Family History and Life Insurance

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2013 Angelina Jolie
risk of developing cancers
family history

Angelina Jolie lost 8 family members to cancer

Interesting debates related to predictive probabilities, risk, insurance and prevention
### Family History

(Please Note The Family Member & Maternal (M) OR Paternal (P) When Appropriate):

<table>
<thead>
<tr>
<th>Disease</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast Cancer</td>
<td>Colon Cancer</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Genetic Disorders</td>
</tr>
<tr>
<td>Heart Disease</td>
<td>High Blood Pressure</td>
</tr>
<tr>
<td>Kidney Disease</td>
<td>Lung Cancer</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>Other Cancer</td>
</tr>
<tr>
<td>Ovarian Cancer</td>
<td>Ovarian Cancer</td>
</tr>
<tr>
<td>Stroke/DVT/Clothing/Bleeding Disorder</td>
<td>Thyroid Disease</td>
</tr>
<tr>
<td>Thyroid Disease</td>
<td>Uterine Cancer</td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
</tbody>
</table>

### Family History (family history is a consideration for each rate class):

To your knowledge, is there any family history (parent or siblings), prior to age 60, of cardiovascular disease, cerebrovascular disease, heart disease, stroke, diabetes, or cancer?  

Yes ☐ No ☐

If yes, provide full details:

- Father: Impairment ____________ Age at Onset ____________ Age at Death (if deceased) ____________
- Mother: Impairment ____________ Age at Onset ____________ Age at Death (if deceased) ____________
- Siblings: Impairment ____________ Age at Onset ____________ Age at Death (if deceased) ____________

### Family History: Please check the box if your family has a history of:

- Diabetes ☐
- High Blood Pressure ☐
- Heart Attack, Heart Disease ☐
- Cancer ☐
- Alzheimer’s ☐
- Family History Unknown ☐
- Blood Clots or Stroke ☐
- Mental Illness ☐
- Tuberculosis ☐
- Epilepsy/Selzure ☐

Any other major conditions?

If you answered Yes to any of the above, please explain:

Are you currently being treated for medical conditions? ☐ Yes ☐ No  If yes, please list:

### Family Medical History

<table>
<thead>
<tr>
<th>Age</th>
<th>Diseases</th>
<th>If Deceased, Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siblings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Agenda

Motivations
Existing Literature
Longitudinal & Collaborative Data
Genealogical Data
‘Family History’ & Life Insurance
Husband-Wife
Children-Parents
Grand Children-Grandparents

Using genealogical trees to understand dependencies in life spans and quantify the impact on (life related) insurance premiums
Literature on Family and Insurance

- Parkes et al. (1969): 4,486 widowers of 55 years old (and older) to confirm the *broken heart syndrome*.
  - In Luciano et al. (2008), subset of 11,454 contracts, born before 1920 (male) and 1923 (female).
- Denuit et al. (2001): selected two cemeteries in Brussels (Koekelberg and Ixelles / Elsene) and collected the ages at death of 533 couples buried there.
Longitudinal data have been used in many demographic projects

- Matthijs and Moreels (2010) (COR*), Antwerp, Belgium, 1846–1920, \( \approx 125k \) events, \( \approx 57k \) individuals

- Mandemakers (2000), Netherlands, 1812–1922, \( \approx 77k \) individuals

- Bouchard et al. (1989) (BALSAC), Québec, Canada, since 17\(^{th}\) century, \( \approx 2M \) events, \( \approx 575k \) individuals

- Bean et al. (1978), mainly Utah, USA, since 18\(^{th}\) century, \( \approx 1.2M \) individuals
Collaborative Data

as well as collaborative data

▶ Fire and Elovici (2015) with data from WikiTree.com, +1M profiles (unknown number of individuals)

▶ Cummins (2017) with data from FamilySearch.org, +1.3M individuals

▶ Gergaud et al. (2016) with biography from wikipedia, +1.2M individuals

▶ Kaplanis et al. (2018) with data from Geni.com, 13M individuals
Genealogical Data

Charpentier and Gallic (2020a) comparing our collaborative based dataset (238,009 users, 1,547,086 individual born in [1800, 1805]), with official historical data

![Genealogical Data Table]

with children, up to 3 generations

- 402 190 children
- 286 071 grand-children
- 222 103 grand-grand-children

Intensive study on exhaustivity & consistency of data
Genealogical Data

Charpentier and Gallic (2020b) on generational migration

(here Generation 0 was born in Paris)
Genealogical Data & “Generations”

Initial starting generation (born in $[1800, 1805]$), children (born $\sim [1815, 1870]$),
grand-children (born $\sim [1830, 1915]$),
grand-grand-children (born $\sim [1850, 1940]$)
Demographic & Insurance Notations

\[ t p_x = \mathbb{P}[T(x) > t] = \mathbb{P}[T-x > t | T > x] = \frac{\mathbb{P}[T > t + x]}{\mathbb{P}[T > x]} = \frac{S(x+t)}{S(x)}. \]

The curtate life expectancy for \( T_x \) is defined as

\[ e_x = \mathbb{E}(\lfloor T_x \rfloor) = \mathbb{E}(\lfloor T - x \rfloor | T > x) = \sum_{t=0}^{\infty} t t p_x \cdot q_{x+t} = \sum_{t=1}^{\infty} t p_x, \]

The actuarial present value of the annuity of an individual age \((x)\) is

\[ a_x = \sum_{k=1}^{\infty} \nu^k k p_x \text{ or } a_x: \bar{n} = \sum_{k=1}^{n} \nu^k k p_x, \]

and whole life insurance (see Bowers et al. (1997))

\[ A_x = \sum_{k=1}^{\infty} \nu^k k p_x \cdot q_{x+k} \text{ or } A_x: \bar{n} = \sum_{k=1}^{n} \nu^k k p_x \cdot q_{x+k}. \]
**Figure 1:** Survival distribution $t p_0 = \mathbb{P}[T > t]$ and force of mortality $1 q_x = \mathbb{P}[T \leq x + 1 | T > x]$ (log scale), against historical data.
Husband-Wife dependencies

<table>
<thead>
<tr>
<th></th>
<th>birth ((b_f))</th>
<th>death ((d_f))</th>
<th>age ((t_f))</th>
<th>birth ((b_m))</th>
<th>death ((d_m))</th>
<th>age ((t_m))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1800-05-04</td>
<td>1835-02-22</td>
<td>34.80356</td>
<td>1762-07-01</td>
<td>1838-01-19</td>
<td>75.55099</td>
</tr>
<tr>
<td>2</td>
<td>1778-02-09</td>
<td>1841-02-02</td>
<td>62.97878</td>
<td>1758-07-05</td>
<td>1825-08-03</td>
<td>67.07734</td>
</tr>
<tr>
<td>3</td>
<td>1771-01-18</td>
<td>1807-01-17</td>
<td>35.99452</td>
<td>1752-12-28</td>
<td>1815-10-31</td>
<td>62.83641</td>
</tr>
<tr>
<td>4</td>
<td>1768-07-01</td>
<td>1814-10-15</td>
<td>46.28611</td>
<td>1768-07-01</td>
<td>1830-12-06</td>
<td>62.42847</td>
</tr>
<tr>
<td>5</td>
<td>1766-07-01</td>
<td>1848-01-12</td>
<td>81.53046</td>
<td>1767-02-10</td>
<td>1851-04-22</td>
<td>84.19165</td>
</tr>
<tr>
<td>6</td>
<td>1769-06-28</td>
<td>1836-08-28</td>
<td>67.16496</td>
<td>1773-12-17</td>
<td>1825-02-15</td>
<td>51.16222</td>
</tr>
</tbody>
</table>

Table 1: Dataset for the joint life model, father/husband \((f)\) and mother/spouse \((m)\)
Figure 2: Spearman correlation \((T_f, T_m)\) - per year of birth of the father.
Husband-Wife dependencies

![3D diagram showing the copula density with Father Lifetime and Mother Lifetime axes.]

**Figure 3:** Nonparametric estimation of the copula density, \((T_f, T_m)\).

(using Geenens et al. (2017) estimate)
Here \(\hat{\rho}_S = 0.168\), 95% confidence interval \((0.166; 0.171)\).
Husband-Wife dependencies

Multiple life quantities, e.g. annuities and (whole) life insurance,

\[ a_x = \sum_{k=1}^{\infty} \nu^k p_{xf} - \sum_{k=1}^{\infty} \nu^k p_{xf,x_m}, \]  

and  

\[ A_x = \sum_{k=1}^{\infty} \nu^k p_{xf} - \sum_{k=1}^{\infty} \nu^k p_{xf,x_m}, \]  

**Figure 4:** Annuities \( a_x \) and (whole) life insurance \( A_x \).
Husband-Wife dependencies

Multiple life quantities, e.g. widow’s pension,

\[ a_{m|f} = \sum_{k=1}^{\infty} \nu^k \mathbb{P}_{x_f} - \sum_{k=1}^{\infty} \nu^k \mathbb{P}_{x_f,x_m}, \]

where \( \mathbb{P}_{x_f,x_m} = \mathbb{P}[T_{x_f} > t, T_{x_m} > t] \)

![Figure 5: Widow’s pension, \( a_{m|f} \) (relative to independent case \( a_{m|f}^\perp \)).](image-url)
“inheritance of longevity” coined in Pearl (1931)

“the life spans of parents and children appear only weakly related, even though parents affect their children’s longevity through both genetic and environmental influences”

Vaupel (1988)

“the chance of reaching a high age is transmitted from parents to children in a modest, but robust way”

Vågerö et al. (2018)

Figure 6: Son vs. parents

Beeton and Pearson (1901).
Beeton and Pearson (1901), regression of $T_x^c$ given $T_x^f$ or $T_x^m$

slope:
Daughter–mother 0.1968 [0.1910,0.20260]
Son–mother 0.1791 [0.1737,0.18443]
Daughter–father 0.1186 [0.1122,0.12507]
Son–father 0.1197 [0.1138,0.12567]

Figure 7: Age of the children given information relative to the parents.
Figure 8: Copula density, children and father/mother/min/max.
Figure 9: Residual life expectancy $e_x$ with information about parents at age 20, 30 or 40.
Figure 10: Annuity $a_x$ and whole life insurance $A_x$, given information about the number of parents still alive, when child has age $x$. 

Both parents deceased | Only one parent still alive | Both parents still alive | Reference
Figure 11: Annuity $a_x$ and whole life insurance $A_x$, given information about the number of parents still alive, when child has age $x$ (relative difference).
Children-Grandparents

won Emily Choi (2020), “little is known about whether and how intergenerational relationships influence older adult mortality”

Figure 12: Copula density, children and grandparents min/max/mean.
Figure 13: Residual life expectancy $e_x$ with information about grandparents, at age 10, 15 or 20.
Children-Grandparents, annuities and insurance

(a) Residual life expectancy of grandsons (in years)

(b) Deviation from baseline (in years)

Figure 14: Annuity $a_x$ and whole life insurance $A_x$, given information about the number of grandparents still alive, when child has age $x$. 


References II


References III


