Regional workshop on the Production of Population Estimates and Demographic Indicators
Addis Ababa, 5-9 October

Evaluation of Mortality Data

François Pelletier
Population Estimates and Projections Section

www.unpopulation.org
Outline

1. **Measures of mortality**
   a) Crude death rates, infant and under five mortality “rates”, age specific mortality rates and life expectancy at birth

2. **Life tables**
   a) Constructing empirical (abridged) life tables
   b) Model life tables
   c) Deriving mortality indicators from life tables components

3. **Survival of children ever born** (Brass type estimates)
   a) Information required
   b) Checking data quality
   c) Estimation using MortPak (Qfive)
   d) Assumptions, violations, and assessing quality of estimates
Measures of mortality

Crude Death Rate ($CDR$)

$$CDR[0, T] = \frac{\text{Number of deaths in the population between times 0 and } T}{\text{Number of person-years lived in the population between times 0 and } T}$$

Usually,

$$\text{Crude Death Rate} = \frac{\text{Number of deaths in a year}}{\text{Mid-year population}} \cdot 1000$$

$$CDR = \frac{D}{\bar{P}} \cdot 1000$$

with

$$\bar{P} = \frac{(P_1 + P_0)}{2}$$

>> Crude rate as no reference to smaller groups which might better represent the population likely to experience the event

>> Influence of age structure
### Measures of mortality

**Source:** Preston et al. (2001: 22)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Mid-year population</th>
<th>Deaths during year</th>
<th>Death rate</th>
<th>Proportion in age category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N_i^{Sw}$</td>
<td>$D_i^{Sw}$</td>
<td>$M_i^{Sw}$</td>
<td>$C_i^{Sw}$</td>
</tr>
<tr>
<td>0</td>
<td>59,727</td>
<td>279</td>
<td>0.00467</td>
<td>0.0136</td>
</tr>
<tr>
<td>1–4</td>
<td>229,775</td>
<td>42</td>
<td>0.00018</td>
<td>0.0524</td>
</tr>
<tr>
<td>5–9</td>
<td>245,172</td>
<td>31</td>
<td>0.00013</td>
<td>0.0559</td>
</tr>
<tr>
<td>10–14</td>
<td>240,110</td>
<td>33</td>
<td>0.00014</td>
<td>0.0548</td>
</tr>
<tr>
<td>15–19</td>
<td>264,957</td>
<td>61</td>
<td>0.00023</td>
<td>0.0604</td>
</tr>
<tr>
<td>20–4</td>
<td>287,176</td>
<td>87</td>
<td>0.00030</td>
<td>0.0655</td>
</tr>
<tr>
<td>25–9</td>
<td>311,111</td>
<td>98</td>
<td>0.00032</td>
<td>0.0709</td>
</tr>
<tr>
<td>30–4</td>
<td>280,991</td>
<td>140</td>
<td>0.00050</td>
<td>0.0641</td>
</tr>
<tr>
<td>35–9</td>
<td>286,899</td>
<td>197</td>
<td>0.00069</td>
<td>0.0654</td>
</tr>
<tr>
<td>40–4</td>
<td>308,238</td>
<td>362</td>
<td>0.00117</td>
<td>0.0703</td>
</tr>
<tr>
<td>45–9</td>
<td>320,172</td>
<td>643</td>
<td>0.00201</td>
<td>0.0730</td>
</tr>
<tr>
<td>50–4</td>
<td>242,230</td>
<td>738</td>
<td>0.00305</td>
<td>0.0552</td>
</tr>
<tr>
<td>55–9</td>
<td>210,785</td>
<td>972</td>
<td>0.00461</td>
<td>0.0481</td>
</tr>
<tr>
<td>60–4</td>
<td>216,058</td>
<td>1,640</td>
<td>0.00759</td>
<td>0.0493</td>
</tr>
<tr>
<td>65–9</td>
<td>224,479</td>
<td>2,752</td>
<td>0.01226</td>
<td>0.0512</td>
</tr>
<tr>
<td>70–4</td>
<td>222,578</td>
<td>4,509</td>
<td>0.02026</td>
<td>0.0508</td>
</tr>
<tr>
<td>75–9</td>
<td>184,102</td>
<td>6,745</td>
<td>0.03664</td>
<td>0.0420</td>
</tr>
<tr>
<td>80–4</td>
<td>140,667</td>
<td>9,587</td>
<td>0.06815</td>
<td>0.0321</td>
</tr>
<tr>
<td>85+</td>
<td>110,242</td>
<td>17,340</td>
<td>0.15729</td>
<td>0.0251</td>
</tr>
<tr>
<td>All</td>
<td>4,385,469</td>
<td>46,256</td>
<td>0.01055</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age group</th>
<th>Mid-year population</th>
<th>Deaths during year</th>
<th>Death rate</th>
<th>Proportion in age category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$N_i^{K}$</td>
<td>$D_i^{K}$</td>
<td>$M_i^{K}$</td>
<td>$C_i^{K}$</td>
</tr>
<tr>
<td>0</td>
<td>174,078</td>
<td>3,720</td>
<td>0.02137</td>
<td>0.0200</td>
</tr>
<tr>
<td>1–4</td>
<td>754,758</td>
<td>1,220</td>
<td>0.00162</td>
<td>0.0868</td>
</tr>
<tr>
<td>5–9</td>
<td>879,129</td>
<td>396</td>
<td>0.00045</td>
<td>0.1011</td>
</tr>
<tr>
<td>10–14</td>
<td>808,510</td>
<td>298</td>
<td>0.00037</td>
<td>0.0929</td>
</tr>
<tr>
<td>15–19</td>
<td>720,161</td>
<td>561</td>
<td>0.00078</td>
<td>0.0828</td>
</tr>
<tr>
<td>20–4</td>
<td>622,988</td>
<td>673</td>
<td>0.00108</td>
<td>0.0716</td>
</tr>
<tr>
<td>25–9</td>
<td>733,057</td>
<td>752</td>
<td>0.00103</td>
<td>0.0843</td>
</tr>
<tr>
<td>30–4</td>
<td>732,312</td>
<td>965</td>
<td>0.00132</td>
<td>0.0842</td>
</tr>
<tr>
<td>35–9</td>
<td>612,825</td>
<td>1,113</td>
<td>0.00182</td>
<td>0.0704</td>
</tr>
<tr>
<td>40–4</td>
<td>487,996</td>
<td>1,405</td>
<td>0.00288</td>
<td>0.0561</td>
</tr>
<tr>
<td>45–9</td>
<td>284,799</td>
<td>1,226</td>
<td>0.00430</td>
<td>0.0327</td>
</tr>
<tr>
<td>50–4</td>
<td>503,608</td>
<td>2,878</td>
<td>0.00571</td>
<td>0.0579</td>
</tr>
<tr>
<td>55–9</td>
<td>301,879</td>
<td>3,266</td>
<td>0.01082</td>
<td>0.0347</td>
</tr>
<tr>
<td>60–4</td>
<td>374,317</td>
<td>5,212</td>
<td>0.01392</td>
<td>0.0430</td>
</tr>
<tr>
<td>65–9</td>
<td>256,247</td>
<td>6,866</td>
<td>0.02679</td>
<td>0.0295</td>
</tr>
<tr>
<td>70–4</td>
<td>154,623</td>
<td>6,182</td>
<td>0.03998</td>
<td>0.0178</td>
</tr>
<tr>
<td>75–9</td>
<td>149,917</td>
<td>8,199</td>
<td>0.05469</td>
<td>0.0172</td>
</tr>
<tr>
<td>80–4</td>
<td>88,716</td>
<td>9,013</td>
<td>0.10159</td>
<td>0.0102</td>
</tr>
<tr>
<td>85+</td>
<td>58,940</td>
<td>10,627</td>
<td>0.18030</td>
<td>0.0068</td>
</tr>
<tr>
<td>All</td>
<td>8,698,860</td>
<td>64,572</td>
<td>0.00742</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

**Sweden, females, 1992**

**Kazakhstan, females, 1992**

**Source:** Preston et al. (2001: 22)

**Regional Workshop on the Production of Population Estimates and Demographic Indicators**

**Addis Ababa, 5–9 October 2015**
Measures of mortality

Infant Mortality Rate (IMR)

- One of the best-known and widely used available measure of mortality in early life

\[
\text{Infant mortality rate} = \frac{\text{Deaths under age 1 during year } t}{\text{Total live births in year } t} \cdot 1000
\]

- Denominator is live births (not than the mid-year population as in ASDR)
- Majority of infant deaths occurs in the first days and weeks or life
  >> Deaths not evenly distributed over the first 12 months, mid-year population is not a valid indicator of average size of the population at risk of infant mortality
Measures of mortality

Under-Five Morality Rate (or ‘Child Mortality’)
Widely used to measure, assess and monitor the progress of countries with respect to child survival

>> MDG-4: Reduce child mortality, Target 4.A: Reduce by two thirds, between 1990 and 2015, the under-five mortality rate

>> IGME (Interagency group for child mortality estimation) estimates available at www.childmortality.org

Definition
Under-five mortality rate is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year
Measures of mortality

Age-specific death rate \((ASDR)\)

\[
\text{Age specific death rate} = \frac{\text{Number of deaths in a year at age } x}{\text{Mid-year population at age } x} \cdot 1000
\]

\[nM_x = \frac{nD_x}{nP_x}\]

- \(ASDR\) measures the incidence of death at each age
- \(ASDR\) may refer to single age or to grouped ages (e.g. 20-24, 25-29)
- Death rate is relatively high for infants under one year declines to its lowest levels for children and slowly increase thereafter
Measures of mortality

**Life expectancy at birth** ($e_0$)

$\gg$ The expectation of life at exact age $x$, i.e. the average number of years lived by a person from exact age $x$
Life tables
Life tables

- One of demography’s most influential “innovation”
- Life tables are useful to examine how many survive to successive ages and to determine the length of life
- Essential tool for population estimates and projections
- Important measure of progress
- Indicates whether the goal of long life for all is achieved
- Most widely known indicator: Life expectancy at birth ($e_0$)
Life tables

- Contain several functions that represent the effects of mortality on a population
  - Life expectancy, age-specific mortality rates, probability of dying by age $x$
- **Cohort life tables** trace the experience of a single birth cohort (e.g. all those born in 1950)
  - Have to wait for entire cohort to die to have full data
- **Period life tables** use a *synthetic cohort* to represent prevailing mortality conditions at present time
  - As if a cohort lived their whole life under the current mortality conditions
The period life table – Example (Preston et al. 2001)

<table>
<thead>
<tr>
<th>Age x</th>
<th>nN_x</th>
<th>nD_x</th>
<th>nm_x</th>
<th>nα_x</th>
<th>nq_x</th>
<th>np_x</th>
<th>lx</th>
<th>nd_x</th>
<th>nL_x</th>
<th>T_x</th>
<th>e_x^0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>47,925</td>
<td>419</td>
<td>0.008743</td>
<td>0.068</td>
<td>0.008672</td>
<td>0.991328</td>
<td>100,000</td>
<td>867</td>
<td>99,192</td>
<td>7,288,901</td>
<td>72.889</td>
</tr>
<tr>
<td>1</td>
<td>189,127</td>
<td>70</td>
<td>0.000370</td>
<td>1.626</td>
<td>0.001479</td>
<td>0.998521</td>
<td>99,133</td>
<td>147</td>
<td>396,183</td>
<td>7,189,709</td>
<td>72.526</td>
</tr>
<tr>
<td>5</td>
<td>234,793</td>
<td>36</td>
<td>0.001015</td>
<td>2.500</td>
<td>0.000766</td>
<td>0.999234</td>
<td>98,986</td>
<td>76</td>
<td>494,741</td>
<td>6,793,526</td>
<td>68.631</td>
</tr>
<tr>
<td>10</td>
<td>238,790</td>
<td>46</td>
<td>0.000193</td>
<td>3.143</td>
<td>0.000963</td>
<td>0.999037</td>
<td>98,910</td>
<td>95</td>
<td>494,375</td>
<td>6,298,785</td>
<td>63.682</td>
</tr>
<tr>
<td>15</td>
<td>254,996</td>
<td>249</td>
<td>0.000976</td>
<td>2.724</td>
<td>0.004872</td>
<td>0.995128</td>
<td>98,815</td>
<td>481</td>
<td>492,980</td>
<td>5,804,410</td>
<td>58.740</td>
</tr>
<tr>
<td>20</td>
<td>326,831</td>
<td>420</td>
<td>0.001285</td>
<td>2.520</td>
<td>0.006405</td>
<td>0.993595</td>
<td>98,334</td>
<td>630</td>
<td>490,106</td>
<td>5,311,431</td>
<td>54.014</td>
</tr>
<tr>
<td>25</td>
<td>355,086</td>
<td>403</td>
<td>0.001135</td>
<td>2.481</td>
<td>0.005659</td>
<td>0.994341</td>
<td>97,704</td>
<td>553</td>
<td>487,127</td>
<td>4,821,324</td>
<td>49.346</td>
</tr>
<tr>
<td>30</td>
<td>324,222</td>
<td>441</td>
<td>0.001360</td>
<td>2.601</td>
<td>0.006779</td>
<td>0.993221</td>
<td>97,151</td>
<td>659</td>
<td>484,175</td>
<td>4,334,198</td>
<td>44.613</td>
</tr>
<tr>
<td>35</td>
<td>269,963</td>
<td>508</td>
<td>0.001882</td>
<td>2.701</td>
<td>0.009368</td>
<td>0.990632</td>
<td>96,492</td>
<td>904</td>
<td>480,384</td>
<td>3,850,023</td>
<td>39.900</td>
</tr>
<tr>
<td>40</td>
<td>261,971</td>
<td>769</td>
<td>0.002935</td>
<td>2.663</td>
<td>0.014577</td>
<td>0.985423</td>
<td>95,588</td>
<td>1,393</td>
<td>474,686</td>
<td>3,369,639</td>
<td>35.252</td>
</tr>
<tr>
<td>45</td>
<td>238,011</td>
<td>1,154</td>
<td>0.004849</td>
<td>2.698</td>
<td>0.023975</td>
<td>0.976025</td>
<td>94,195</td>
<td>2,258</td>
<td>465,777</td>
<td>2,894,953</td>
<td>30.734</td>
</tr>
<tr>
<td>50</td>
<td>261,612</td>
<td>1,866</td>
<td>0.007133</td>
<td>2.676</td>
<td>0.035082</td>
<td>0.964918</td>
<td>91,937</td>
<td>3,225</td>
<td>452,188</td>
<td>2,429,176</td>
<td>26.422</td>
</tr>
<tr>
<td>55</td>
<td>181,385</td>
<td>2,043</td>
<td>0.012163</td>
<td>2.645</td>
<td>0.054861</td>
<td>0.945139</td>
<td>88,711</td>
<td>4,867</td>
<td>432,096</td>
<td>1,976,988</td>
<td>22.286</td>
</tr>
<tr>
<td>60</td>
<td>187,962</td>
<td>3,496</td>
<td>0.018600</td>
<td>2.624</td>
<td>0.089062</td>
<td>0.910938</td>
<td>83,845</td>
<td>7,467</td>
<td>401,480</td>
<td>1,544,893</td>
<td>18.426</td>
</tr>
<tr>
<td>65</td>
<td>153,832</td>
<td>4,366</td>
<td>0.028382</td>
<td>2.619</td>
<td>0.132925</td>
<td>0.867075</td>
<td>76,377</td>
<td>10,152</td>
<td>357,713</td>
<td>1,143,412</td>
<td>14.971</td>
</tr>
<tr>
<td>70</td>
<td>105,169</td>
<td>4,337</td>
<td>0.041238</td>
<td>2.593</td>
<td>0.187573</td>
<td>0.812427</td>
<td>66,225</td>
<td>12,422</td>
<td>301,224</td>
<td>785,699</td>
<td>11.864</td>
</tr>
<tr>
<td>75</td>
<td>73,694</td>
<td>5,279</td>
<td>0.071634</td>
<td>2.518</td>
<td>0.304102</td>
<td>0.695898</td>
<td>53,803</td>
<td>16,362</td>
<td>228,404</td>
<td>484,475</td>
<td>9.005</td>
</tr>
<tr>
<td>80</td>
<td>57,512</td>
<td>6,460</td>
<td>0.112324</td>
<td>2.423</td>
<td>0.435548</td>
<td>0.564452</td>
<td>37,441</td>
<td>16,307</td>
<td>145,182</td>
<td>256,070</td>
<td>6.839</td>
</tr>
<tr>
<td>85</td>
<td>32,248</td>
<td>6,146</td>
<td>0.190585</td>
<td>5.247</td>
<td>1.000000</td>
<td>0.000000</td>
<td>21,134</td>
<td>21,134</td>
<td>110,889</td>
<td>110,889</td>
<td>5.247</td>
</tr>
</tbody>
</table>

## Definition of the life table functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$l_x$</td>
<td>Number of persons surviving to exact age $x$ (out of the original 100,000)</td>
</tr>
<tr>
<td>$nq_x$</td>
<td>Probability of dying between exact ages $x$ and $x+n$</td>
</tr>
<tr>
<td>$np_x$</td>
<td>Probability of surviving from exact age $x$ to exact age $x+n$</td>
</tr>
<tr>
<td>$nd_x$</td>
<td>Number of deaths between ages $x$ and $x+n$</td>
</tr>
<tr>
<td>$nL_x$</td>
<td>Average number alive in the interval between exact ages $x$ and $x+n$. It also denotes the number of person-years lived in the interval between exact ages $x$ and $x+n$</td>
</tr>
<tr>
<td>$T_x$</td>
<td>Total population aged $x$ and over, or the total number of person-years lived from exact age $x$</td>
</tr>
<tr>
<td>$e_x$</td>
<td>Expectation of life at exact age $x$, i.e. the average number of years lived by a person from exact age $x$</td>
</tr>
</tbody>
</table>
## Life table – Point and interval measures

<table>
<thead>
<tr>
<th>Functions referring to exact age ( x )</th>
<th>Functions referring to the interval between exact ages ( x ) to ( x + n )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( l_x )</td>
<td>( n q_x )</td>
</tr>
<tr>
<td>( T_x )</td>
<td>( n p_x )</td>
</tr>
<tr>
<td>( e_x )</td>
<td>( n d_x )</td>
</tr>
<tr>
<td></td>
<td>( n L_x )</td>
</tr>
</tbody>
</table>

### Formatting conventions

- \( l_x, d_x, L_x, \) and \( T_x \) \( \gg \) whole number of persons
- \( M_x, q_x, \) and \( p_x \) \( \gg \) five decimal places for rates and probabilities
- \( e_x \) \( \gg \) two decimal places for life expectancy

Calculating the period (abridged) life table

1. Age-specific death rate \((\frac{nM_x}{n})\)

\[nM_x = \frac{nD_x}{nN_x}\]

2. Probability of dying between ages \(x\) and \(x+n\) \((\frac{nq_x}{n})\)

> assuming that persons dying in the interval do so, on average, half-way through the interval

\[nq_x = \frac{2n \cdot nM_x}{2 + n \cdot nM_x}\]

For open-ended age group

3. Probability of surviving from one age to the next \((\frac{npx}{n})\)

\[np_x = 1 - nq_x\]
Calculating the period (abridged) life table

4. Number surviving at exact ages \((l_x)\) →

\[ l_{x+n} = l_x \cdot n p_x \]

\[ l_{x+n} = l_x - n d_x \]

>> At age 0, \( l_0 = 100,000 \)

5. Deaths between ages \( x \) and \( x+n \) \((n d_x)\) →

\[ n d_x = l_x \cdot n q_x \]

\[ n d_x = l_x - l_{x+n} \]
Calculating the period (abridged) life table

6. Average number alive between exact ages $x$ and $x+n$ ($nL_x$)

$$nL_x = \frac{n}{2} \cdot (l_x + l_{x+n})$$

For $L_0$, $L_0 = 0.3l_0 + 0.7l_1$

For open-ended age group

7. Total population aged $x$ and over ($T_x$)

$$T_x = \sum_{i=x}^{\infty} nL_i$$

For open-ended age group

Working from the bottom of the life table

$$T_x = T_{x+n} + nL_x$$
Calculating the period (abridged) life table

8. Expectation of life from age $x$ ($e_x$) →

$e_x = \frac{T_x}{l_x}$

→ Life expectancy at birth ($e_0$) = $\frac{T_0}{l_0}$
Data checks: does the life table make sense?

Source: Swedish females, 1895 vs 1995 (Preston et. al. 2001)
Rectangularization of the life table, Sweden, Females

Data Source: Human Mortality Database
Example – using MortPak LIFTB
Central African Republic, 1988 Census, Men


Regional Workshop on the Production of Population Estimates and Demographic Indicators
Addis Ababa, 5-9 October 2015
Deriving mortality indicators from life table functions (example with Central African Republic)

- **Under five mortality (5q0):**
  \[
  5q0 = \frac{l(0) - l(5)}{l(0)}
  \]
  \[
  = \frac{(100,000 - 87,080)}{100,000} = 0.1292
  \]

- **Adult mortality (45q15):**
  \[
  45q15 = \frac{l(15) - l(60)}{l(15)}
  \]
  \[
  = \frac{(84,350 - 53,323)}{84,350} = 0.3678
  \]

- **Life expectancy for open age groups:**
  \[
  e(95+) = \frac{1}{m95+}
  \]
  \[
  = \frac{1}{0.19621} = 5.097
  \]
Example – using MortPak LIFTB
Central African Republic, 1988 Census, Men

Model life tables

- Represent expected age patterns of mortality
- Created to estimate demographic parameters for countries with limited data
- Built on empirical studies of age-specific mortality patterns in the past
- Two groups of model life tables:
  - Coale-Demeny (1968, 1983): based on European populations
    - North, South, East and West European models
    - West only model based on some non-European life tables
  - United Nations (1982): based on developing countries
    - Latin American, Chilean, South Asian, Far Eastern, General
Model life tables (2)

Age-specific shape of mortality – relative probabilities of dying at different ages

Relationship between infant mortality ($_1q_0$) and child mortality ($_4q_1$)

Model life tables (3)

United Nations Model Life Tables — Males

<table>
<thead>
<tr>
<th>AGE</th>
<th>M(X)</th>
<th>Q(X)</th>
<th>I(X)</th>
<th>D(X)</th>
<th>L(X)</th>
<th>T(X)</th>
<th>E(X)</th>
<th>A(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.23469</td>
<td>0.20429</td>
<td>100000</td>
<td>20429</td>
<td>86313</td>
<td>350000</td>
<td>355000</td>
<td>0.330</td>
</tr>
<tr>
<td>1</td>
<td>0.24472</td>
<td>0.16631</td>
<td>7957</td>
<td>25224</td>
<td>289241</td>
<td>341567</td>
<td>42901</td>
<td>1.352</td>
</tr>
<tr>
<td>2</td>
<td>0.29982</td>
<td>0.10790</td>
<td>66337</td>
<td>3178</td>
<td>323742</td>
<td>313046</td>
<td>47190</td>
<td>2.350</td>
</tr>
<tr>
<td>3</td>
<td>0.30111</td>
<td>0.25252</td>
<td>63160</td>
<td>1593</td>
<td>311817</td>
<td>286704</td>
<td>44438</td>
<td>2.500</td>
</tr>
<tr>
<td>4</td>
<td>0.30497</td>
<td>0.30407</td>
<td>61967</td>
<td>2110</td>
<td>302841</td>
<td>249867</td>
<td>40523</td>
<td>2.632</td>
</tr>
<tr>
<td>5</td>
<td>0.30666</td>
<td>0.35051</td>
<td>59457</td>
<td>3003</td>
<td>299037</td>
<td>219324</td>
<td>38868</td>
<td>2.865</td>
</tr>
<tr>
<td>6</td>
<td>0.31169</td>
<td>0.35679</td>
<td>56645</td>
<td>3206</td>
<td>274346</td>
<td>190009</td>
<td>33607</td>
<td>3.259</td>
</tr>
<tr>
<td>7</td>
<td>0.31352</td>
<td>0.46449</td>
<td>53248</td>
<td>3534</td>
<td>237753</td>
<td>169765</td>
<td>35567</td>
<td>3.558</td>
</tr>
<tr>
<td>8</td>
<td>0.31228</td>
<td>0.47363</td>
<td>49814</td>
<td>3660</td>
<td>239990</td>
<td>169909</td>
<td>33691</td>
<td>3.767</td>
</tr>
<tr>
<td>9</td>
<td>0.31257</td>
<td>0.58418</td>
<td>46146</td>
<td>3883</td>
<td>221132</td>
<td>112991</td>
<td>24485</td>
<td>3.959</td>
</tr>
<tr>
<td>10</td>
<td>0.30992</td>
<td>0.99948</td>
<td>42232</td>
<td>4204</td>
<td>200900</td>
<td>908762</td>
<td>21504</td>
<td>3.517</td>
</tr>
<tr>
<td>11</td>
<td>0.32817</td>
<td>1.1849</td>
<td>38058</td>
<td>4599</td>
<td>179185</td>
<td>707852</td>
<td>18259</td>
<td>2.538</td>
</tr>
<tr>
<td>12</td>
<td>0.3223</td>
<td>1.49193</td>
<td>33548</td>
<td>5012</td>
<td>155420</td>
<td>598667</td>
<td>13725</td>
<td>2.542</td>
</tr>
<tr>
<td>13</td>
<td>0.42431</td>
<td>1.92035</td>
<td>28537</td>
<td>5460</td>
<td>199117</td>
<td>377237</td>
<td>15509</td>
<td>2.543</td>
</tr>
<tr>
<td>14</td>
<td>0.46056</td>
<td>2.63237</td>
<td>23056</td>
<td>6070</td>
<td>100230</td>
<td>244050</td>
<td>10584</td>
<td>2.520</td>
</tr>
<tr>
<td>15</td>
<td>0.48574</td>
<td>3.23096</td>
<td>16986</td>
<td>5950</td>
<td>49547</td>
<td>143830</td>
<td>84466</td>
<td>2.481</td>
</tr>
<tr>
<td>16</td>
<td>0.51848</td>
<td>5.1210</td>
<td>11006</td>
<td>4976</td>
<td>42023</td>
<td>74053</td>
<td>67729</td>
<td>2.386</td>
</tr>
<tr>
<td>17</td>
<td>0.54258</td>
<td>6.53932</td>
<td>6500</td>
<td>3400</td>
<td>20953</td>
<td>32003</td>
<td>5112</td>
<td>2.295</td>
</tr>
<tr>
<td>18</td>
<td>0.53474</td>
<td>11.5300</td>
<td>4650</td>
<td>2650</td>
<td>11097</td>
<td>4211</td>
<td>4.211</td>
<td></td>
</tr>
</tbody>
</table>

Level of mortality – each model has several different levels that correspond with different levels of life expectancy at birth ($e_0$)

Relationship between 45q15 and 5q0 based on Model life tables
The impact of the HIV/AIDS epidemic on mortality levels and age patterns

- Spectrum (http://spectrumbeta.futuresinstitute.org/)
- No-Aids Scenario
- Under five mortality (5q0)
- Adult mortality (45q15)
Survival of children ever born

Indirect estimation of child mortality
Mortality estimates from population censuses: Introduction

- A group of questions can be used to obtain mortality data in a census
- Two distinctions:
  a) Level and trend of mortality vs age pattern of mortality
     • Survival of children ever born: level and trend of mortality
     • Household deaths: age pattern of mortality
  b) Deaths of younger persons vs. deaths of adults
     • Younger persons: survival of children ever born
     • Adults: household deaths
- All approaches are to supplement death registration data, not to replace it
Quick review - children ever born data

- Have been used for the past 50 years to collect data on infant and child mortality

- For every woman the following information is collected:
  a) the total number of female children she has had in her lifetime.
  b) the total number of male children she has had in her lifetime.
  c) the number of female children who are surviving
  d) the number of male children who are surviving
Survival of children ever born

- Ever born – Surviving = Children deceased
- Children deceased / Ever born = Proportion deceased
- Life table measures of infant, child and young adult mortality may be derived from the proportion of deceased
  - In combination with data on age of mother
Brass type estimates

- Provide *indirect estimation* of *level and trend* of mortality for about 20 years prior to a census or survey

- Data required:
  - Number of women by
    - 5 year age group or;
    - Duration of marriage (5 year groups)
  - Total number of children born alive to women in corresponding 5-year groups
  - Total number of children still alive (or deceased) at time of census by corresponding 5-year groups
Brass type estimates (2)

<table>
<thead>
<tr>
<th>Age group of mother in years</th>
<th>Age group index</th>
<th>Proportion of children dead approximates</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>1</td>
<td>q(1)</td>
</tr>
<tr>
<td>20-24</td>
<td>2</td>
<td>q(2)</td>
</tr>
<tr>
<td>25-29</td>
<td>3</td>
<td>q(3)</td>
</tr>
<tr>
<td>30-34</td>
<td>4</td>
<td>q(5)</td>
</tr>
<tr>
<td>35-39</td>
<td>5</td>
<td>q(10)</td>
</tr>
<tr>
<td>40-44</td>
<td>6</td>
<td>q(15)</td>
</tr>
<tr>
<td>45-49</td>
<td>7</td>
<td>q(20)</td>
</tr>
</tbody>
</table>
Brass type estimation – data checks

Women in the age group should include all women, not only those who respond to CEB/CS questions

>>Important to check in the context where it is inappropriate to ask unmarried women about childbearing

Note small number of women in 0-14 age group; unmarried women were not included

Brass type estimation – data checks (2)

- Experience has shown that it is possible to get high quality responses to summary birth histories in any data collection exercise, including censuses
  - If both CEB and CS are understated, some cancellation of errors will occur
  - But in practice, the reporting of CS is more likely to be complete than the reporting of CEB
  - Calculated proportions of deceased children are likely to be too low

- Make sure trends in children ever born/surviving/deceased are consistent

- Check for missing data and/or editing
Brass type estimation – data checks (3)

Example: missing or implausible values of CEB and CS data

Table 5.1 Percentage of cases where no editing of children ever born and children surviving data was required, by population group and age group

<table>
<thead>
<tr>
<th>Age</th>
<th>African</th>
<th>Coloured</th>
<th>Indian/Asian</th>
<th>White</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CEB</td>
<td>CS</td>
<td>CEB</td>
<td>CS</td>
</tr>
<tr>
<td>12-14</td>
<td>65.2</td>
<td>34.5</td>
<td>53.5</td>
<td>27.2</td>
</tr>
<tr>
<td>15-19</td>
<td>73.5</td>
<td>44.0</td>
<td>63.7</td>
<td>37.2</td>
</tr>
<tr>
<td>20-24</td>
<td>82.5</td>
<td>62.5</td>
<td>78.5</td>
<td>59.5</td>
</tr>
<tr>
<td>25-29</td>
<td>88.2</td>
<td>75.6</td>
<td>87.6</td>
<td>75.4</td>
</tr>
<tr>
<td>30-34</td>
<td>90.9</td>
<td>81.2</td>
<td>91.2</td>
<td>82.0</td>
</tr>
<tr>
<td>35-39</td>
<td>91.9</td>
<td>83.2</td>
<td>92.6</td>
<td>84.5</td>
</tr>
<tr>
<td>40-44</td>
<td>91.4</td>
<td>83.3</td>
<td>92.5</td>
<td>84.7</td>
</tr>
<tr>
<td>45-49</td>
<td>89.9</td>
<td>82.3</td>
<td>91.3</td>
<td>83.7</td>
</tr>
</tbody>
</table>

### Brass type estimation – data checks (4)

#### Turkey, 2000

<table>
<thead>
<tr>
<th>Age group of women</th>
<th>Total women</th>
<th>Total CEB</th>
<th>Average CEB</th>
<th>Total CS</th>
<th>Average children deceased (CD)</th>
<th>Proportion deceased (CEB-CS)/CEB</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 - 19</td>
<td>3518257</td>
<td>294628</td>
<td>0.08</td>
<td>281296</td>
<td>0.003789</td>
<td>0.045</td>
</tr>
<tr>
<td>20 - 24</td>
<td>3263432</td>
<td>2078364</td>
<td>0.64</td>
<td>1991445</td>
<td>0.026634</td>
<td>0.042</td>
</tr>
<tr>
<td>25 - 29</td>
<td>2918825</td>
<td>4522719</td>
<td>1.55</td>
<td>4312404</td>
<td>0.072055</td>
<td>0.047</td>
</tr>
<tr>
<td>30 - 34</td>
<td>2457285</td>
<td>5700038</td>
<td>2.32</td>
<td>5395143</td>
<td>0.124078</td>
<td>0.053</td>
</tr>
<tr>
<td>35 - 39</td>
<td>2400808</td>
<td>7036619</td>
<td>2.93</td>
<td>6563946</td>
<td>0.196881</td>
<td>0.067</td>
</tr>
<tr>
<td>40 - 44</td>
<td>1985225</td>
<td>6707033</td>
<td>3.38</td>
<td>6131544</td>
<td>0.289886</td>
<td>0.086</td>
</tr>
<tr>
<td>45 - 49</td>
<td>1658012</td>
<td>6394157</td>
<td>3.86</td>
<td>5722904</td>
<td>0.404854</td>
<td>0.105</td>
</tr>
</tbody>
</table>

- Unless fertility has been rising, average CEB should increase with age group.
- Unless fertility or child mortality are increasing, average CD should increase with age group.

**Source:** UN *Demographic Yearbook*

Regional Workshop on the Production of Population Estimates and Demographic Indicators
Addis Ababa, 5-9 October 2015
Brass type estimation – data checks (5)

- Check sex ratio at birth implied by the CEB data for different mother age groups if gender is disaggregated (from age and sex structure)
  - Is it plausible?
  - Can help to identify underreporting of female births

- Is proportion of children surviving/deceased plausible?
  - Compare with other sources on child mortality
A rapid assessment of CEB/CS data:
Central African Republic, 1988 census (1)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Total women</th>
<th>CEB</th>
<th>CS</th>
<th>CS/CEB</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 - 19</td>
<td>131,066</td>
<td>63,993</td>
<td>52,767</td>
<td>0.825</td>
</tr>
<tr>
<td>20 - 24</td>
<td>116,171</td>
<td>195,571</td>
<td>163,269</td>
<td>0.835</td>
</tr>
<tr>
<td>25 - 29</td>
<td>103,544</td>
<td>290,398</td>
<td>241,083</td>
<td>0.830</td>
</tr>
<tr>
<td>30 - 34</td>
<td>78,005</td>
<td>302,869</td>
<td>247,719</td>
<td>0.818</td>
</tr>
<tr>
<td>35 - 39</td>
<td>62,179</td>
<td>277,866</td>
<td>220,937</td>
<td>0.795</td>
</tr>
<tr>
<td>40 - 44</td>
<td>51,230</td>
<td>239,595</td>
<td>182,832</td>
<td>0.763</td>
</tr>
<tr>
<td>45 - 49</td>
<td>47,250</td>
<td>216,587</td>
<td>158,773</td>
<td>0.733</td>
</tr>
</tbody>
</table>
A rapid assessment of CEB/CS data: Central African Republic, 1988 census (2)

- Proportion deceased for the 30-34 age group = $(1 - 0.818) = 0.182$
  - Proportion of children deceased born to mothers of 30-34 years of age approximates $q(5)$, the proportion of children born who die before their 5th birthday, about 7 years before the data collection.

- Compare with other estimates (e.g., UN Population Division)
  - 1988 census ‘quick’ estimates of $q(5) = 182$ per 1000 for 1981
  - UN Pop Division = 183 per 1000 (for 1980-1985 period)
  - IGME = 183.5 per 1000 (for 1980.5)
  - Possible overestimation of $q(5)$ in census data?
UN Population Division: World Population Prospects

http://esa.un.org/unpd/wpp/DVD/

Regional Workshop on the Production of Population Estimates and Demographic Indicators
Addis Ababa, 5-9 October 2015
IGME: Child mortality estimates
http://www.childmortality.org

Regional Workshop on the Production of Population Estimates and Demographic Indicators
Addis Ababa, 5-9 October 2015
IGME: Child mortality estimates (www.childmortality.org)
Brass type estimation with MortPak QFIVE

- Calculate the sex ratio at birth
  - If not available, can use standard 1.05

- Calculate the mean age of childbearing (only for UN model life tables)

\[
M = \frac{17.5 \cdot B_{15-19} + 22.5 \cdot B_{20-24} + \cdots + 47.5 \cdot B_{45-49}}{B_{15-19} + B_{20-24} + \cdots + B_{45-49}}
\]

where \( B_{x, x+n} \) = Births in past year to women age \( x \) to \( x+n \)
Brass-type estimation with QFIVE (input)

1. Enter the requested data (Month, Year, Sex…)
2. Select type of inputs based on data available
3. Click ‘Run’ or
4. The results will appear on the far right of the screen (see next slide)
Indicators:
- $q(0)$
- $q(1, 4)$
- $q(5)$
- $e(0)$

9 Models:
- 5 United Nations
- 4 Coale-Demeny

Brass output with QFIVE in MortPak

Regional Workshop on the Production of Population Estimates and Demographic Indicators
Addis Ababa, 5-9 October 2015
How to identify the right model life table (1)

Relationship between mortality risk during the first year of life and between ages 1-4

Coale-Demeny Models

United Nations Models

How to identify the right model life table (2)

Comparison of $q(1)$ & $q(1,4)$ estimates with Coale-Demeny models

How to identify the right model life table (3)

Direct estimates of $q(0)$ and $q(1,4)$ from Central African Republic 1988 Census and 1994-95 DHS, and the relationships to Coale-Demeny and UN model life tables
Change of families of Model Life Table through time

Source: Guillot et al. (2012)
Estimated $1q_0$ and $5q_0$ over time (CD Model North)
Central African Republic, 1988 census

Most recent estimates should be disregarded as estimates based on reports from young mothers tend to be exaggerated.
Brass: relationship of mother’s age and timing of the under-5 mortality estimates

Bangladesh, 1974 Retrospective Survey of Fertility and Mortality

Brass: Assumptions, violations (1)

1. In any time period, mortality of children does not vary by five-year grouping of mothers
   - This assumption is usually violated for the mother age group 15-19, and to a lesser extent for the age group 20-24, because children of young mothers are known to have higher risk of mortality
   - Why?
     - First births have higher mortality risk than higher-order births and children of younger mothers are more likely to be first births
     - Youngest mothers tend to be socio-economically disadvantaged

Source: Moultrie et al. (2013)
Brass: Assumptions, violations (2)

2. No correlation exists between mortality risks of children and survival of mothers in the population
   - This is a problem when certain mothers are not captured in the data (because of mortality or migration) whose children might also have higher mortality risk
   - Most common case is countries with high HIV prevalence – results in downward bias in estimates
     - Younger mother age groups (20-24, 25-29) less likely to be biased
     - Upward adjustment of 3 points per 1000 for every 10 percentage points of HIV prevalence (Hill 2013, based on Ward and Zaba 2008)

Source: Moultrie et al. (2013)
Brass: Assumptions, violations (3)

3. Population age patterns of fertility and child mortality are adequately represented by the model patterns used in developing the method.

4. Any changes in child mortality in the recent past have been gradual and unidirectional.

5. Cross-sectional average numbers of children ever born by age adequately reflect cohort patterns of childbearing.

- Note that when fertility has been changing (falling) rapidly, the Brass method will tend to over-estimate child mortality.
- Variants of the technique grouping mothers by duration of marriage or time since first birth have been developed to address some of these issues.

Source: Moultrie et al. (2013)
Quality of estimates: Checking multiple sources

- 1975 Census, Indirect
- 1988 Census, Direct
- 1988 Census, Indirect
- 1994-95 DHS, Direct adj.
- 1994-95 DHS, Indirect
- 2000 MICS, Indirect
- 2006 MICS, Indirect
- 2010 MICS, Indirect
Quality of estimates: Comparison with existing external sources

Central African Republic

IGME estimates

Source: www.childmortality.org

Regional Workshop on the Production of Population Estimates and Demographic Indicators
Addis Ababa, 5-9 October 2015
Quality of estimates:
Comparison with existing external sources

Source: http://esa.un.org/unpd/wpp/DVD/

Central African Republic

UN Population Division
(World Population Prospects)

Source: http://esa.un.org/unpd/wpp/DVD/
Quality of estimates:
Implied life expectancy at birth using Model Life Tables

Central African Republic
1988 Census

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy at birth (years)</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>55</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
</tr>
</tbody>
</table>
CORMOR in MortPak

CORMOR >> “Corresponding Mortality Indicators”

- Give corresponding probabilities of dying for various pre-selected age groups in the 9 model life table families
References


Thank you

Questions?

>> until 9 October:

>> After 9 October: pelletierf@un.org

spooorenberg@un.org