Cultivating A Culture of Health Equity
Sub-County Analysis of Life Expectancy and Alameda County Uses of the Life Expectancy Measure

Matt Beyers
Epidemiologist II
Alameda County Public Health Department
Health Care Services Agency
Outline

- Why measure life expectancy?
- SCALE: a collaborative LE project
- The life table
- Alameda County results
  - Census tract
  - Linear approximation → $/year of life
  - Social gradient
- Potential gains in life expectancy
  - Versus other measures of mortality
    - YLL
    - Age-adjusted mortality
    - Leading causes of death
- The Age Adjuster — Excel tool
Why Measure Life Expectancy?

- **Advantages**
  - Good overall measure of health
  - Intuitive to laypersons
  - Not affected by the population age distribution

- **Drawbacks**
  - People think LE is a *prediction* of how long people are going to live
    - Is only a prediction if mortality rates were to not change over a person’s lifetime
  - Small variations are significant but can seem trivial to laypersons
SCALE (Sub-County Analysis of Life Expectancy): A Collaborative LE Project

- Three-year project beginning in 2014
  - CDC, Council for State and Tribal Epidemiologists, 8 health departments
  - Draft guide & software for pilots July, 2015

- Goal
  - Develop, pilot, and disseminate a stakeholder-driven, easy-to-use guide: *Guide for Calculating and Visualizing Life Expectancy Estimates at the Census Tract Level*

- Public health practice and research applications
  - Examine the degree to which LE and associated contributing factors vary across populations and geographies
  - Identify and monitor community hot spots of health disparities
  - Once hot spots are identified, investigate behavioral, social, and environmental factors
  - Raise public awareness on the importance of multi-sector place-based factors (i.e., education, transportation, community development, and business) in improving health and reducing health disparities
Phase II began in July 2015
- 17 more state and local health departments pilot testing the tool
- Small area estimation for areas without sufficient populations
- Panel discussion, poster sessions

Phase III will begin in July 2016; looking for more participants
- Will be mentored through producing small-area life expectancy
- Need death data with address; population at the census tract level; ability to use death data from 2008-2012 (around the 2010 Census)
- Must be able to participate in bi-monthly phone calls to discuss progress and roadblocks

Contact Jessica Wurster, Vickie Boothe, or Amy Laurent for more information

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Vickie Booth | CDC | 404.498.2826 | veb6@cdc.gov
Amy Laurent | King County | 206.263.8779 | Amy.Laurent@kingcounty.gov
The Life Table

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<th>Age Interval Width</th>
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\[
\frac{2}{0.16224} = 12.3
\]

\[M_i = \text{Age-specific death rate} = \text{death/population}\]
### The Life Table

The Life Table is a statistical tool used in demography to describe the mortality experience of a population. It provides information on the probability of dying during an age interval, based on the survival status at the beginning of the interval.

**Conditional probability** $q_i$ is defined as the probability that an individual who has survived to the start of the age interval will die in the age interval, given by the formula:

$$q_i = \frac{n \cdot M_i}{1 + n \cdot (1-n) \cdot M_i}$$

where
- $n$ is the survival rate at the start of the age interval,
- $M_i$ is the number of deaths in the age interval.

### Table

| Age Interval Index | Age Interval Start | Age Interval End | Interval Width | Fraction of Last Age Interval of Life | Population Years at Risk | Number of Deaths in Interval | Death Rate in Interval | Probability of Dying in Interval | Probability of Surviving Interval | Number Alive at Start of Interval | Number Dying in Interval | Number of Years Lived in Interval | Number of Years Lived Beyond Start of Interval | Total Number of Years Lived Beyond Start of Interval | Expected bushing of Life at Start of Interval |
|--------------------|--------------------|------------------|----------------|--------------------------------------|--------------------------|----------------------------|-------------------------|---------------------------------|-----------------------------------|-------------------------------|-----------------------------|---------------------------------------------|-------------------------------------------------|---------------------------------|
| 0                  | 0                  | 0                | 1.0            | 0.10                                 | 7,060                    | 17                        | 0.00241                 | 0.00240                        | 0.99760                           | 100,000                       | 240                         | 99,784                      | 8,016,950                                      | 80.17                          |
| 1                  | 1                  | 1-4              | 4.0            | 0.50                                 | 35,059                   | 9                         | 0.00026                 | 0.00103                        | 0.99897                           | 99,760                       | 102                        | 398,834                    | 7,917,167                                      | 79.36                          |
| 2                  | 5                  | 5-9              | 5.0            | 0.50                                 | 46,974                   | 4                         | 0.00009                 | 0.00043                        | 0.99957                           | 99,657                       | 42                         | 498,181                    | 7,518,333                                      | 75.44                          |
| 3                  | 10                 | 10-14            | 5.0            | 0.50                                 | 48,489                   | 8                         | 0.00016                 | 0.00082                        | 0.99918                           | 99,615                       | 82                          | 497,869                    | 7,020,152                                      | 70.47                          |
| 4                  | 15                 | 15-19            | 5.0            | 0.50                                 | 43,219                   | 20                        | 0.00046                 | 0.00231                        | 0.99769                           | 99,533                       | 230                        | 497,089                    | 6,522,283                                      | 65.53                          |
| 5                  | 20                 | 20-24            | 5.0            | 0.50                                 | 38,561                   | 15                        | 0.00039                 | 0.00194                        | 0.99806                           | 99,303                       | 193                        | 496,031                    | 6,025,194                                      | 60.67                          |
| 6                  | 25                 | 25-29            | 5.0            | 0.50                                 | 46,009                   | 24                        | 0.00052                 | 0.00260                        | 0.99740                           | 99,110                       | 258                        | 494,904                    | 5,529,162                                      | 55.79                          |
| 7                  | 30                 | 30-34            | 5.0            | 0.50                                 | 57,208                   | 33                        | 0.00056                 | 0.00288                        | 0.99712                           | 98,852                       | 285                        | 493,546                    | 5,034,259                                      | 50.93                          |
| 8                  | 35                 | 35-39            | 5.0            | 0.50                                 | 61,435                   | 50                        | 0.00081                 | 0.00406                        | 0.99594                           | 98,567                       | 400                        | 491,834                    | 4,540,712                                      | 46.07                          |
| 9                  | 40                 | 40-44            | 5.0            | 0.50                                 | 55,601                   | 71                        | 0.00128                 | 0.00636                        | 0.99364                           | 98,167                       | 625                        | 489,271                    | 4,048,879                                      | 41.24                          |
| 10                 | 45                 | 45-49            | 5.0            | 0.50                                 | 50,209                   | 100                       | 0.00199                 | 0.00991                        | 0.99009                           | 97,542                       | 967                        | 485,293                    | 3,559,607                                      | 36.49                          |
| 11                 | 50                 | 50-54            | 5.0            | 0.50                                 | 56,416                   | 163                       | 0.00289                 | 0.01434                        | 0.98566                           | 96,575                       | 1,385                       | 474,194                    | 3,074,314                                      | 31.83                          |
| 12                 | 55                 | 55-59            | 5.0            | 0.50                                 | 46,411                   | 263                       | 0.00567                 | 0.02794                        | 0.97206                           | 95,190                       | 2,659                       | 469,302                    | 2,594,900                                      | 27.26                          |
| 13                 | 60                 | 60-64            | 5.0            | 0.50                                 | 39,820                   | 304                       | 0.00763                 | 0.03746                        | 0.96254                           | 92,531                       | 3,466                       | 453,989                    | 2,152,598                                      | 22.97                          |
| 14                 | 65                 | 65-69            | 5.0            | 0.50                                 | 37,978                   | 536                       | 0.01411                 | 0.06816                        | 0.93184                           | 89,065                       | 6,071                       | 430,147                    | 1,671,609                                      | 18.77                          |
| 15                 | 70                 | 70-74            | 5.0            | 0.50                                 | 37,039                   | 872                       | 0.02354                 | 0.11117                        | 0.88883                           | 82,994                       | 9,226                       | 391,904                    | 1,241,462                                      | 14.96                          |
| 16                 | 75                 | 75-79            | 5.0            | 0.50                                 | 33,288                   | 1,390                     | 0.04176                 | 0.18905                        | 0.81095                           | 73,767                       | 13,946                      | 333,973                    | 849,558                                      | 11.52                          |
| 17                 | 80                 | 80-84            | 5.0            | 0.50                                 | 23,306                   | 1,605                     | 0.06887                 | 0.29376                        | 0.70624                           | 59,822                       | 17,573                      | 255,176                    | 515,585                                      | 8.62                           |
| 18                 | 85                 | 85+              | 12.3           | 0.50                                 | 23,872                   | 3,873                     | 0.16224                 | 1.00000                        | 0.00000                           | 42,249                       | 42,249                      | 260,409                    | 260,409                                      | 6.16                           |
### The Life Table

- **pi** = Conditional probability that an individual entering the age interval will survive the age interval

\[ p_i = 1 - q_i \]
The Life Table

\[ l_i = \text{Life table cohort population. The hypothetical population of newborn babies on which the life table is based. The radix is usually defined as 100,000.} \]
### The Life Table

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<td>1,390</td>
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<td>80-84</td>
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<td>0.5</td>
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<td>1,605</td>
<td>0.06887</td>
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<td>0.70624</td>
<td>59,822</td>
<td>17,573</td>
<td>255,176</td>
<td>515,585</td>
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<td>260,409</td>
<td>6.16</td>
<td></td>
</tr>
</tbody>
</table>

\[ d_i = \text{Number of life table deaths in the age interval} \]

\[ = l_i(i) - l_i(i+1) \]
# The Life Table

\[ L_i = \text{Total number of years lived during the age interval} \]

\[ = n^* (i \cdot (i+1) + (n_i \cdot a_i)) \]
## The Life Table

<table>
<thead>
<tr>
<th>Age Interval Index</th>
<th>Age At Start Of Interval</th>
<th>Age Interval Width</th>
<th>Fraction of Last Age Interval Of Life</th>
<th>Population Years At Risk</th>
<th>Number Of Deaths In Interval</th>
<th>Death Rate In Interval</th>
<th>Probability Of Dying In Interval</th>
<th>Probability Of Surviving Interval</th>
<th>Number Alive At Start Of Interval</th>
<th>Number Dying In Interval</th>
<th>Number Of Years Lived In Interval</th>
<th>Number Of Years Lived Beyond Start Of Interval</th>
<th>Total Number Of Years Lived Beyond Start Of Interval</th>
<th>Observed Expectation Of Life At Start Of Interval</th>
</tr>
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<tbody>
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<td>2,659</td>
<td>95,025</td>
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<td>65</td>
<td>65-69</td>
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<td>0.06616</td>
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<td>70-74</td>
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<td>0.11117</td>
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<td>82,901</td>
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<td>16</td>
<td>75</td>
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<td>0.81095</td>
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<td>17</td>
<td>80</td>
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<tr>
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<td>42,249</td>
<td>42,249</td>
<td>260,409</td>
<td>260,409</td>
<td>6.16</td>
</tr>
</tbody>
</table>

$T_i = \text{Cumulative number of years lived by the cohort population in the age interval and all subsequent age intervals}$
The Life Table

\[ e_i = \text{Life expectancy at the beginning of the age interval} \]

\[ = \frac{l_i}{T_i} \]
Alameda County Results
Alameda County Diversity

Source: CAPE, with data from Census 2010.
## Alameda County Diversity

<table>
<thead>
<tr>
<th>Location</th>
<th>Diversity Index</th>
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<tr>
<td>Highest Possible</td>
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<tr>
<td>Hawaii County, Hawaii</td>
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</tr>
<tr>
<td>Queens County, New York</td>
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</tr>
<tr>
<td>Maui County, Hawaii</td>
<td>0.7633</td>
</tr>
<tr>
<td>Aleutians East Borough, Alaska</td>
<td>0.7586</td>
</tr>
<tr>
<td>Kauai County, Hawaii</td>
<td>0.7565</td>
</tr>
<tr>
<td><strong>Alameda County, California</strong></td>
<td><strong>0.7498</strong></td>
</tr>
<tr>
<td>Fort Bend County, Texas</td>
<td>0.7398</td>
</tr>
<tr>
<td>Solano County, California</td>
<td>0.7325</td>
</tr>
<tr>
<td>Honolulu County, Hawaii</td>
<td>0.7291</td>
</tr>
</tbody>
</table>

Source: CAPE, with data from Census 2010.
Life Expectancy vs Income

For each $17,370 in income, you get one year of life expectancy

LE = 5.76e-5(Income) + 76.953

R² = 0.4185

Sources: Alameda County vital statistics files, 2010-2014; American Community Survey 2014 5-year files.
The Social Gradient

1989-1991

Life Expectancy at Birth (Years)

Census Tract Poverty Group

- API
- Hisp/Lat
- All Races
- White
- AfAm/Black
The Social Gradient

Change in Life Expectancy Over Time

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Poverty Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-1991</td>
<td></td>
</tr>
<tr>
<td>1999-2001</td>
<td></td>
</tr>
<tr>
<td>2009-2011</td>
<td></td>
</tr>
</tbody>
</table>

Census Tract Poverty Group:
- <5.0%
- 5.0-9.9%
- 10.0-19.9%
- 20.0-29.9%
- 30.0%+
- Total
Potential Gains in Life Expectancy vs Other Measures of Mortality

- Measuring potential gains in life expectancy
  - Multiple-decrement life table
  - An easier method
- Years of life lost/years of potential life lost (YLL/YPLL)
- Age-adjusted mortality
- Leading causes of death
Potential gains in life expectancy or years of potential life lost: impact of competing risks of death

Dejian Lai and Robert J Hardy

Background  Measuring the impact of competing risks of death on society is important for setting public health policy and allocating resources. However, various indicators may result in inconsistent conclusions. The potential gains in life expectancy (PGLE) by elimination of deaths from HIV/AIDS, diseases of the heart and malignant neoplasms were compared to the years of potential life lost (YPLL) due to these causes in measuring the impact of premature death for the US population of working age (15–64 years).

Methods  The PGLE and the YPLL were computed from mortality reports (1987–1992) by race and gender group for deaths from HIV/AIDS, diseases of the heart and malignant neoplasms for the US population of working age.
Potential Gains in Life Expectancy

An Easier Method

J. Racial and Ethnic Health Disparities
DOI 10.1007/s40615-015-0156-1

Potential Gains in Life Expectancy from Reductions in Leading Causes of Death, Los Angeles County: a Quantitative Approach to Identify Candidate Diseases for Prevention and Burden Disparities Elimination

Alex Ho¹ · Heena Hameed¹ · Alice W. Lee² · Margaret Shih¹

Received: 27 April 2015 / Revised: 10 July 2015 / Accepted: 6 August 2015
© W. Montague Cobb-NMA Health Institute 2015
Published online: 01 October 2015
## Potential Gains in Life Expectancy

<table>
<thead>
<tr>
<th>Cause</th>
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<th>2012-2014</th>
</tr>
</thead>
<tbody>
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<td>LE</td>
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<td>82.00</td>
</tr>
<tr>
<td>Female</td>
<td>81.39</td>
<td>84.21</td>
</tr>
<tr>
<td>Male</td>
<td>76.54</td>
<td>79.63</td>
</tr>
<tr>
<td>Heart Disease</td>
<td>4.73</td>
<td>3.15</td>
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<tr>
<td><strong>Coronary Heart Disease</strong></td>
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<td><strong>1.91</strong></td>
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<tr>
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</tr>
<tr>
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<tr>
<td>Lung Cancer</td>
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<td>Female Breast Cancer*</td>
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<tr>
<td>Prostate Cancer†</td>
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<tr>
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<td>Unintentional Injuries</td>
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<tr>
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<td>0.28</td>
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<td>Chronic Liver Disease &amp; Cirrhosis</td>
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<tr>
<td>All Other</td>
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* Population at risk female only  
† Population at risk male only
## Years of Life Lost

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<th>Cause</th>
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<tbody>
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<td><strong>YLL per death</strong></td>
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The Age Adjuster

- Excel tool (addin)
- Calculates various measures
  - Age-adjusted rate — LCL, UCL, SE, RSE
  - Age-specific rates
  - YLL/YPLL — various methods including GBD 2010
  - Life expectancy — LCL, UCL, SE
# The Age Adjuster

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The Age Adjuster

- Calculate age-adjusted rates/LE
- Calculate YLL (GBD 2010 method)
The Age Adjuster

What are your age groups?

Ten-year age groups
- <1, 1-4, 5-14, 15-24, ..., 65-74, 75-84, 85+
- <5, 5-14, 15-24, ..., 65-74, 75-84, 85+
- <5, 5-14, 15-24, ..., 55-64, 65-74, 75+

Five-year age groups
- <1, 1-4, 5-9, 10-14, ..., 75-79, 80-84, 85+
- <5, 5-9, 10-14, 15-19, ..., 75-79, 80-84, 85+

Truncated age groups
- 18-24, 25-34, 35-44, 45-54, 55-64
- 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85+
- <1, 1-4, 5-11, 12-17
- <5, 5-11, 12-17
- 65-74, 75-84, 85+
- 55-64, 65-74, 75-84, 85+
- 1-4, 5-14, 15-24, ..., 65-74, 75-84, 85+
- 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85+
The Age Adjuster

Indicate the first data cell in the numerator and denominator rows.

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The Age Adjuster

How many years of data? 3

Calculate life expectancy

[Image of the Age Adjuster software interface]
## The Age Adjuster

### Output (partial)

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Contact Information

Please contact me if you want more information on calculating PGLE or YLL, or especially if you would like the Age Adjuster Excel addin.

Matt Beyers
Epidemiologist II
Alameda County Public Health Department
Health Care Services Agency
matt.beyers@acgov.org
510.267.3225

For more information on the SCALE project:
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