Family History and Life Insurance

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https://arxiv.org/abs/2006.08446

Family History & Risk

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

The New York Times

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.

‘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

  $\rightarrow$ 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, $\approx 77k$ indivivuals
- Bouchard et al. (1989) (BALSAC), Québec, Canada, since 17$^{\text{th}}$ century, $\approx 2M$ events, $\approx 575k$ individuals
- Bean et al. (1978) , mainly Utah, USA, since 18$^{\text{th}}$ 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

	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

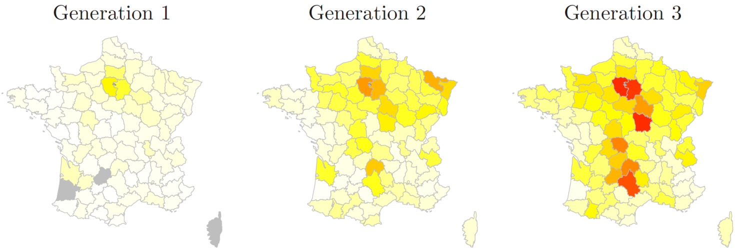
with children, up to 3 generations

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

Intensive study on exhaustivity & consistency of data

Genealogical Data

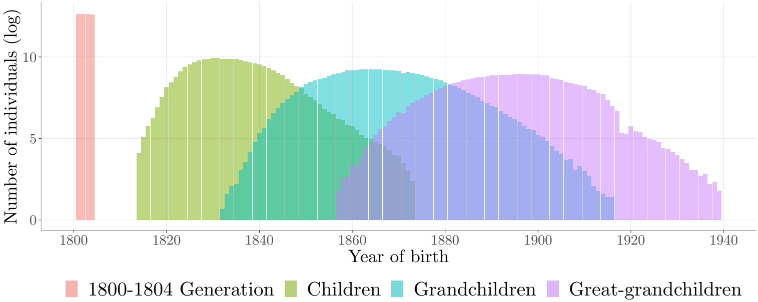
Charpentier and Gallic (2020b) on generational migration



(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

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

curtate life expectancy for T_x is defined as

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

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

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

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

$$ A_x = \sum_{k=1}^{\infty} \nu^k \, {}_kp_x \cdot q_{x+k} \text{ or } A^1_{x:\overline{n}|} = \sum_{k=1}^{n} \nu^k \, {}_kp_x \cdot q_{x+k}. $$

Historical Mortality

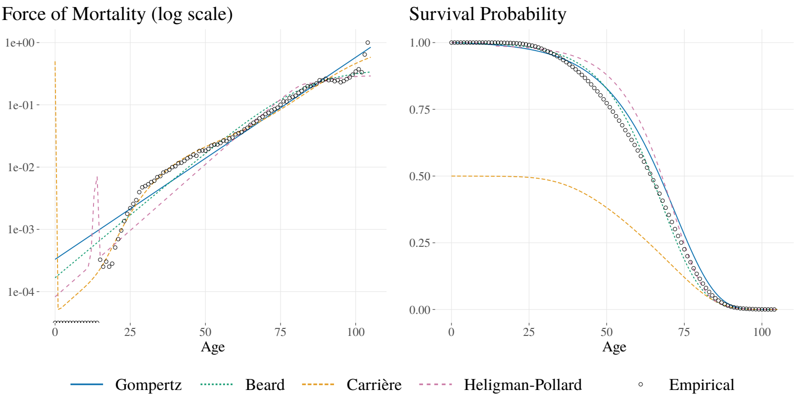
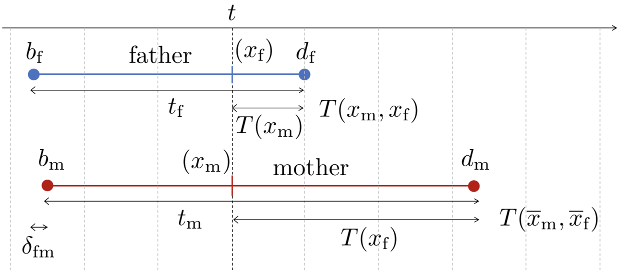


Figure 1: Survival distribution ${}_tp_0 = \mathbb{P}[T > t]$ and force of mortality ${}_1q_x = \mathbb{P}[T \leq x + 1 | T > x]$ (log scale), against historical data.

Husband-Wife dependencies

i	birth (b_{f}) $b_{\text{f},i}$	death (d_{f}) $d_{\text{f},i}$	age (t_{f}) $t_{\text{f},i}$	birth (b_{m}) $b_{\text{m},i}$	death (d_{m}) $d_{\text{m},i}$	age (t_{m}) $t_{\text{m},i}$
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

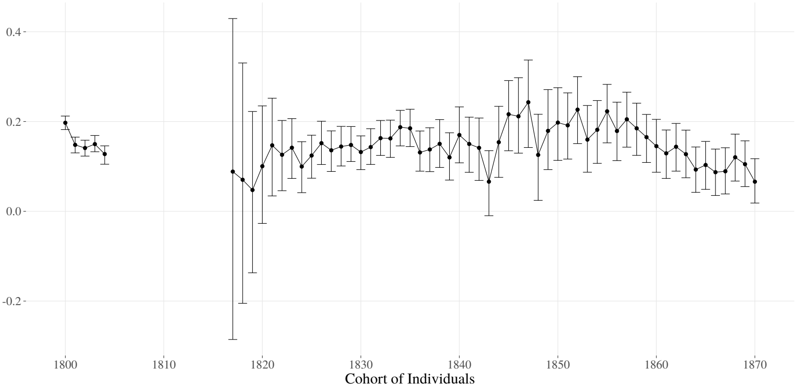


Figure 2: Spearman correlation $(T_{\text{f}}, T_{\text{m}})$ - per year of birth of the father.

Husband-Wife dependencies

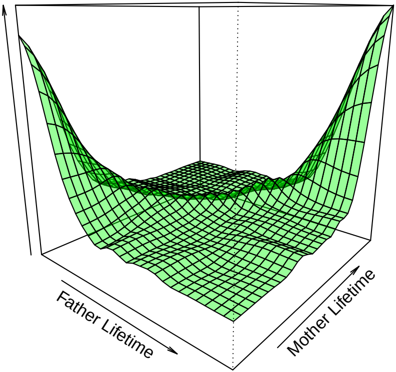


Figure 3: Nonparametric estimation of the copula density, $(T_{\mathrm{f}}, T_{\mathrm{m}})$.

(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,

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

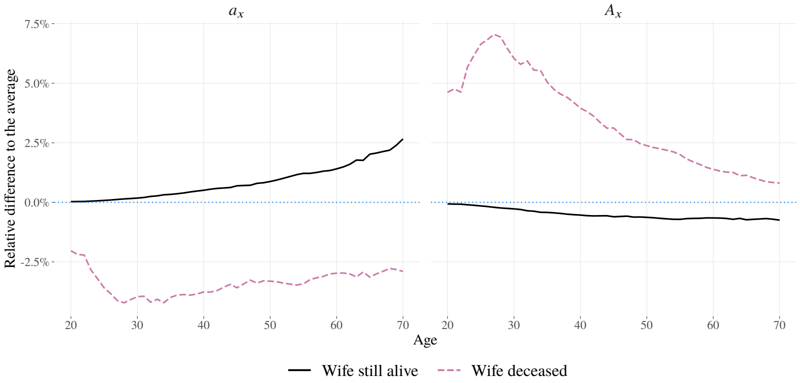


Figure 4: Annuities a_x and (whole) life insurance A_x.

Husband-Wife dependencies

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

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

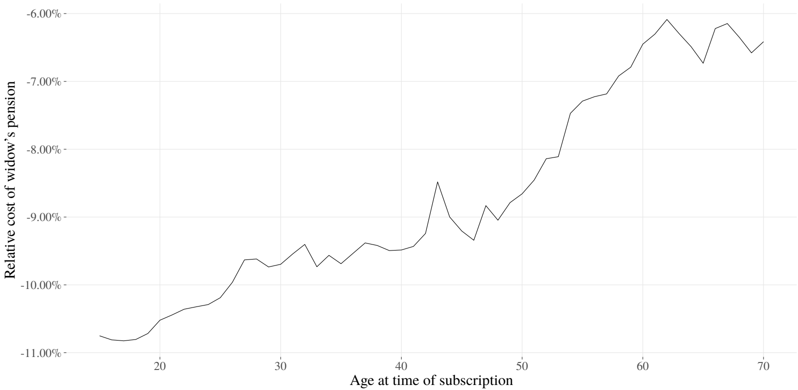


Figure 5: Widow's pension, $a_{\mathrm{m}|\mathrm{f}}$ (relative to independent case $a^{\perp}_{\mathrm{m}|\mathrm{f}}$).

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)

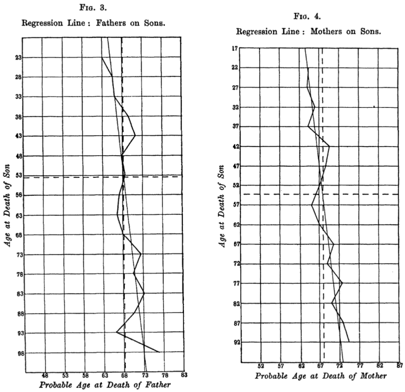


Figure 6: Son vs. parents Beeton and Pearson (1901).

Children-Parents

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]

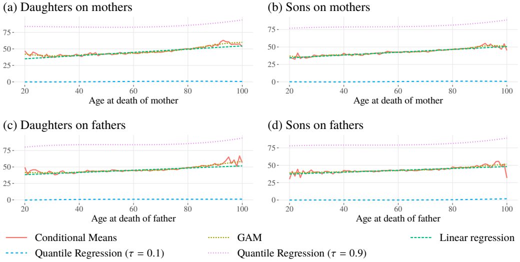


Figure 7: Age of the children given information relative to the parents.

Children-Parents

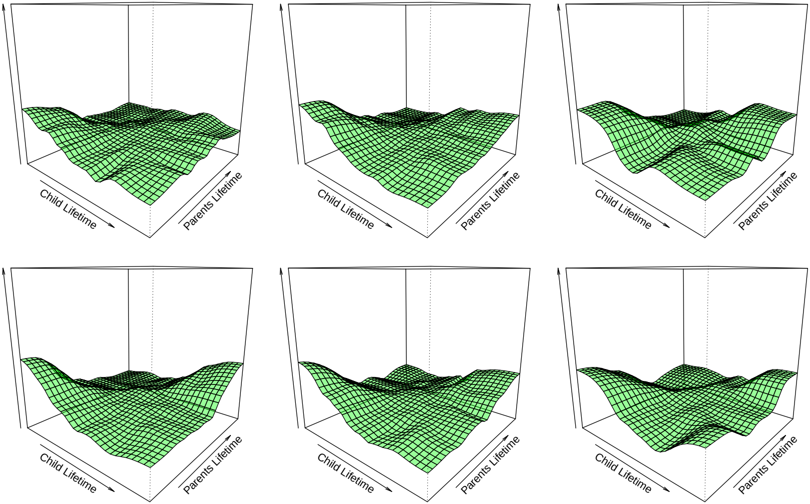


Figure 8: Copula density, children and father/mother/min/max.

Children-Parents, life expectancy

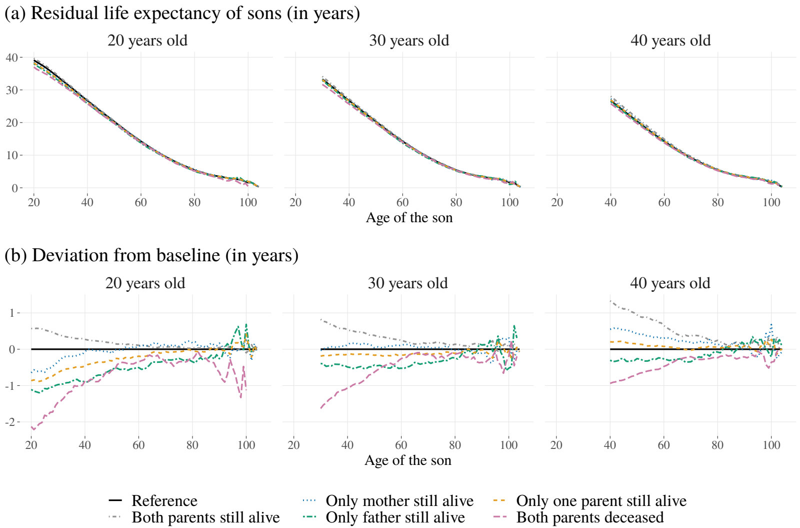


Figure 9: Residual life expectancy e_x with information about parents at age 20, 30 or 40.

Children-Parents, annuities and insurance

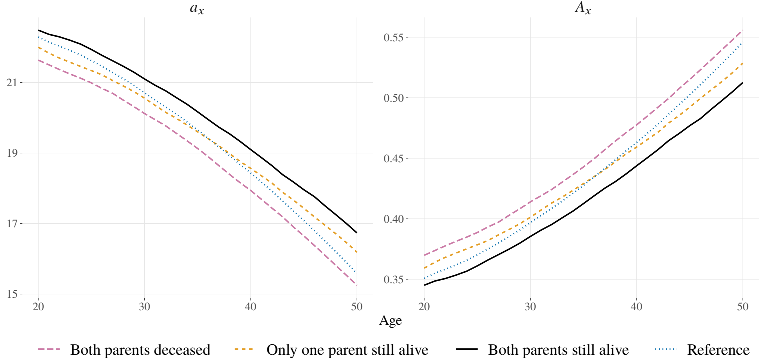


Figure 10: Annuity a_x and whole life insurance A_x, given information about the number of parents still alive, when child has age x.

Children-Parents, annuities and insurance

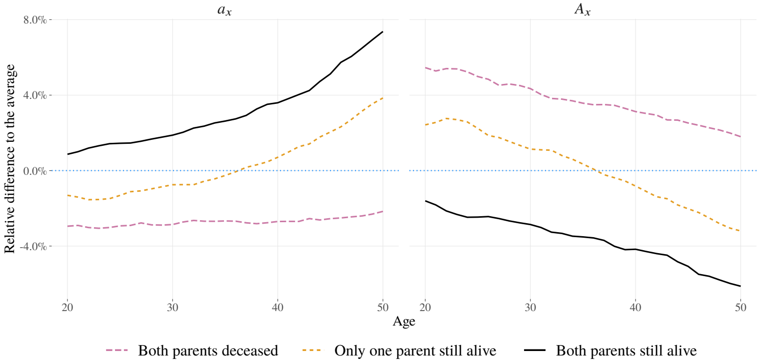


Figure 11: Annuity a_x and whole life insurance A_x, given information about the number of parents still alive, when child has age x (relative difference).

Children-Grandparents

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

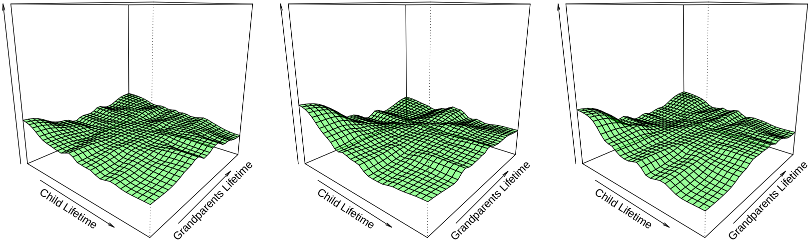


Figure 12: Copula density, children and grandparents min/max/mean.

Children-Grandparents, life expectancy

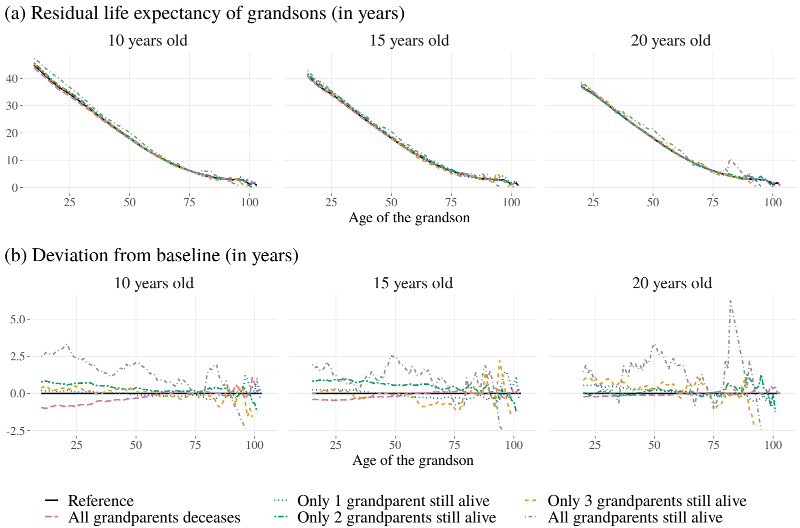


Figure 13: Residual life expectancy e_x with information about grandparents, at age 10, 15 or 20.

Children-Grandparents, annuities and insurance

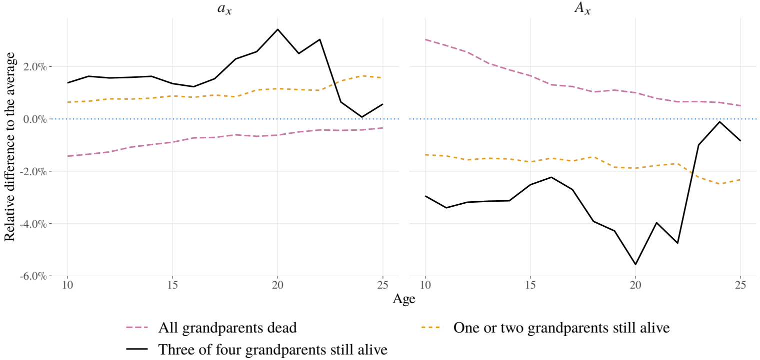


Figure 14: Annuity a_x and whole life insurance A_x, given information about the number of grandparents still alive, when child has age x.

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