high birth rates, while Western Europe has a middle-aged bulge as a result of high post-war reproductive rates followed by a recent reduction in birth rates. While these age structures reflect the histories of the populations, as discussed in the introduction, they influence future rates of population growth. Consider your data in Table 1, what is the shape of your population’s age structure? Use the following methods to create a graph of the age structure of your population.

1. Close the web browser and open a spreadsheet in Excel.
2. Highlight column A, select *Format, Cell, Text*.
3. Type the data from Table 1 into the spreadsheet in the following format. It may be best to have one student read the data while another types.
  - a. Type Age Class in cell A1 and type the age class categories from Table 1 into this first column.
  - b. Type Male in B1 and then type the percent male values in this second column. *Include a negative sign* in front of each value for the males.
  - c. Type Female in C1 and then type the percent female values into this third column.
  - d. Proof your data by having one student read the values from Table 1 as another student checks them on the screen.
4. Highlight your data including the column titles. Select *Insert, Chart*.
5. Select *Bar* in the Chart Type list and then choose the *Clustered Bar* Chart subtype. Notice as you choose different sub-types the name of the type appears below the examples. Click *Next*.
6. Click *Next* again to reach Step 3 in the Chart Wizard.
  - a. In the Chart Title window type Age Structure and the name of the country.
  - b. Use the Tab key to move to the Category (X) Axis window and type Age Class (4-year intervals).
  - c. Use the Tab key to move to the Value (Y) Axis window and type Male, Female (%).
  - d. Select the Gridlines tab and deselect all gridlines.

- e. Select the Legend tab and select Bottom placement of the legend. Select *Next*. Select *Finish* (but you are not quite done).
7. Hold the cursor over one of the bars in the graph until it indicates *Series* and then double-click the mouse.
  - a. Select the *Options* tab.
  - b. Highlight the *Overlap* window and type in 100.
  - c. Tab to *Gap Width* window and type in 0. Click OK.
  - d. Hold the cursor over the horizontal axis until it indicates *Value Axis*, and then double-click.
  - e. Select the *Number* tab.
  - f. Select the *Custom category*.
  - g. Type 0;0 into the window just below the word Type. Select OK.
8. Hold the cursor in the graph beyond the bars until it indicates *Plot Area*. Double-click the mouse. Select *None* under *Area*. Click OK.
9. Click once to the left of the title of your graph to highlight the entire graph. Go to the File menu and print your graph!

### Population Dynamics

You are now ready to determine the characteristics of your population that are used to estimate how the size of the population will change in the future.

1. Use your web browser to return to the U.S. Census Bureau's International Database.
2. Select *Online Demographic Aggregation*.
3. Select *Vital Rates and Events*, and then submit your query.
4. Page down to the country window and highlight your country; page down to year selection and select *latest available year*; submit your query.
5. Record the following information about your population:
6. **Year** \_\_\_\_\_
7. **Births** / 1,000 per year \_\_\_\_\_; **Deaths** / 1,000 per year \_\_\_\_\_
8. Net **migration** (immigration - emigration/1000 per year) \_\_\_\_\_
9. Per capita **growth**  $[(b-d)+(i-e)]$  \_\_\_\_\_. These numbers are presented per thousand individuals. In order to calculate growth on a per capita scale, you will need to subtract deaths from births, add net migration, and divide by 1000. Notice that the Census Bureau has multiplied this result by 100 to convert it to a percent population growth / year.
10. Click the Back button twice to return to the IDB Aggregations -- Access Options page. Select *Total Midyear Population, Area, Density*. Submit your query.
11. Scroll down and select your country, *select all available years*, and submit your query.
12. Record each decade's data in Table 2. Record the number of thousands of individuals at each decade, and in your subsequent graph, indicate that the Y-axis is in thousands. For example, if there are 27,534,456 individuals, record 27,534.

**Table 2.** Population Size

Year	Population	Year	Population
1950		2010	
1960		2020	
1970		2030	
1980		2040	
1990		2050	
2000			

13. Close the web browser and open a spreadsheet in Excel. Type the data from Table 2 into the spreadsheet.
14. Highlight the labels and data and insert a chart.
15. Select an XY (scatter) chart and select the subtype that shows data points connected by smoothed lines.
16. At Step 3 of the chart wizard, deselect Show legend. Under titles, add the name of your country to the chart title and type in appropriate axes titles. Remember to indicate that your Y-axis values are in thousands. Select Next and Finish.
17. Remove the fill from the plot area.
18. Double click on the Value (Y) axis. Select *Scale* and type in an appropriate minimum value.
19. Select and print your graph.

### **The Poster Session**

Each group will use their graphs and a white board to prepare a poster describing the demography of their country. Clip your two graphs onto your white board and present the additional demographic data that you have collected on the white board. Carefully label each statistic (e.g., don't confuse fertility with population birth rate). When your board is ready, prop it up in a chair at your group's table.

Circulate between the tables, take notes, and compare the demographic characteristics of the different countries. Look ahead to the discussion questions to be sure that you collect relevant information from each group.

### Discussion Questions

You can work with your group to answer Questions 1-3. If you work with your group on these first three questions, acknowledge their contribution in your paper. You must work individually as you write your answer to Question 4.

1. How do the demographic statistics that describe the average individual (life expectancy and number of children per female) of your population compare to that of other populations? In general, what seems to be the relationship between life expectancy and fecundity? For example, if life expectancy is high, does that suggest fecundity will also be high, low, or are they not correlated?
2. Compare and contrast the age structures of the different countries.
3. Compare the patterns of population growth of the countries. What variables seem to be the best predictors of population growth? Explain examples to support your answer to this question.
4. You have developed a description of the demographic status of your population, and you have seen how it compares to other countries. Write a two-page (10 or 12-point font, double-spaced) essay that considers the social conditions, belief systems, and the economic conditions that might help explain why your population has these particular characteristics.

In your essay, first describe the most striking demographic characteristics of your population. Mention how they compare to the characteristics of other countries. Return to the web sites or use the library's article database search programs to learn about the lives of people in this population. Next, develop an argument that proposes an explanation of the more human dimension that underlies your population's demographic statistics. Why might the population have these particular characteristics? Include two outside citations to support your argument.

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