Diversity and Equity as Part of Personal Decision-Making

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Abstract

Diversity, equity, and inclusion can be difficult to incorporate into an engineering economy course. There are financial products and services where diversity and demographics are directly linked with personal financing decisions and economic equity. For example, engineering economy courses can cover useful qualitative perspectives for life, vehicle, and medical insurance. Engineering economy courses traditionally cover saving for retirement. This paper extends this to include explicit consideration of career length, period of retirement, and average age at death (career and retirement planning).

Mortality data from the National Vital Statistics System show large differences in the "expectation of life at age *x*." The tabulated value at age 22 for a male American Indian or Alaska Native is 65.3 years and for a female Asian it is 21.1 years longer at 86.4 years. Differences like these are substantial, of major social importance, and highly relevant for personal financial planning by students—now and as retirement nears.

We assert that engineering economy courses should include the use of relevant demographic based information for personal financial decision making. Students will begin making financial decisions regarding insurance, investing, and retirement planning soon after entering the workplace, if they haven't already. Students need to understand how they compare to the "average" that is used to determine costs and benefits. Very often these averages are the basis for published advice on what choices should be made and for marketing materials for products and services.

Introduction

Engineering economy is often the only engineering course dealing with money. Nearly every text and course include some level of personal finance, as well they should. Class testing of material has demonstrated that students have a keen interest in personal finance examples because they can identify with the topics [1]. Those topics include loans, investing for retirement, insurance, social security, stocks and bonds, and annuities.

We came to this work from studying when an individual should start social security benefits. We used gender as a defining characteristic because of the well-known fact that "women live longer." We then used ethnicity to explore the impact of different mortality distributions on the relative importance of risk and expected return [2]. Classroom application of this work has convinced us that students are interested in and motivated by data that applies to them.

Mortality statistics show clear differences in life expectancy between demographic groups, no matter the age of the individual. These differences in life expectancy drive huge differences in economic equity that can be expected between various groups, whether we are looking at saving for retirement during a working career or deciding when to begin social security benefits.

This paper is our initial work on planned length of working life and of retirement (career and retirement planning). For this paper we use Equation 1. This is our initial analysis using data differentiated by ethnicity which is an opportunity to directly link questions of diversity, equity, and inclusion with topics in engineering economy. We warn that the topic could also be a potential career-ender for non-tenured faculty who raise it with insufficient sensitivity.

$$\text{career length} + \text{retirement period} = \text{average age at death} - \text{age 22 career start} \tag{1}$$

Mortality data are from the 2020 National Vital Statistics System (NVSS) database [3]. The 2020 report includes two ethnic categories that started being published with the 2019 data: American Indian or Alaska Native (AIAN) and Asian populations. The published data now tracks information for five ethnic groups, each broken out for male, female, and total. We recognize that a significant part of the U.S. population are people of mixed ethnicity, as does NVSS. The official statement from the Office of Management and Budget is, “The category which most closely reflects the individual's recognition in his community should be used for purposes of reporting on persons who are of mixed racial and/or ethnic origins” [4]. Individuals need to use their own judgement in choosing the appropriate demographic group, or to interpolate the data between groups as might be appropriate.

In this paper, we focus on the student at age 22, because that is a common age for starting work after obtaining an engineering degree. Conditional probabilities must be used, assuming the person is alive at 22, to create Figure 1. This shows the probability of dying at various ages for several demographic groups. Clearly, gender and ethnicity can be significant in estimating an individual’s mortality—along with other factors. While the vertical differences in the mortality (cumulative density) functions are substantial, for this figure it is easier to use horizontal differences. For example, values on the 50% *y*-axis are medians which could be used instead of the averages used in the abstract and later in this paper. NVSS tabulates the *expectation of life at age x* and simply adding age *x* results in *expected or average age at death.*

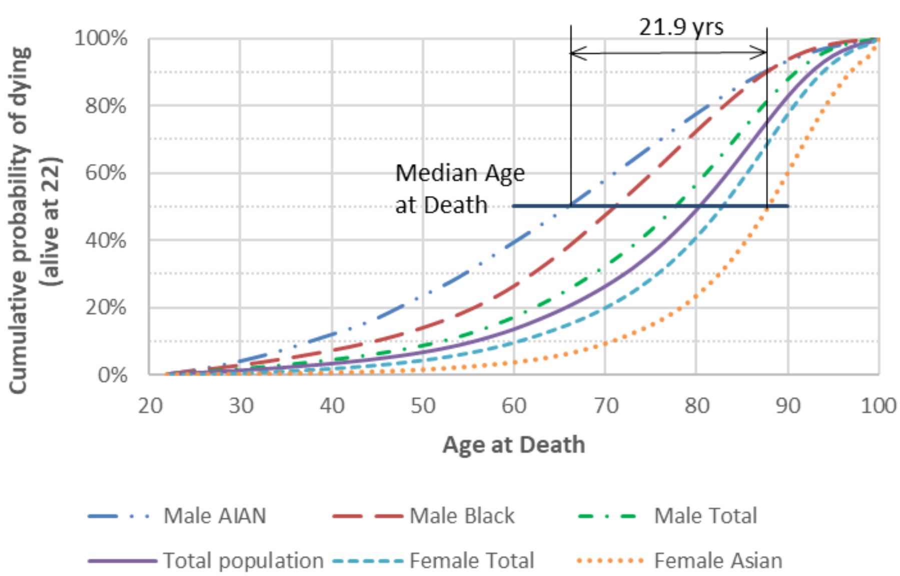

Fig. 1. Cumulative probability of dying, alive at 22.

NVSS reports 18 different demographic groupings that would be overwhelming if presented in a single figure. Figure 1 highlights the most significant differences, but other choices are available including a 3-curve worst/total/best, an emphasis on gender totals, and an emphasis on ethnic totals. We will report the expected age at death for all 18 demographic groups.

While race and ethnicity certainly have their impacts on mortality, family history, health, and personal habits can be more consequential than the gender and ethnicity categories used by NVSS. A person's diet, level of nutrition, exercise, family history of disease and longevity, and general state of health contribute to the wide variation in mortality in all ethnicities. However, the NVSS demographic breakouts provide a quantitative analysis that is driven by many of these variables. Using the statistics for other demographic groups can act as a proxy for expressing personal risk. We will assume average life expectancies for this paper as students can update examples when new NVSS data is published. However, it should be emphasized that there are high levels of variability within each group. A detailed analysis of mortality risk is part of an article on starting social security benefits in *The Engineering Economist* [2].

This paper is focused on career and retirement planning, but when discussing the variability within mortality distributions classes can consider and we believe should at least mention the impact of obesity, smoking, binge drinking, drug use, and fitness (see Example 5).

Literature Review

NVSS publishes the United States Life Tables each year [3]. These reports present mortality data with demographic breakouts, covering ages 0 to 100. At this writing, the most recent data are for 2020 [3] and are used for the calculations.

Mortality has been studied as it relates to various factors. Life expectancy as a function of education attainment has been widely studied [5-8]. Life expectancy as a function of economic status has been also been studied [9-10]. Race and ethnic group have also been analyzed [11-14].

Financial inequality is linked with many of these same issues [15]. There is a large and growing literature on Diversity, Equity, and Inclusion (DEI). The topic has also been highlighted in the press as it becomes a politically contentious issue [16]. We do not have the knowledge or expertise to discuss causes, impacts, remedies, etc.

We cannot find publications that link DEI with engineering economy. We also cannot find ASEE material, including conference papers, linking DEI with personal finance. Substantial and varied work on DEI is accessible through ASEE's best DEI paper award [17]—including all finalists' papers. Ortiz-Rosario, et al. [18] describe career and educational choices at graduation for female/male and under-represented minorities (URM)/(non-URM) students for 4 engineering majors at Ohio State. Li, et al. [19] focus on workplace experiences depending on ethnic and gender categories. These and other papers demonstrate that diversity and demographics have profound impacts. This paper presents quantitative results that can be personalized by students.

Method

Detailed mortality data are presented annually by NVSS [3]. NVSS tabulates the *expectation of life at age x* and simply adding age *x* results in *expected or average age at death*—as shown in Tables 1 and 2. Demographic groups are ordered from lowest to highest expected age at death. By focusing on expected age at death, it allows financial planning without the complexity of students having to calculate probabilities.

TABLE 1.
EXPECTED AGE AT DEATH FOR POPULATIONS.

Alive at Age	22
Total American Indian/ Alaska Native	68.5
Total Black	73.1
Total Male	75.2
Total Population	77.8
Total White	78.1
Total Hispanic	78.7
Total Female	80.6
Total Asian	84.2

Average life expectancy can be estimated at any age. As stated earlier, we focus on the student at age 22 in this paper. In the past, we have used a decision point of age 62 for determining when to start social security benefits because that is the earliest age when benefits can begin.

TABLE 2.
EXPECTED AGE AT DEATH FOR GENDER & ETHNICITY.

Alive at Age	22
American Indian/ Alaska Native Male	65.3
Black Male	69.6
American Indian/ Alaska Native Female	71.9
Hispanic Male	75.5
White Male	75.7
Black Female	76.6
White Female	80.7
Asian Male	81.7
Hispanic Female	82.0
Asian Female	86.4

When presenting or using the data in the tables, we suggest the importance of noting that engineering students as a group are above average for the population in both education and expected future income—both of which as noted in the literature review raise the expected age at death. This *effect* will be more significant for those groups with below average age at death.

Examples for Career and Retirement Planning

These examples show the broad range of results and the importance of students considering their potential age at death as part of their career and retirement planning. The differences by ethnicity and gender demonstrate the importance of addressing diversity, inclusion, and equity within an engineering economy course. For simplicity all examples assume constant-value dollars and a real interest rate of 3%. Calculations are shown for one case of each question and results are shown for all three, and summarized in Table 3.

Example 1. Using Table 2, if you are 22 years old and plan to retire at age 62, how many years would you likely spend in retirement? A student might combine data from different groups or make personal adjustments based on family history, health, and habits. Compare your result with the worst avg., total population, and best avg. from Table 1. Table 2 values would expand the ranges from best to worst.

Total pop: 77.8 – 62 = 15.8 yrs.; Worst avg.: total AIAN 6.5 yrs.; Best avg.: total Asian 22.2 yrs.

Example 2. For the total population, best avg., and worst avg. in Example 1, how much must be saved by age 62 to have $100,000/year to spend in retirement?

$PW_{62\ total}$ = 100K (*P*/*A*, 3%, 77.8 – 62) = $1.24M; Worst avg. = $0.58M; Best avg. = $1.60M

Example 3. With a working life of 40 years, how much must be saved each year to accumulate the three required sums in Example 2?

$Annual_{22-62}$ = 1.24M (*A*/*F*, 3%, 40) = $16,445; Worst avg. = $7,692; Best avg. = $21,220

Example 4. If a 25-year retirement is desired for each of the three averages, when does the 22-year-old individual retire and how much must be saved each year to have $100,000/year to spend in retirement?

$PW_{for\ 25\text{-}yr\ retirement}$ = 100K (*P*/*A*, 3%, 25) = $1,741,315
Total population: Age at retirement = 77.8 – 25 = 52.8; Number of working years = 52.8 – 22 = 30.8; Savings/yr. = 1,741,315(*A*/*F*, 3%, 30.8) = $87,409
Worst avg.: $Age_{retirement}$ = 43.5; # working years = 21.5; Savings/yr. = $111,068;
Best avg.: $Age_{retirement}$ = 61.4; # of working years = 39.4; Savings/yr. =$75,934

Example 5. Using total population and gender averages, consider three average individuals: a person representing the total population, a female whose health and lifestyle habits add 10 years to her expected age at death, and a male whose health and lifestyle habits subtract 10 years from his expected age at death. If a 25-year retirement is desired, when does each 22-year-old individual retire and how much must be saved each year to have $100,000/year to spend in retirement?

$PW_{\text{for 25-yr retirement}}$ = 100K (*P*/*A*, 3%, 25) = $1,741,315
Total population: Age at retirement = 77.8 – 25 = 52.8; Number of working years = 52.8 – 22 = 30.8; Savings/yr. = 1,741,315(*A*/*F*, 3%, 30.8) = $87,409
Male avg. – 10 years: $Age_{retirement}$ = 40.2; # working years = 18.2; Savings/yr. =$125,555
Female avg. + 10 years: $Age_{retirement}$ = 65.6; # working years = 43.6; Savings/yr. =$72,115

Example 5 uses gender data only where the difference is well-known, part of pricing on life insurance and annuities, and frequently cited when calculating the value of Social Security benefits. Note that Example 5 could be easily modified to include data from articles about doing or avoiding activities that would shorten or increase the average age at death.

These examples have assumed annual cash flows and compounding. Monthly cash flows would be a more accurate model, but the mortality data is only available annually. Also, shifting from annual to monthly modeling has offsetting impacts on the savings over the career and spending during the retirement period. Thus, the net differences between monthly and annual compounding are small.

TABLE 3.
SUMMARY OF ANSWERS TO QUESTIONS

Exp.	Question	Total Pop.	Worst Case	Best Case
1	Years in retirement	15.8	6.5	22.2
2	Savings needed	$1.24M	$0.58M	$1.60M
3	Savings per year	$16,445	$7,692	$21,220
4	25-yr Retirement age	52.8	43.5	61.4
	Savings/year	$87,409	$111,068	$75,934
			Male − 10	Female + 10
5	25-yr Retirement age	52.8	40.2	65.6
	Savings/year	$87,409	$125,555	$72,115

Discussion

Diversity, Equity, and Inclusion can be very difficult to discuss, and engineers are often not trained to lead such a discussion. Depending on the makeup of the group, it can become a potentially explosive topic. In fact, having such discussions could be threatening to faculty in some locations. We do not recommend that faculty lead such a discussion if they are unprepared or find the situation threatening. The use of DEI in higher education is a point of contention and is starting to be regulated in some parts of the country [16].

We can introduce the idea that personal decision making can and should consider the available data, including personal mortality. If average ages at death for the total population are used, mortality data can be introduced as part of retirement planning without including gender and ethnicity. A simplified Table 2 could have 3 rows of data—minimum average for NVSS data, total population, and maximum average for NVSS data. This supports the examples to show how consequential assumed mortalities are.

Conclusion

Given the shift from defined benefit pensions to defined contribution investments, students need to start thinking early about retirement. Do they want to work as long as possible, retire at a specific age, or have a 10, 20, or 30-year retirement? Engineering economics not only provides the proper tools; it is often the only engineering course where personal finance is mentioned. Career and retirement planning should start when students start working, about age 22. We suggest that initial study should precede a student's career and employer choices.

Career and retirement planning needs to include life expectancy. One way is to use probabilities, based on recent mortality data. A simpler approach is to present expected lifetime, using expected age or median age at death, and this approach is recommended for a first analysis. More in-depth courses can include probabilities, expected values, and risk.

A class case study can focus on the individual, where a student can determine their expected mortality based on a demographic that the student feels most nearly meets their criteria. This can help the student to personally identify with the situation presented. Class testing of personal finance topics has demonstrated that students become deeply involved when they see a problem being relevant to their personal situation. The engineering economic skills developed apply just as well to the professional tasks of an engineer.

A broader approach is to have students use these and similar examples to look at mortality for themselves compared to other groups. There are 18 groups to choose from (including total population, total female, total male). This will display very large differences in the mortality of different groups. These large differences in mortality lead to large differences in economic equity.

This work is meant to open a discussion on how to approach this information. It is fact-based and real. Some instructors, particularly those who are early in their career, may feel uncomfortable and perhaps threatened by this topic. In some parts of the country, discussions of this sort are becoming prohibited. We realize that instructors must take care whether to include this material in their courses.

Many students may be uncomfortable with the material. We believe that an ASEE presentation is the right place to discuss how best to approach this information (and even if ethnicity or gender should be discussed). DEI has a direct impact on everyone's personal financial equity, and engineering economics is usually the only place that an engineering student will be exposed to financial topics. Is it appropriate to include this discussion in engineering economy courses? How do we best use this material in class?

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