

# Family History and Life Insurance

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<https://arxiv.org/abs/2006.08446>

## Opinion

OP-ED CONTRIBUTOR

# My Medical Choice

By Angelina Jolie

May 14, 2013



LOS ANGELES

MY MOTHER fought cancer for almost a decade and died at 56. She held out long enough to meet the first of her grandchildren and to hold them in her arms. But my other children will never have the chance to know her and experience how loving and gracious she was.

We often speak of “Mommy’s mommy,” and I find myself trying to explain the illness that took her away from us. They have asked if the same could happen to me. I have always told them not to worry, but the truth is I carry a “faulty” gene, BRCA1, which sharply increases my risk of developing breast cancer and ovarian cancer.

My doctors estimated that I had an 87 percent risk of breast cancer and a 50 percent risk of ovarian cancer, although the risk is different in the case of each woman.

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' & Insurance Forms

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

Breast Cancer: \_\_\_\_\_ Colon Cancer: \_\_\_\_\_  
 Diabetes: \_\_\_\_\_ Genetic Disorders: \_\_\_\_\_  
 Heart Disease: \_\_\_\_\_ High Blood Pressure: \_\_\_\_\_  
 Kidney Disease: \_\_\_\_\_ Lung Cancer: \_\_\_\_\_  
 Osteoporosis: \_\_\_\_\_ Other Cancer: \_\_\_\_\_  
 Ovarian Cancer: \_\_\_\_\_ Ovarian Cancer: \_\_\_\_\_  
 Stroke/DVT/Clotting/Bleeding Disorder: \_\_\_\_\_  
 Thyroid Disease: \_\_\_\_\_ Uterine Cancer: \_\_\_\_\_  
 Other: \_\_\_\_\_

**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 ☐ Blood Clots or Stroke ☐ Tuberculosis  
☐ Cancer ☐ Alzheimer's ☐ Family History Unknown ☐ Mental Illness ☐ Epilepsy/Seizure

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

	Age	Diseases	If Deceased, Cause of Death
Father	_____	_____	_____
Mother	_____	_____	_____
Siblings	_____	_____	_____
Spouse	_____	_____	_____
Children	_____	_____	_____

# 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 yearsold (and older) to confirm the *broken heart syndrom*
- ▶ Frees et al. (1996): 14,947 insurance contracts, Canadian insurance company, in force in 1988-1993  
→ censoring problem  
used also in Carriere (1997), Youn and Shemyakin (1999), Shemyakin and Youn (2001)  
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

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<sup>th</sup> century,  $\approx 2M$  events,  $\approx 575k$  individuals
- ▶ **Bean et al. (1978)**, mainly Utah, USA, since 18<sup>th</sup> 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

	ID_user	ID_np	ID_num	Name tabular	Surname	Sex	Date_b
1	daage	besnard jean 1	575	BESNARD	Jean	1	18000227
2	denisgallienne	besnard louis 1	22771	BESNARD	Louis	1	18040603
3	domiassi	besnard jean	1748	BESNARD	Jean	1	18000227
4	dutheilfr	besnard pierre	729	BESNARD	Pierre	1	18001221
5	dvivier1	besnard louis 1	65196	BESNARD	Louis	1	18001215

	Date_d	Type	Location	Lat	Long	ID_num_m	ID_num_p
1	16810000	NM	Longué, 0180	47.37806	-0.10806	4457	574
2	18831027	ND	Cunault, 49350	47.30833	-0.15389	994	1620
3	18560000	NM	Longué, 49180	47.37806	-0.10806		
4		N	Gennes, 49350	47.34083	-0.23278	99	59
5	18490717	N	Pommeraye, 49244	47.35528	-0.86028	43116	4063

with children, up to 3 generations

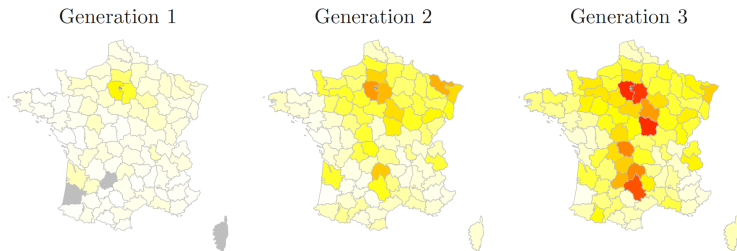
- ▶ 402 190 children
- ▶ 286 071 grand-children
- ▶ 222 103 grand-grand-children

Intensive study on exhaustivity & consistency of data



# Genealogical Data

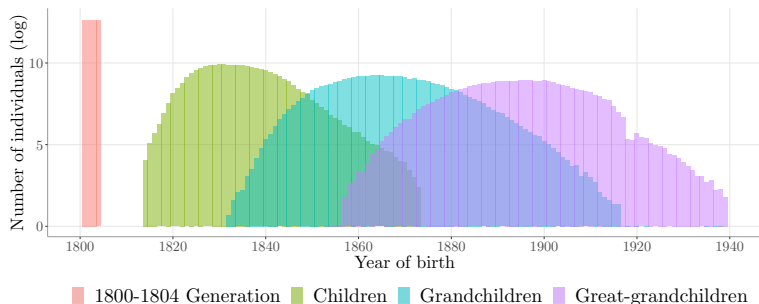
Charpentier and Gallic (2020b) on generational migration



(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

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

curtate **life expectancy** for  $T_x$  is defined as

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

actuarial present value of the **annuity** of an individual age ( $x$ ) is

$$a_x = \sum_{k=1}^{\infty} \nu^k {}_k p_x \text{ or } a_{x:\overline{n}|} = \sum_{k=1}^n \nu^k {}_k p_x,$$

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

$$A_x = \sum_{k=1}^{\infty} \nu^k {}_k p_x \cdot q_{x+k} \text{ or } A_{x:\overline{n}|}^1 = \sum_{k=1}^n \nu^k {}_k p_x \cdot q_{x+k}.$$

# Historical Mortality

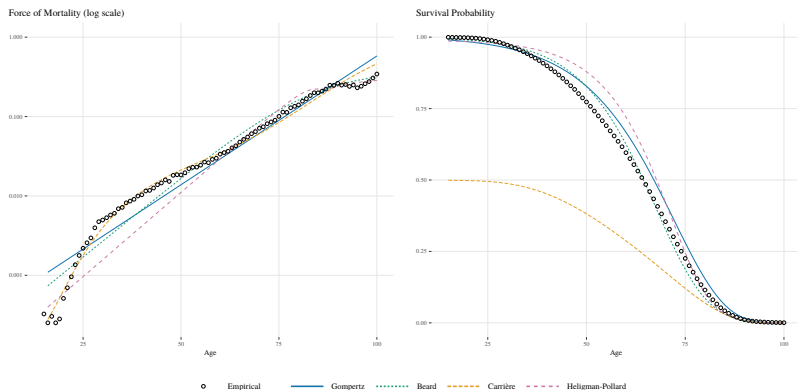
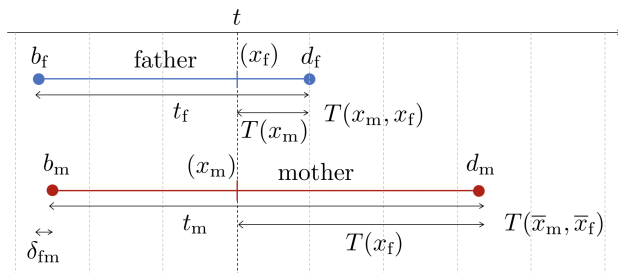


Figure 1: Survival distribution  ${}_t p_0 = \mathbb{P}[T > t]$  and force of mortality  ${}_1 q_x = \mathbb{P}[T \leq x + 1 | T > x]$  (log scale), against historical data.

# Husband-Wife dependencies

$i$	birth ( $b_f$ ) $b_{f,i}$	death ( $d_f$ ) $d_{f,i}$	age ( $t_f$ ) $t_{f,i}$	birth ( $b_m$ ) $b_{m,i}$	death ( $d_m$ ) $d_{m,i}$	age ( $t_m$ ) $t_{m,i}$
1	1800-05-04	1835-02-22	34.80356	1762-07-01	1838-01-19	75.55099
2	1778-02-09	1841-02-02	62.97878	1758-07-05	1825-08-03	67.07734
3	1771-01-18	1807-01-17	35.99452	1752-12-28	1815-10-31	62.83641
4	1768-07-01	1814-10-15	46.28611	1768-07-01	1830-12-06	62.42847
5	1766-07-01	1848-01-12	81.53046	1767-02-10	1851-04-22	84.19165
6	1769-06-28	1836-08-28	67.16496	1773-12-17	1825-02-15	51.16222

**Table 1:** Dataset for the joint life model, father/husband (f) and mother/spouse (m)



# Husband-Wife dependencies - Temporal Stability

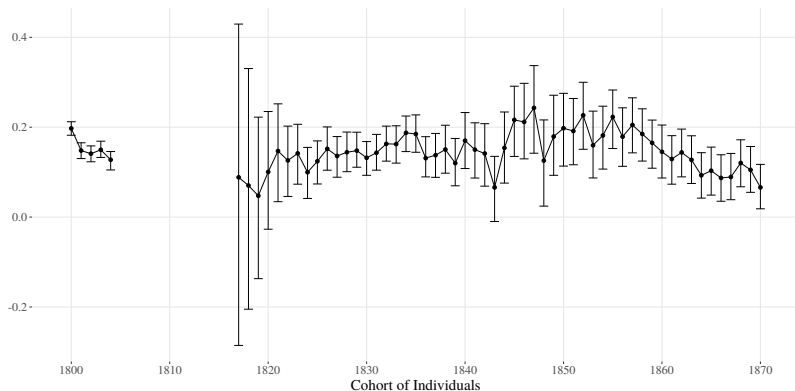


Figure 2: Spearman correlation ( $T_f, T_m$ ) - per year of birth of the father.

# Husband-Wife dependencies

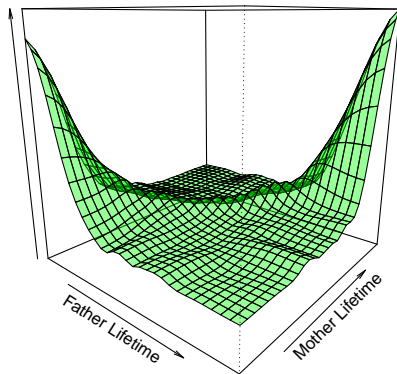


Figure 3: Nonparametric estimation of the copula density,  $(T_f, T_m)$ .

(using [Geenens et al. \(2017\)](#) estimate)

Here  $\widehat{\rho_S} = 0.168$ , 95% confidence interval  $(0.166; 0.171)$

# Husband-Wife dependencies

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

$$a_x = \sum_{k=1}^{\infty} \nu^k {}_k p_{x_f} - \sum_{k=1}^{\infty} \nu^k {}_k p_{x_f, x_m}, \quad \text{and} \quad A_x = \sum_{k=1}^{\infty} \nu^k {}_k p_{x_f} - \sum_{k=1}^{\infty} \nu^k {}_k p_{x_f, x_m}$$

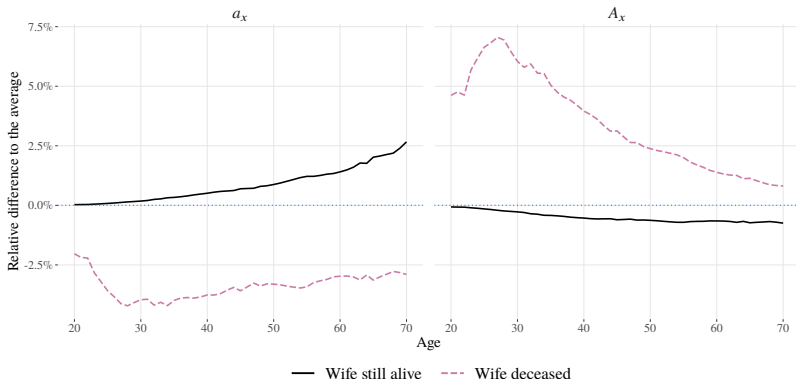


Figure 4: Annuities  $a_x$  and (whole) life insurance  $A_x$ .



# Husband-Wife dependencies

Multiple life quantities, e.g. **widow's pension**,

$$a_{m|f} = \sum_{k=1}^{\infty} \nu^k {}_k p_{x_f} - \sum_{k=1}^{\infty} \nu^k {}_k p_{x_f, x_m}, \quad \text{where } {}_t p_{x_f, x_m} = \mathbb{P}[T_{x_f} > t, T_{x_m} > t,]$$

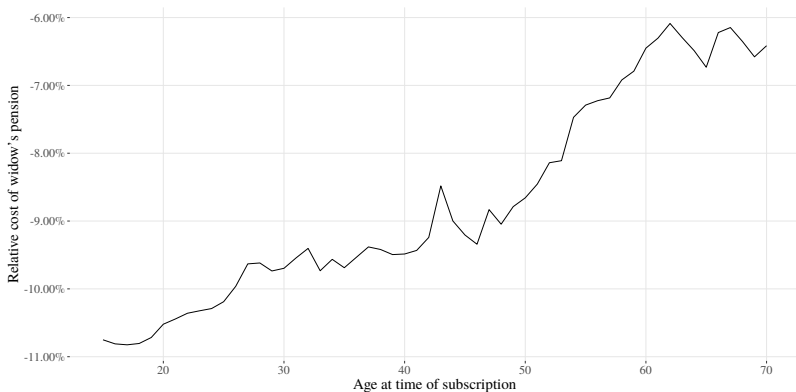


Figure 5: Widow's pension,  $a_{m|f}$  (relative to independent case  $a_{m|f}^{\perp}$ ).

# Children-Parents

*“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)

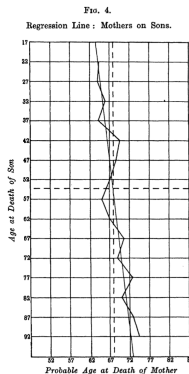
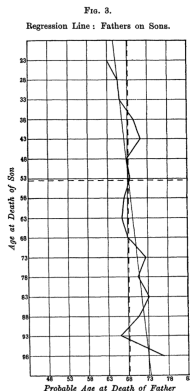


Figure 6: Son vs. parents  
Beeton and Pearson (1901).

Beeton and Pearson (1901), regression of  $T_{xc}$  given  $T_{xf}$  or  $T_{xm}$

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]

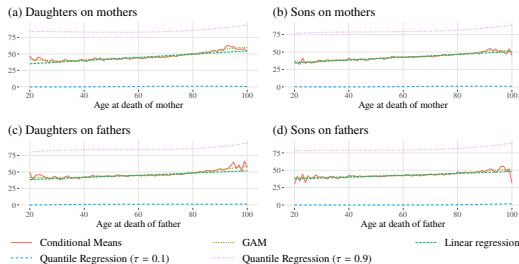


Figure 7: Age of the children given information relative to the parents.

# Children-Parents

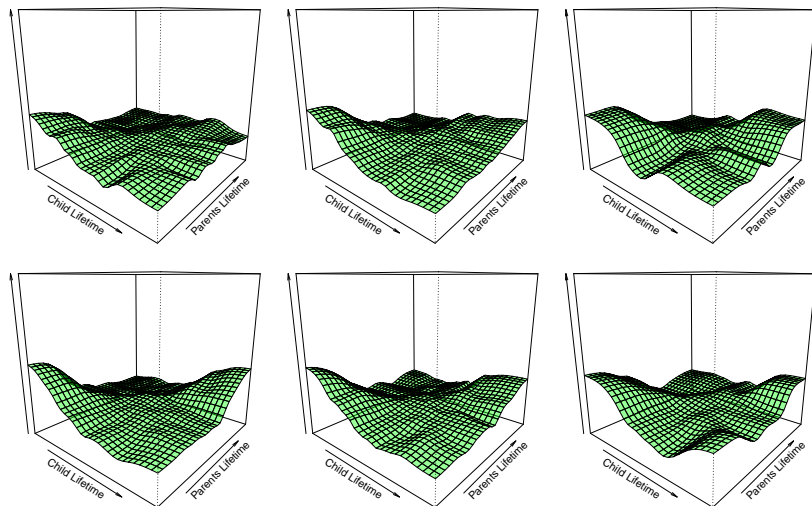
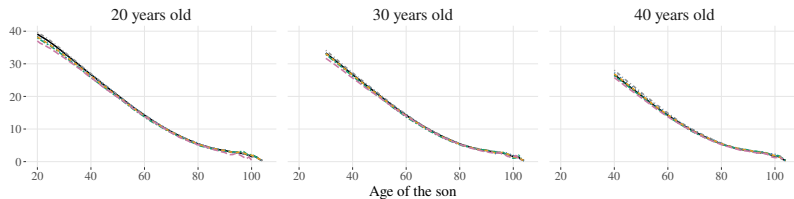


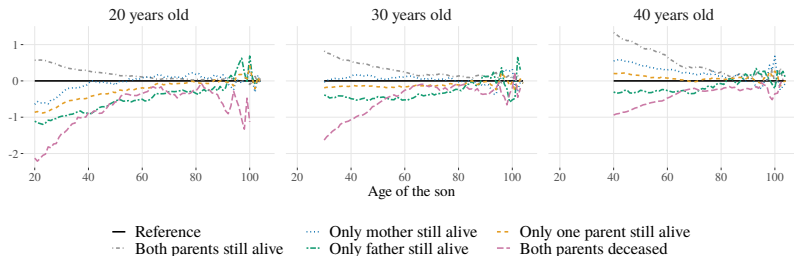
Figure 8: Copula density, children and father/mother/min/max.

# Children-Parents, life expectancy

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



(b) Deviation from baseline (in years)



**Figure 9:** Residual life expectancy  $e_x$  with information about parents at age 20, 30 or 40.

# Children-Parents, annuities and insurance

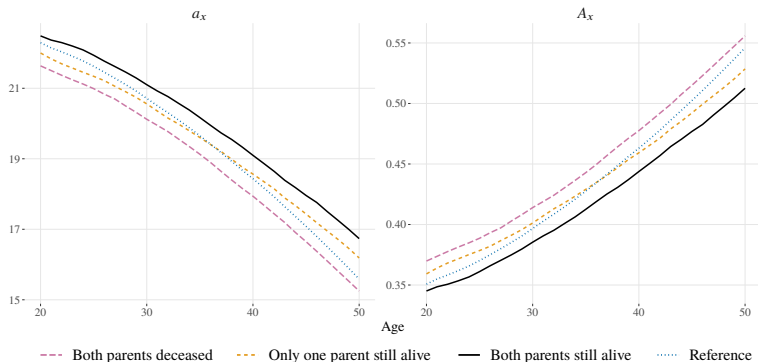


Figure 10: Annuity  $a_x$  and whole life insurance  $A_x$ , given information about the number of parents still alive, when child has age  $x$ .

# Children-Parents, annuities and insurance

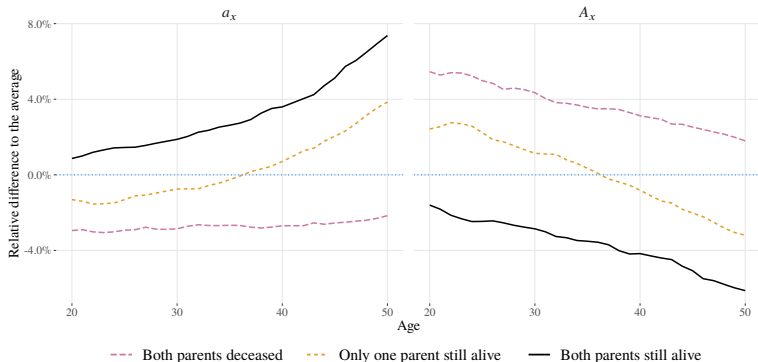


Figure 11: Annuity  $a_x$  and whole life insurance  $A_x$ , given information about the number of parents still alive, when child has age  $x$  (relative difference).

# Children-Grandparents

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

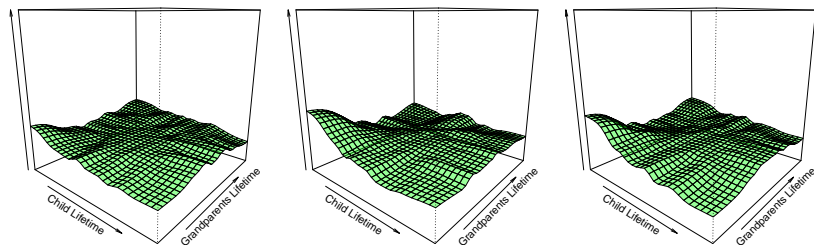
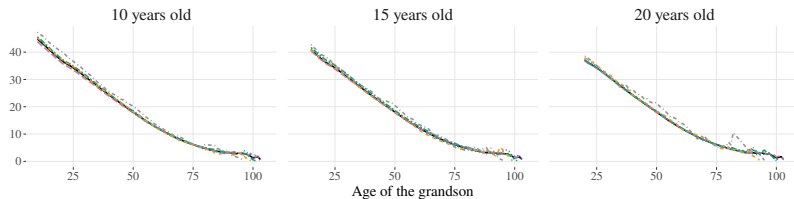


Figure 12: Copula density, children and grandparents min/max/mean.



# Children-Grandparents, life expectancy

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



(b) Deviation from baseline (in years)



**Figure 13:** Residual life expectancy  $e_x$  with information about grandparents, at age 10, 15 or 20.

# Children-Grandparents, annuities and insurance

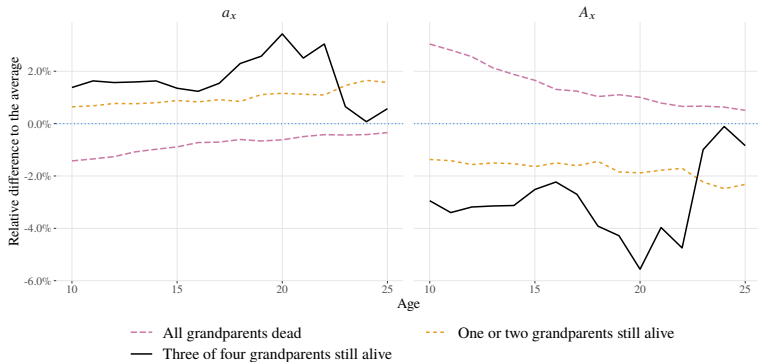


Figure 14: Annuity  $a_x$  and whole life insurance  $A_x$ , given information about the number of grandparents still alive, when child has age  $x$ .

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