Towards Fair Retirement Outcomes: Socio-Economic Mortality Differentials in Australia and Retirement Product Implications

Fei Huang (UNSW), **Francis Hui (ANU)**, **Andrés Villegas (UNSW)**

We thank the **Australian Government Actuary Guy Thorburn** and his team for their invaluable support.
We thank **Philip Clark** for his helpful comments to improve the paper.

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Motivation

- The Australian superannuation system faces the challenge of **delivering equitable and sustainable income in retirement.**
- Uptake of longevity products remains **low**. A key barrier is the lack of detailed understanding in mortality differentials across socio-economic groups.
- Australian Life Table (ALT) lacks detail beyond age and gender

Investigate mortality differences by socio-economic variable to improve longevity pool design for enhanced retirement outcomes

Dataset

- Data sourced from Person Level Integrated Data Asset (PLIDA) via ABS DataLab.
- Collaborators: ABS, ATO, Department of Education, Health, Human Services, and Social Services.

Available Data

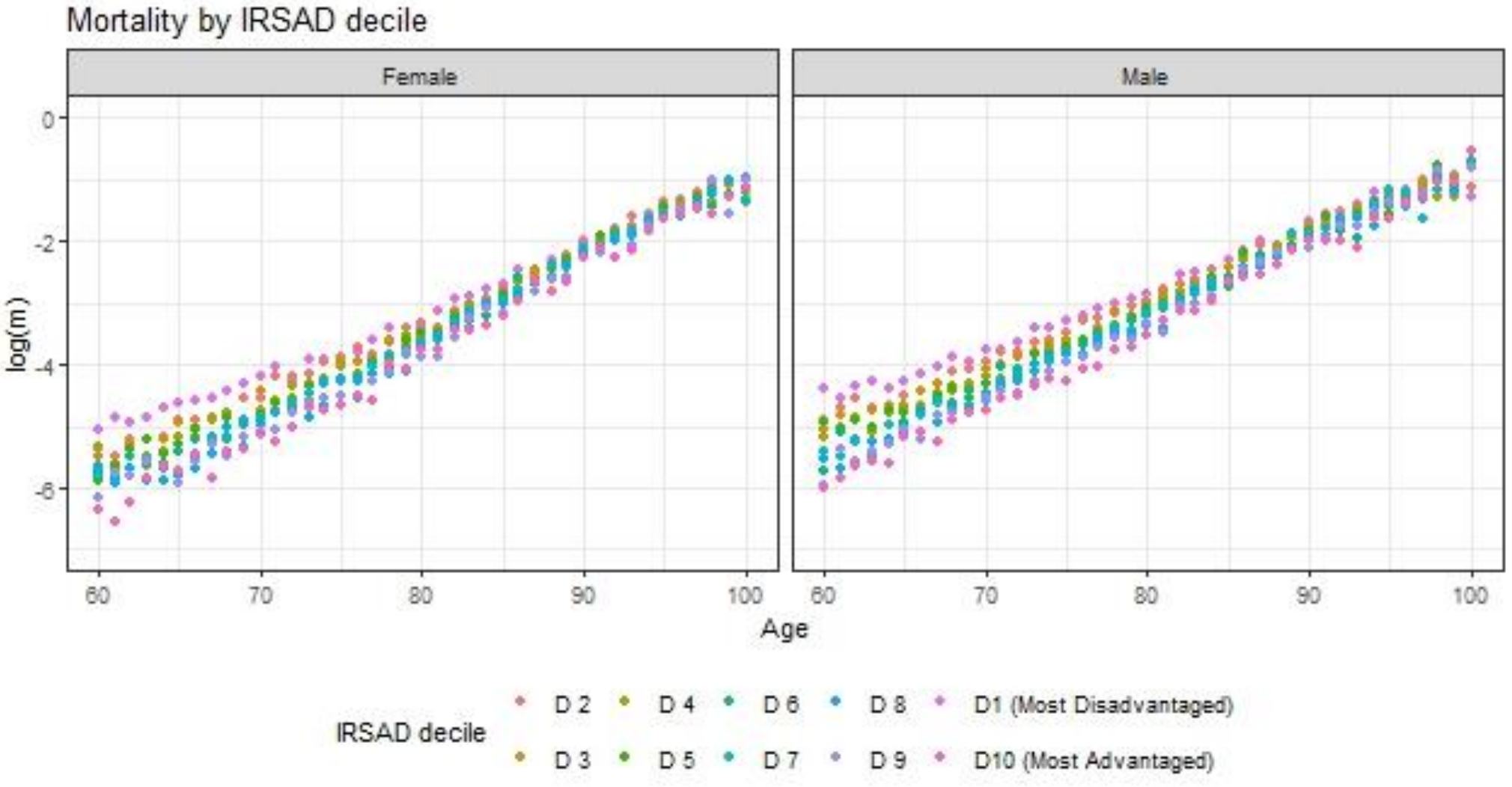
- **2016 Census Data**: Entire population snapshot as of August 9, 2016.
- **2009–2016 Social Security Related Information (SSRI):** Benefits, payments, marital status, education.
- **Demographics**: For individuals aged 50+ (post-Dec 2007). Includes gender, birth/death dates, indigenous status.

Socio-economic Variables

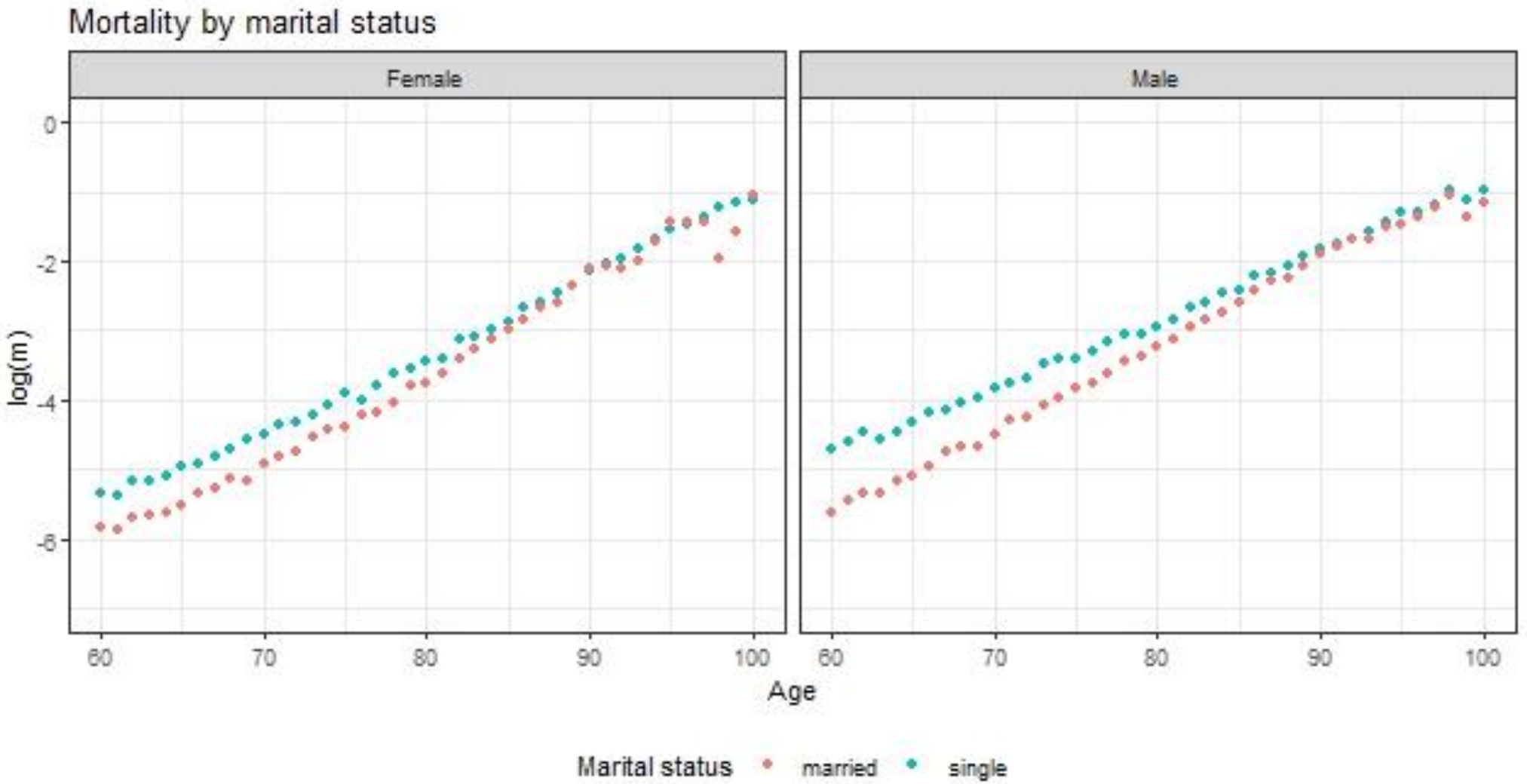
- Age
- Sex
- Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) -- one of the SEIFA variables
- Marital Status
- Income
- Homeownership

Note: Education and Occupation are not considered as they are noisy and contains significant missing data for the retirement age population. SEIFA already contains information about education and employment. Health index will be considered in the follow-up study. No smoking status data in the datasets.

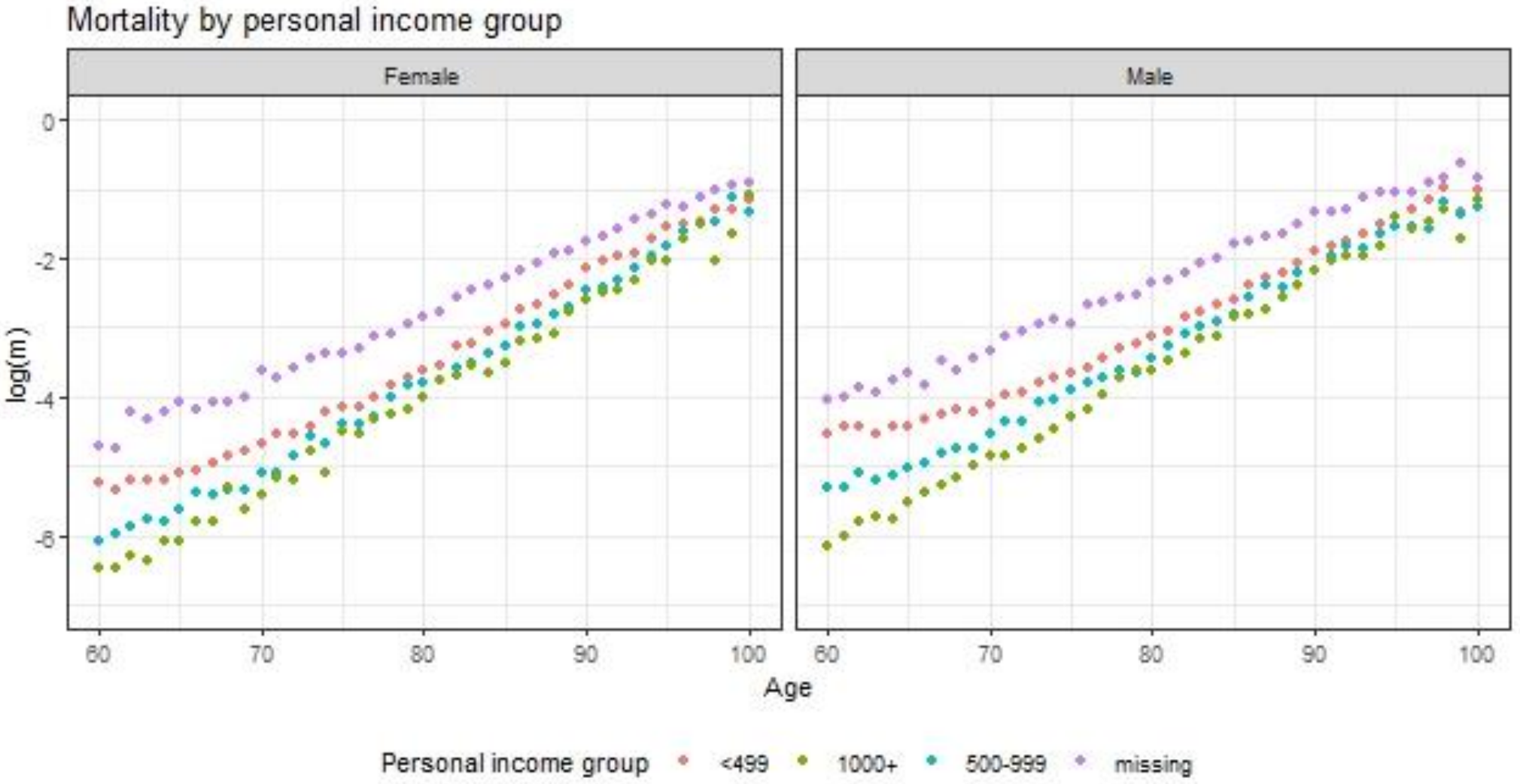
Index of Relative Socio-economic Advantage and Disadvantage (IRSAD)



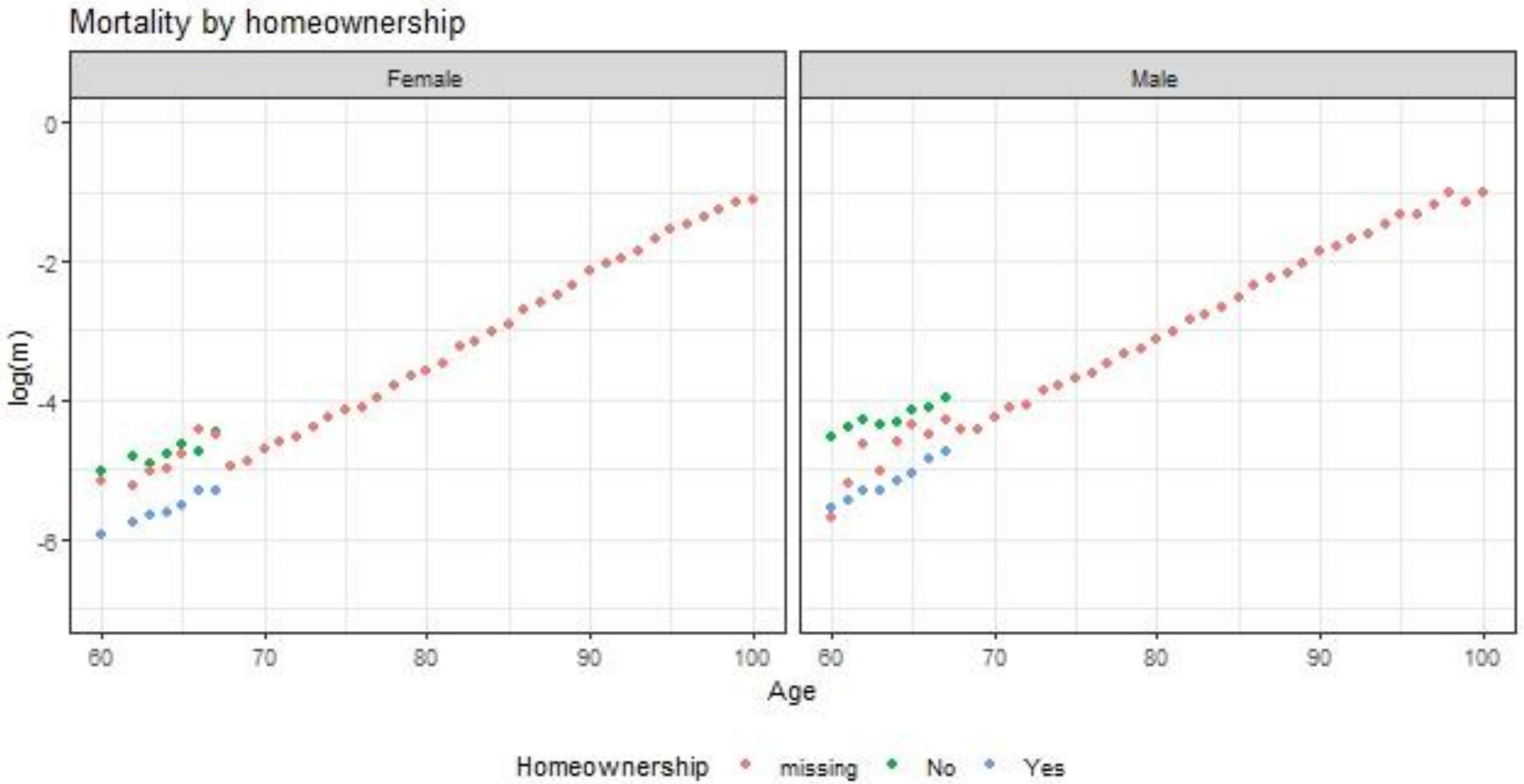
Marital Status



Income (Personal weekly income)



Homeownership



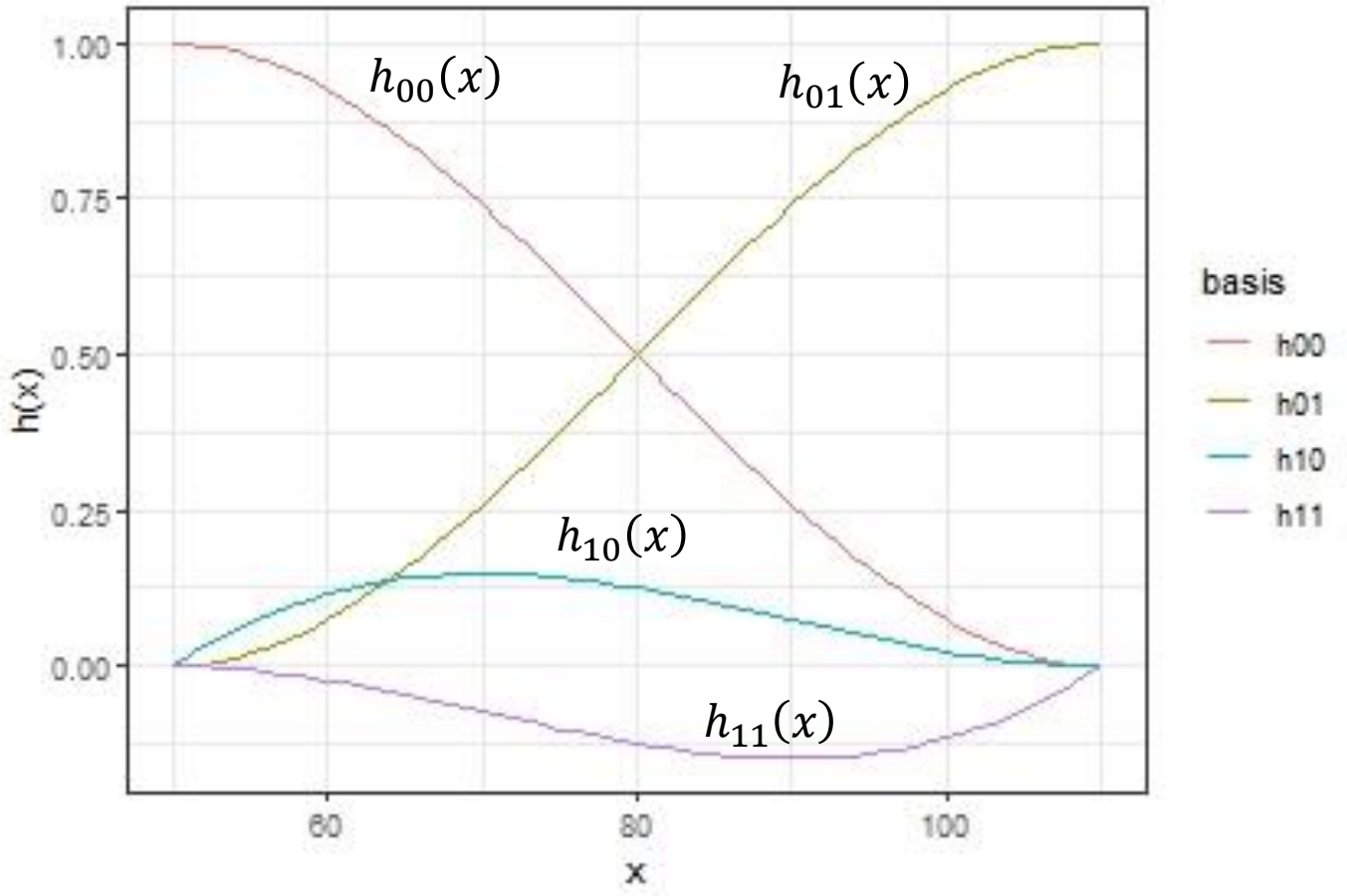
Our main goal

Develop a **parsimonious model** to produce life tables that **simultaneously** account for the **combined effects** of:

- Age
- Gender
- IRSAD
- Marital Status
- Income
- Homeownership

Hermite splines model (Richards, 2020)

$$\log \mu_x = a h_{00}(x) + \omega h_{01}(x) + m_0 h_{10}(x) + m_1 h_{11}(x)$$



Hermite splines model with covariates

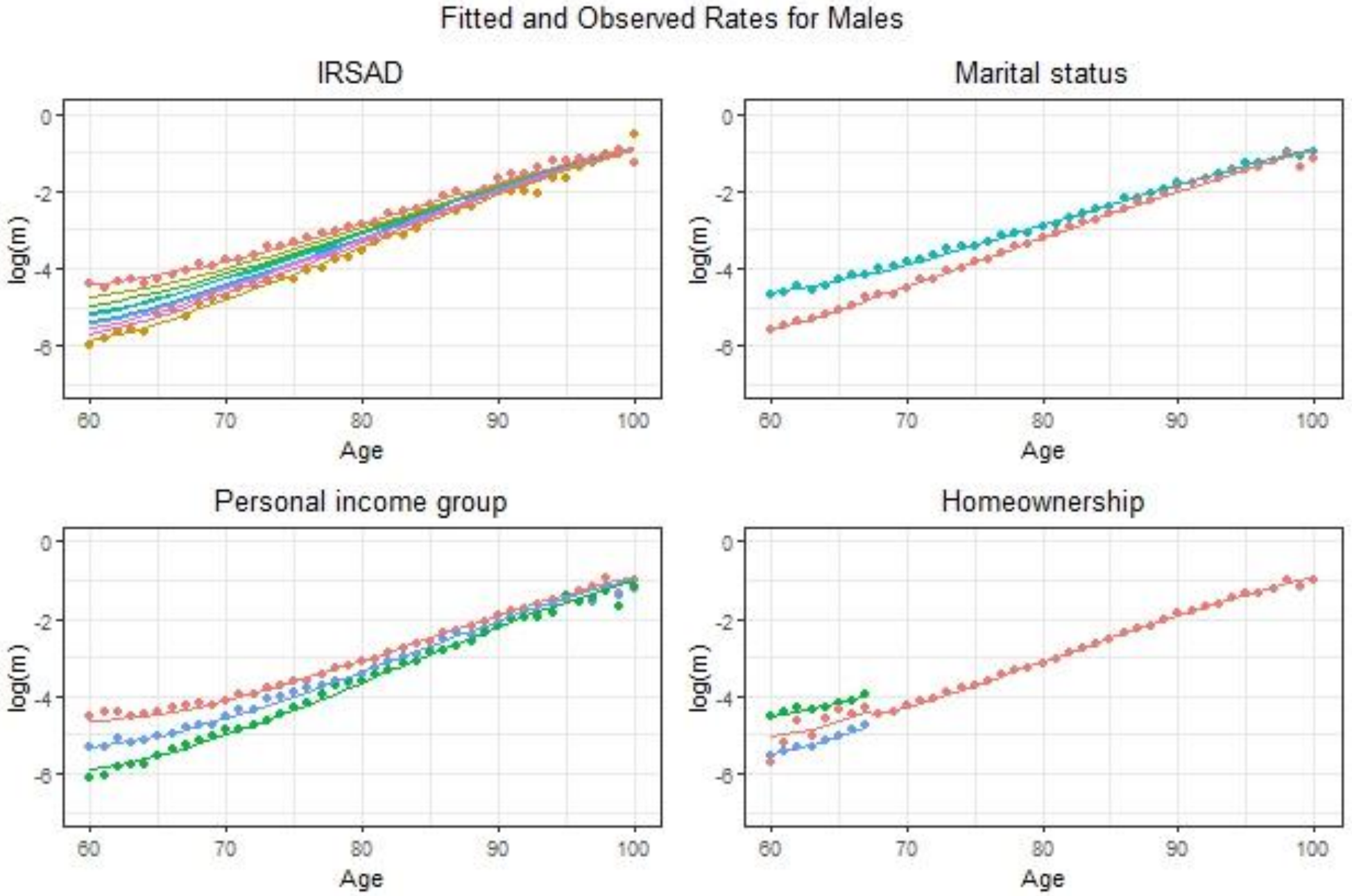
$$\log \mu_{x,s,m,i,h} = a h_{00}(x) + \omega h_{01}(x) + m_0 h_{10}(x) + m_1 h_{11}(x) +$$

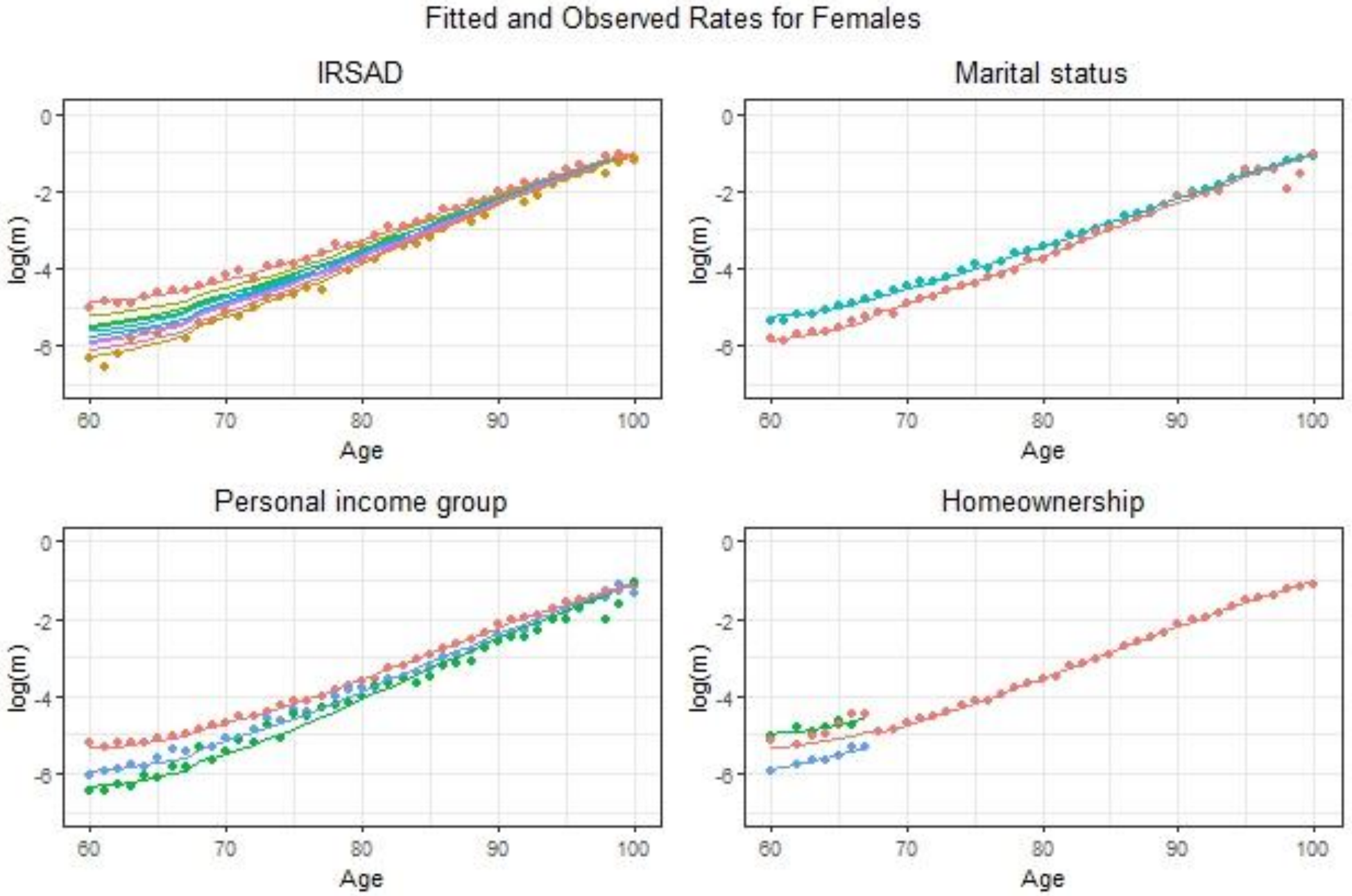
$$\left(\begin{array}{c} IRSAD\ (s) \\ + \\ Marital\ Status\ (m) \\ + \\ Income\ (i) \\ + \\ Homewonership\ (h) \end{array} \right) \times h_{00}(x)$$

19 parameters = 4 (age) + 9 (IRSAD) + 1 (Marital Status) + 3 (Income) + 2 (Homeownership)

240 Life Tables = 10 (IRSAD) x 2 (Marital Status) x 4 (Income) x 3 (Homeownership)

Coefficient	Male	Female	
a	-3.96	-4.08	4 Age Parameters
ω	-0.30	-0.24	
m_0	-1.13	-4.79	
m_1	2.23	3.12	
$a_{IRSAD,D2}$	-0.14	-0.19	9 IRSDA Parameters
$a_{IRSAD,D3}$	-0.26	-0.37	
$a_{IRSAD,D4}$	-0.37	-0.39	
$a_{IRSAD,D5}$	-0.35	-0.45	
$a_{IRSAD,D6}$	-0.51	-0.55	
$a_{IRSAD,D7}$	-0.52	-0.61	
$a_{IRSAD,D8}$	-0.57	-0.66	
$a_{IRSAD,D9}$	-0.65	-0.79	
$a_{IRSAD,D10}$	-0.75	-0.87	
$a_{married}$	-0.53	-0.45	1 Marital Status Parameters
$a_{income,500-999}$	-0.53	-0.59	3 Income Parameters
$a_{income,1000+}$	-0.96	-0.88	
$a_{income,missing}$	1.16	1.37	
$a_{homewoner,Yes}$	-0.51	-0.51	2 Homeownership Parameters
$a_{homewoner,missing}$	-0.34	-0.23	


Fitted and Observed Rates for Males
IRSAD
Marital status
Personal income group
Homeownership
log(m)
Age
0
-2
-4
-6
60
70
80
90
100


Fitted and Observed Rates for Females
IRSAD
Marital status
Personal income group
Homeownership
log(m)
Age
0
-2
-4
-6
60
70
80
90
100

Model use

Coefficient	Male
a	-3.96
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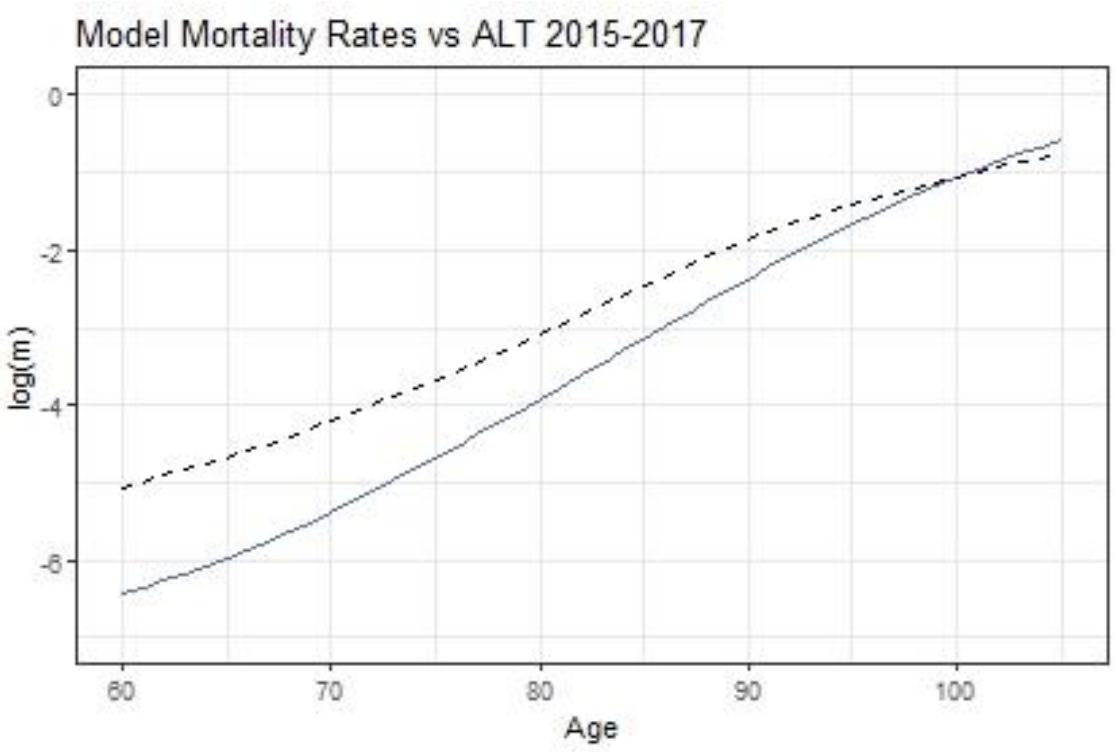
$a_{IRSAD,D8}$	-0.57
$a_{IRSAD,D9}$	-0.65
$a_{IRSAD,D10}$	-0.75
$a_{married}$	-0.53
$a_{income,500-999}$	-0.53
$a_{income,1000+}$	-0.96
$a_{income,missing}$	1.16
$a_{homewoner,Yes}$	-0.51
$a_{homewoner,missing}$	-0.34

Homeownership	Marital Status	Weekly Income	IRSAD
Yes	Married	$1000 or more	D10 (most Advantaged)

$$\log \mu_x = -6.71h_{00}(x) - 0.3h_{01}(x) - 1.13h_{10}(x) + 2.23h_{11}(x)$$

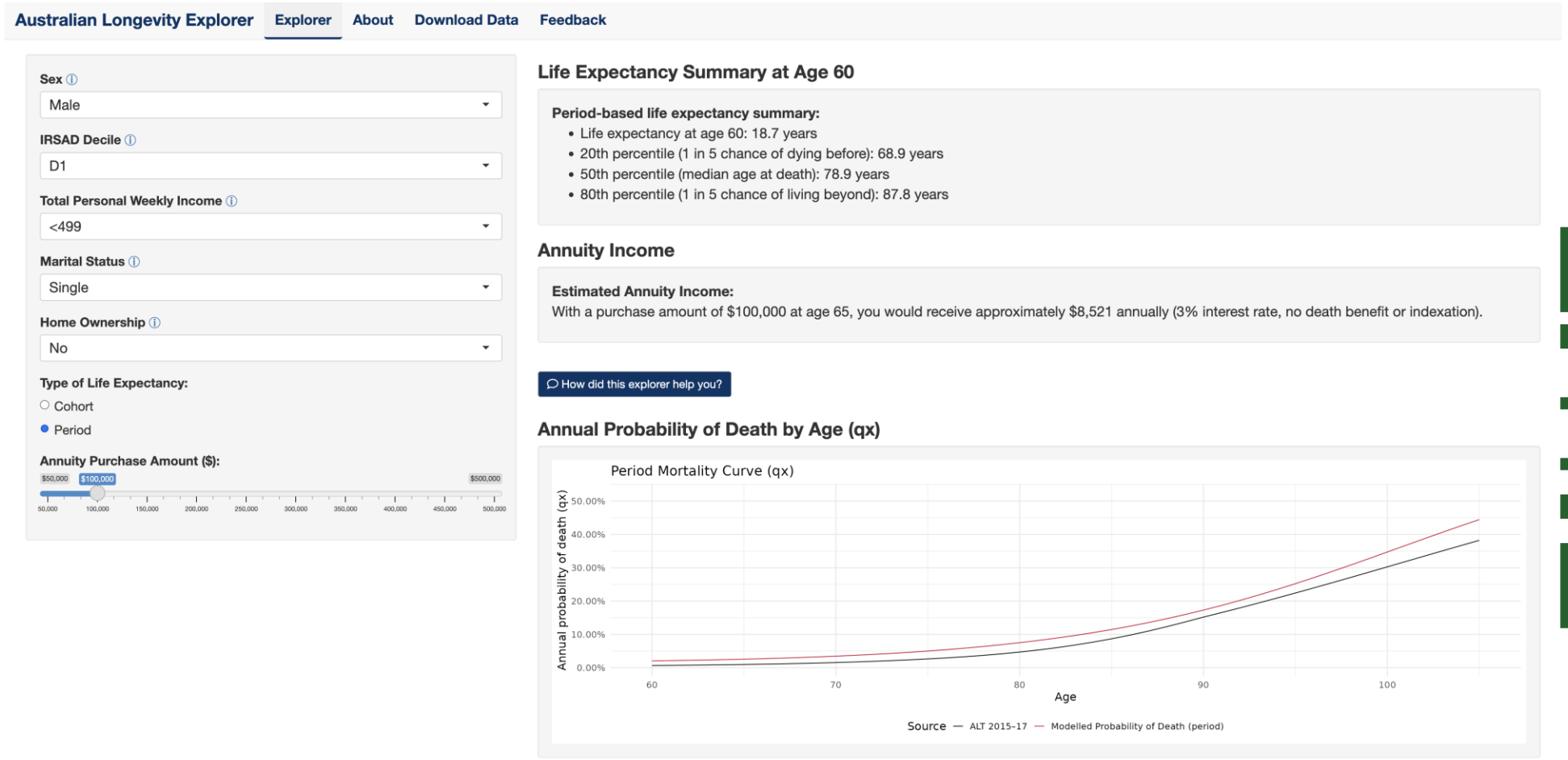


Period Life Expectancy in 2016 at 60

ALT 2015-2017: 24.05

Model: 30.20

An Interactive App - “Australian Longevity Explorer”



https://auslongevity.shinyapps.io/explorer/

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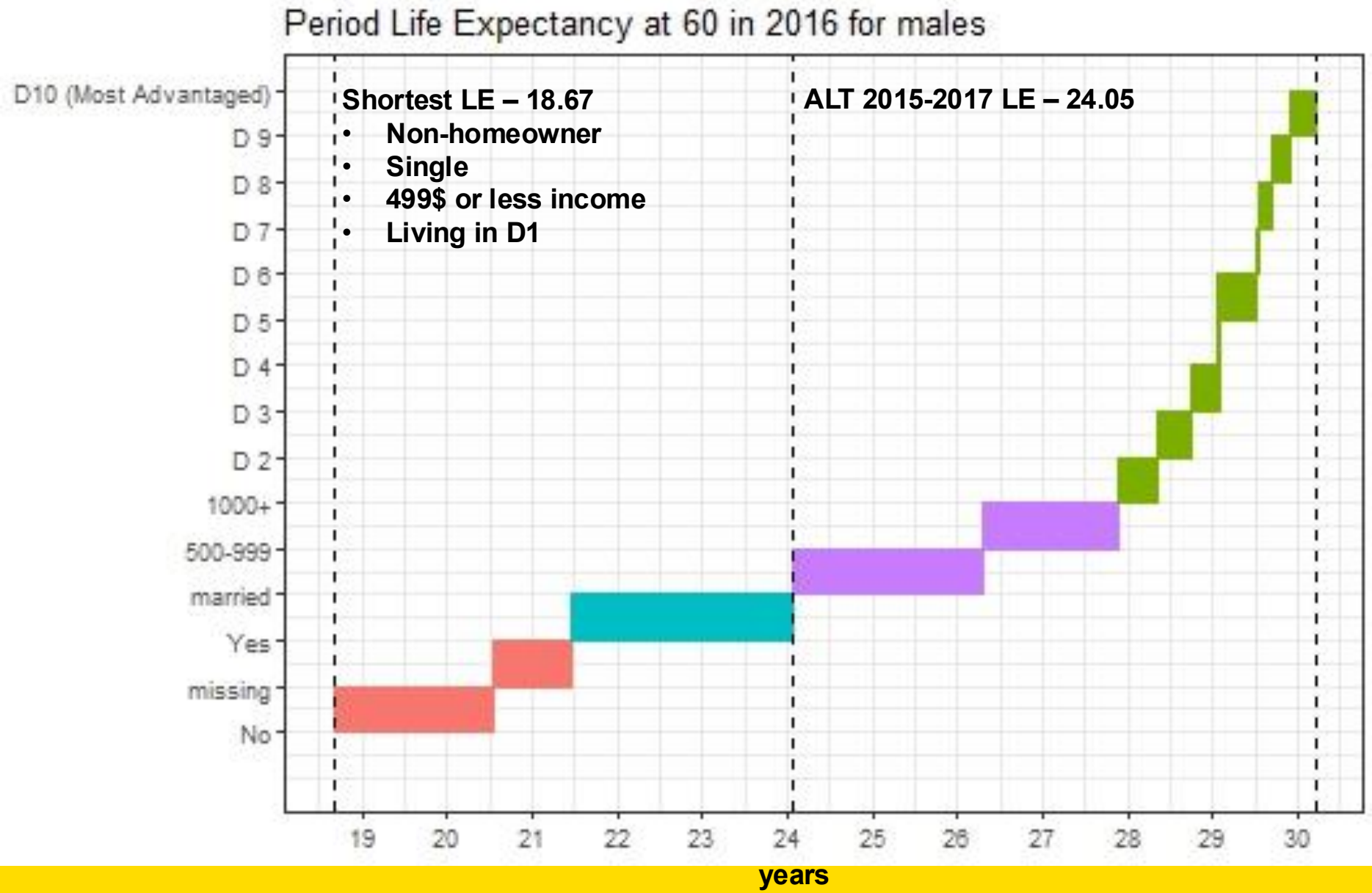
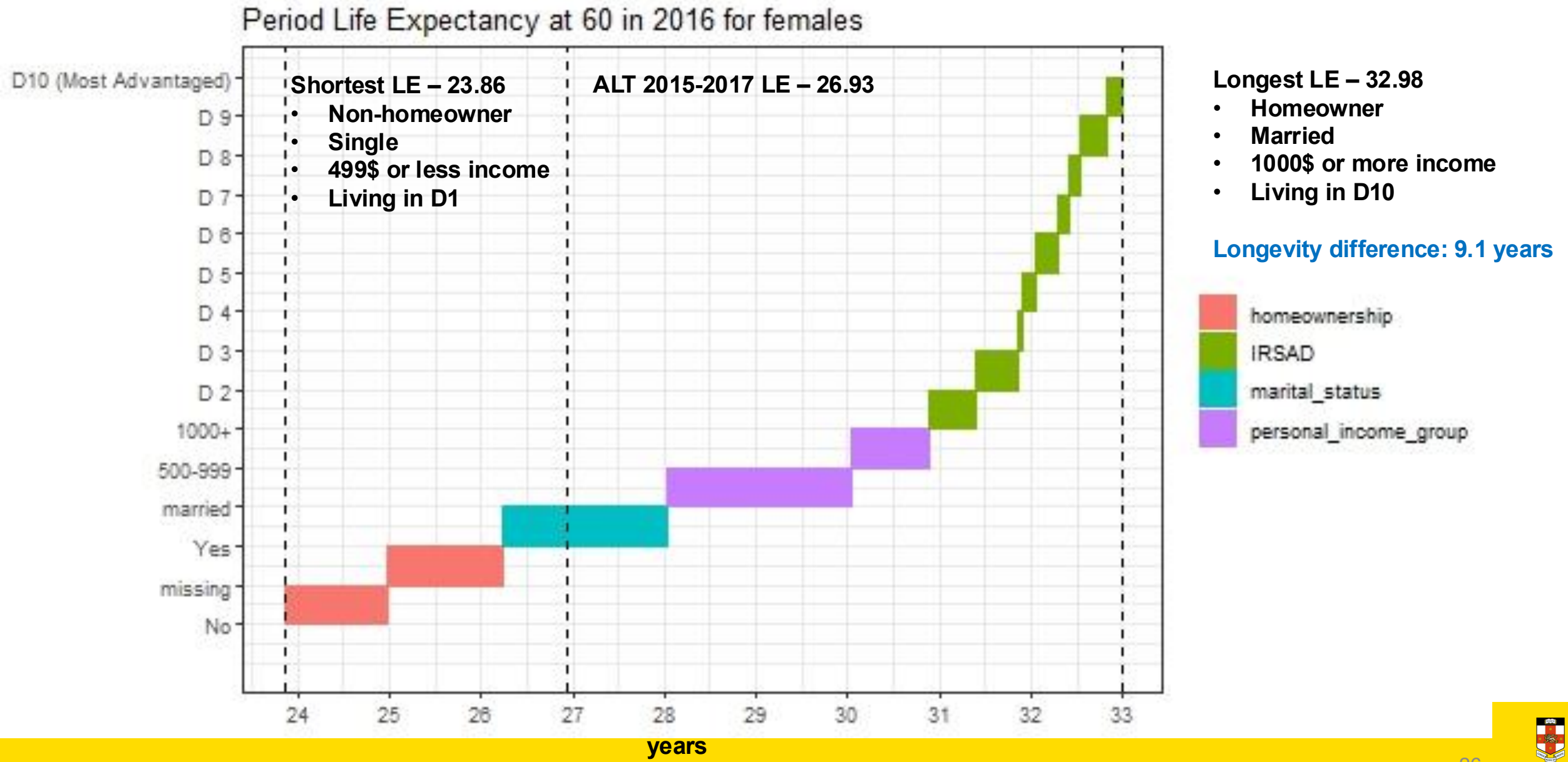


Longest LE – 30.20

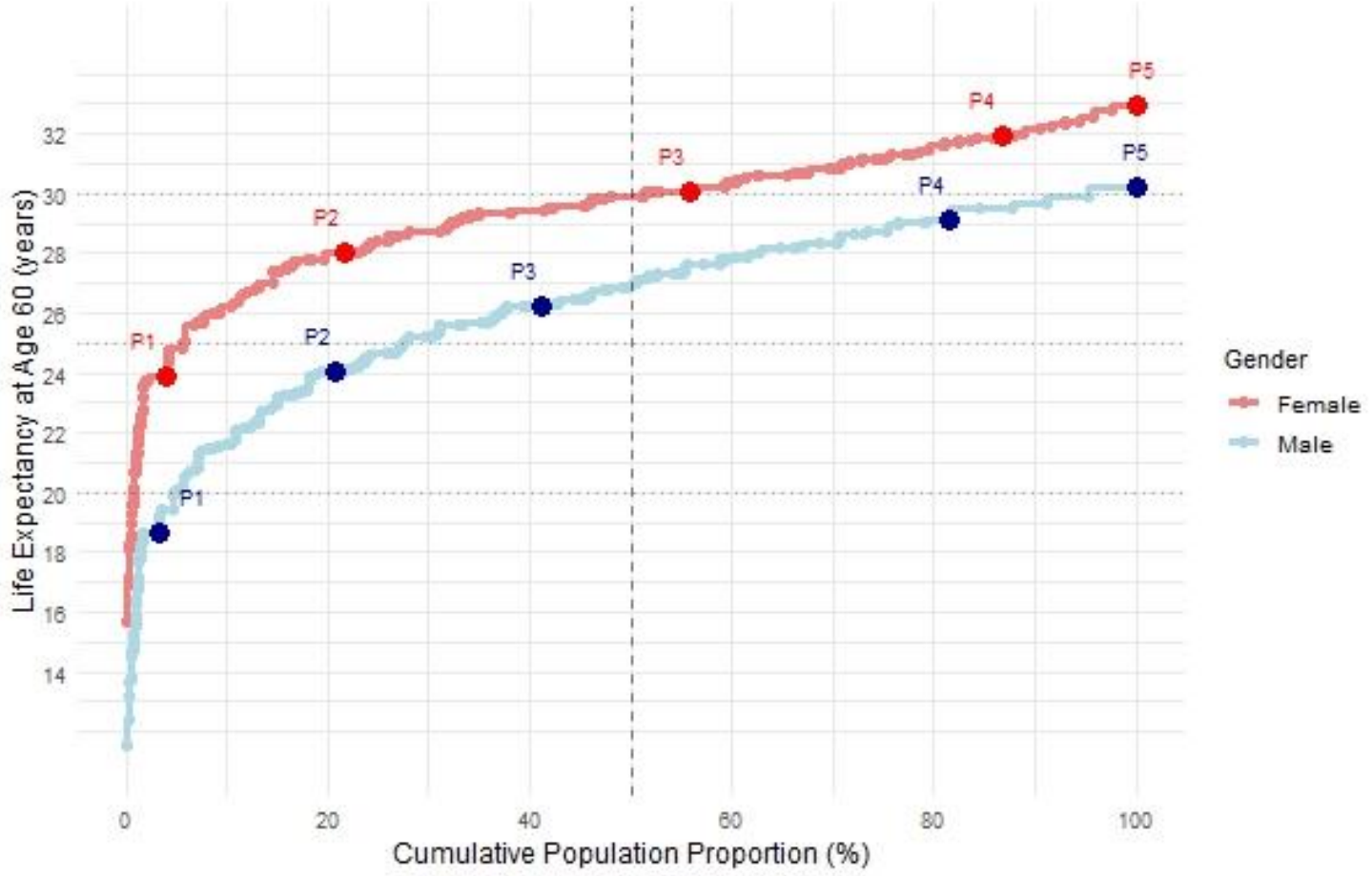
- **Homeowner**
- **Married**
- **1000$ or more income**
- **Living in D10**

Longevity difference: 11.5 years

homeownership
IRSAD
marital_status
personal_income_group

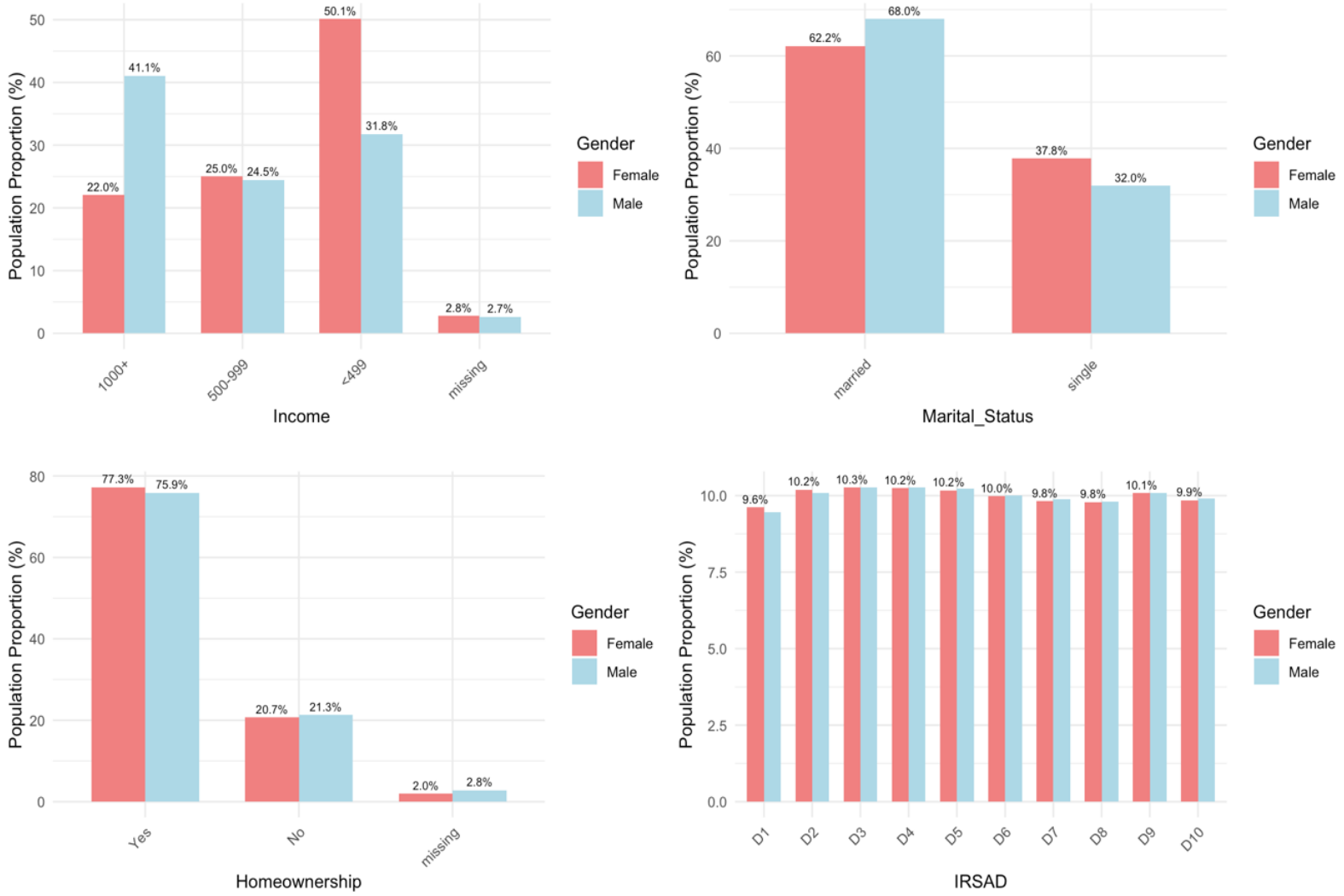

Period Life Expectancy at 60 in 2016 for females
Shortest LE – 23.86
• Non-homeowner
• Single
• 499$ or less income
• Living in D1
ALT 2015-2017 LE – 26.93
Longest LE – 32.98
• Homeowner
• Married
• 1000$ or more income
• Living in D10
Longevity difference: 9.1 years
D10 (Most Advantaged)
D 9
D 8
D 7
D 6
D 5
D 4
D 3
D 2
1000+
500-999
married
Yes
missing
No
homeownership
IRSAD
marital_status
personal_income_group
24
25
26
27
28
29
30
31
32
33
years

Cumulative distribution of life expectancy across the Australian population aged 60



- P1. Single, Non-homeowner, <499 income, D1
- P2. Married, Homeowner, <499 income, D1
- P3. Married, Homeowner, <499 income, D7
- P4. Married, Homeowner, 1000+ income, D4
- P5. Married, Homeowner, 1000+ income, D10

Demographic breakdown of the population across key socio-economic factors.



Case Study: Annuity Implications

Annuity Types Considered:

1. Immediate annuity (no death benefit)
2. Deferred annuity (no death benefit) – payments start at age 75
3. Immediate annuity (with death benefit)
4. Deferred annuity (with death benefit) – payments start at age 75

Common Assumptions:

1. Investment: $100,000 at age 65
2. Interest rate: 3% p.a.
3. No administration fees (for illustration)
4. Excludes: expenses, cost of capital, and profit margins

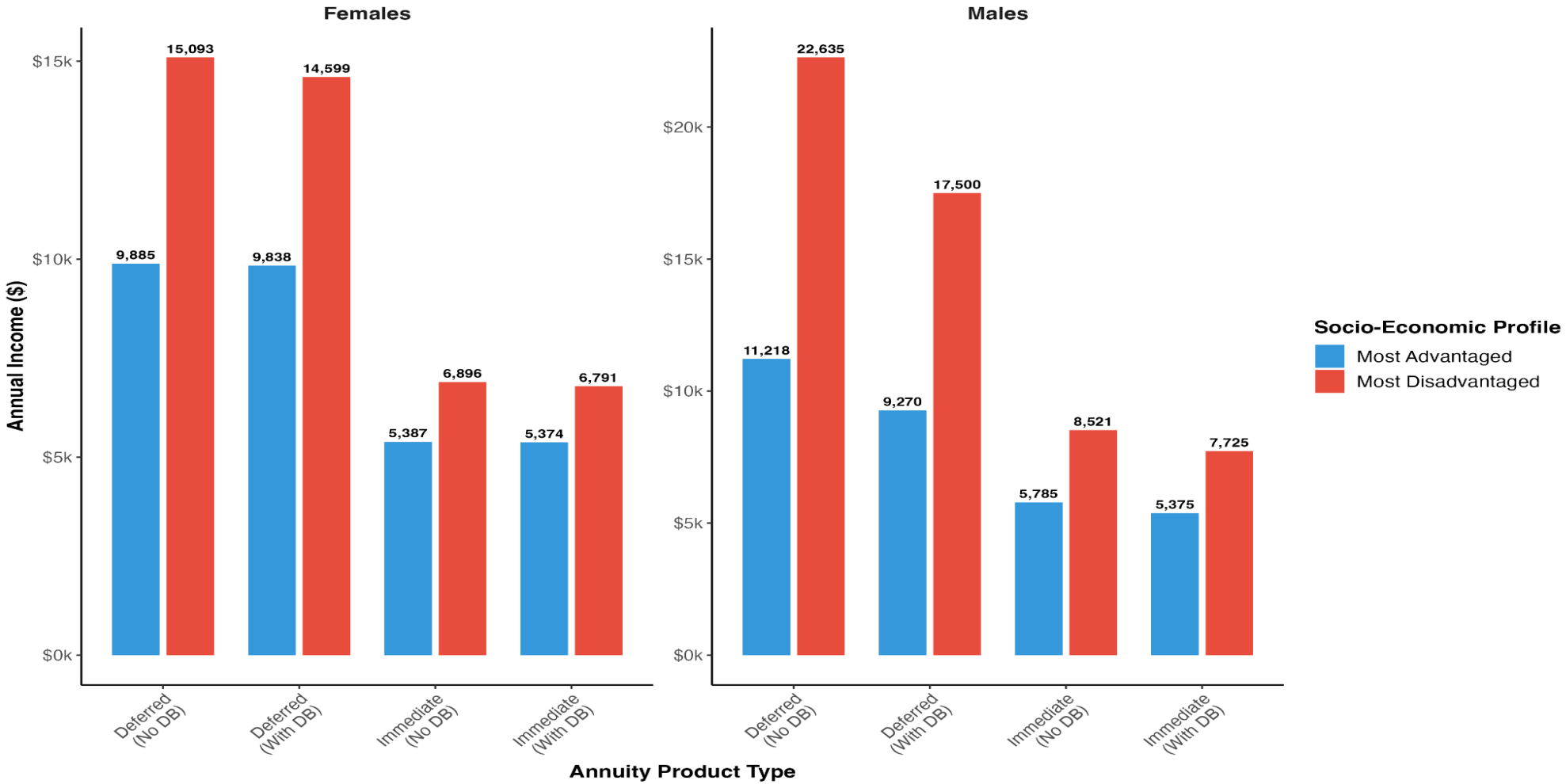
Mortality Assumptions:

1. Mortality improvement: Australian Life Tables (ALT) 2015–2017, 125-year scenario, age 65 in 2017
2. Death benefits (DB):
    - Withdrawal period of 22 years for females and 20 years for males.
    - Within the first half of the withdrawal period, investments totally refunded.
    - During the second half, DB declines linearly from 100% to 0%

Variation in annuity income under risk-based pricing accounting for socio-economic mortality

Product Type	Gender	Most Disadvantaged Income ($)	Most Advantaged Income ($)	% Difference
Immediate annuity (no death benefit)	Female	6,896	5,387	28%
	Male	8,521	5,785	47%
Deferred annuity (no death benefit)	Female	15,093	9,885	53%
	Male	22,635	11,218	102%
Immediate annuity (with death benefit)	Female	6,791	5,374	26%
	Male	8,281	5,298	43%
Deferred annuity (with death benefit)	Female	14,599	9,838	48%
	Male	21,017	11,130	89%

Variation in annuity income under risk-based pricing accounting for socio-economic mortality differences



Most Disadvantaged: D1 IRSAD, lowest income (<$499), single, non-homeowner
Most Advantaged: D10 IRSAD, highest income ($1000+), married, homeowner

Policy and Practice Implications

Uniform pricing of lifetime income products

- Creates hidden cross-subsidies or leads to poor perceived value and lower take up among those with shorter LE.

Cohorting & customised longevity assumptions

- Incorporate cohort-based longevity assumptions into product design, pricing, and advice.
- Supports obligations under the Retirement Income Covenant.

Longevity literacy & advice

- Advisers and calculators play a key role in correcting longevity underestimation.
- Public tools should include more longevity-risk content.

Resources: Paper

- The paper is available on SSRN.

Towards Fairer Retirement Outcomes: Socio-Economic Mortality Differentials in Australia

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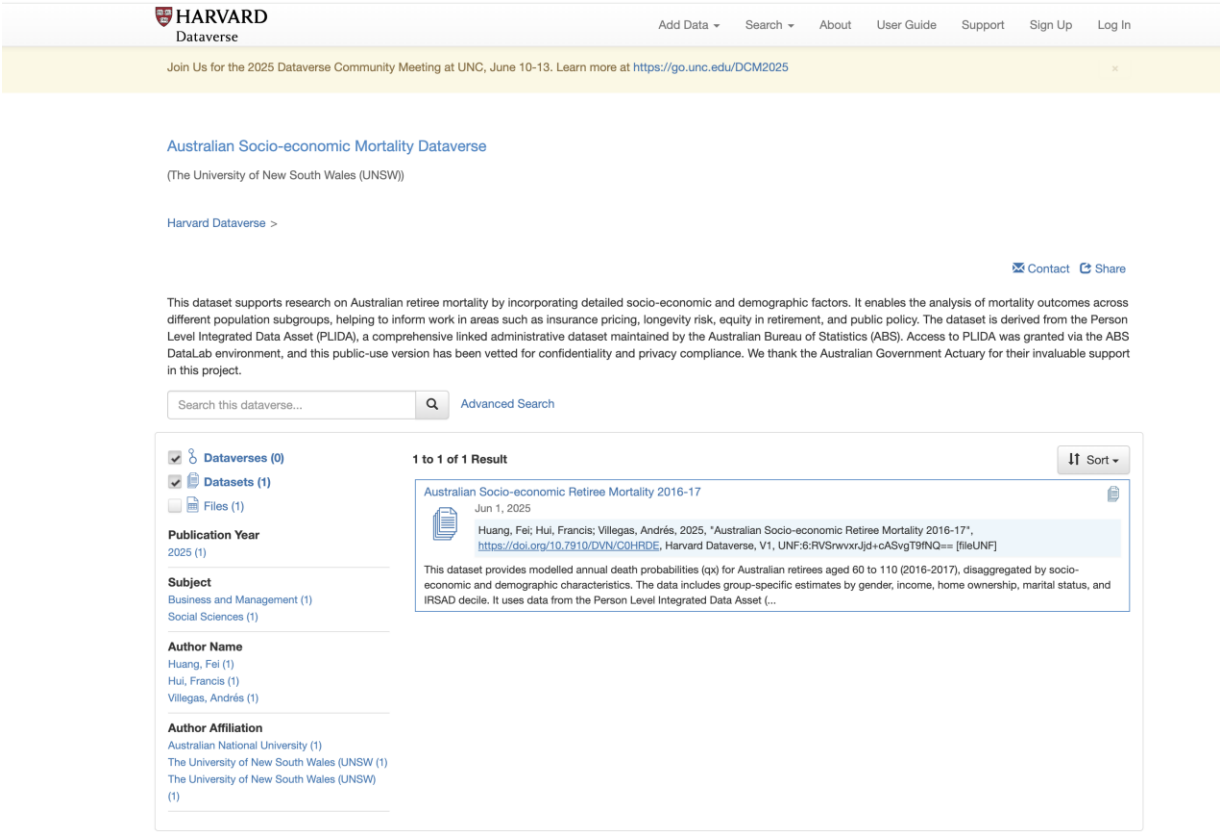
Date Written: May 14, 2025

Abstract

The Australian superannuation system faces the challenge of delivering equitable and sustainable income in retirement, yet the development of effective longevity products remains limited. A key barrier is the lack of detailed understanding of mortality differentials across socioeconomic groups, which complicates the pricing and design of retirement income products. While it is known that mortality varies by factors such as income and education, comprehensive evidence for Australia has been scarce, particularly for the post-retirement population. This paper addresses this gap by analysing individual-level linked data from the Australian Bureau of Statistics' Personal Level Integrated Data Asset (PLIDA), covering the entire Australian population aged 60-100 over 2016-2017. We examine mortality differentials across socioeconomic indicators including area-level socioeconomic advantage and disadvantage, income, marital status, and home ownership using flexible Hermite-spline Poisson regression models. Our results reveal substantial disparities in mortality and life expectancy across socioeconomic groups, with differences narrowing at older ages. For example, at age 60, the gap in period life expectancy between the most and least advantaged males is 11.5 years, and 9.1 years for females. Longevity differences translate into substantial variation in annuity income. The large and persistent differences by socioeconomic characteristics suggest that uniform approaches to longevity product pricing may unintentionally disadvantage certain groups. These findings highlight the importance of accounting for heterogeneity in longevity when designing retirement income products and inform policies aimed at fairer outcomes in the retirement phase.

Resources: Open Dataset “Australian Socio-Economic Mortality Dataverse”

- The dataset on the modelled annual probability of death (q_x) for ages 60–100 is openly available on the Harvard Dataverse: Australian Socio-economic Mortality Dataverse.



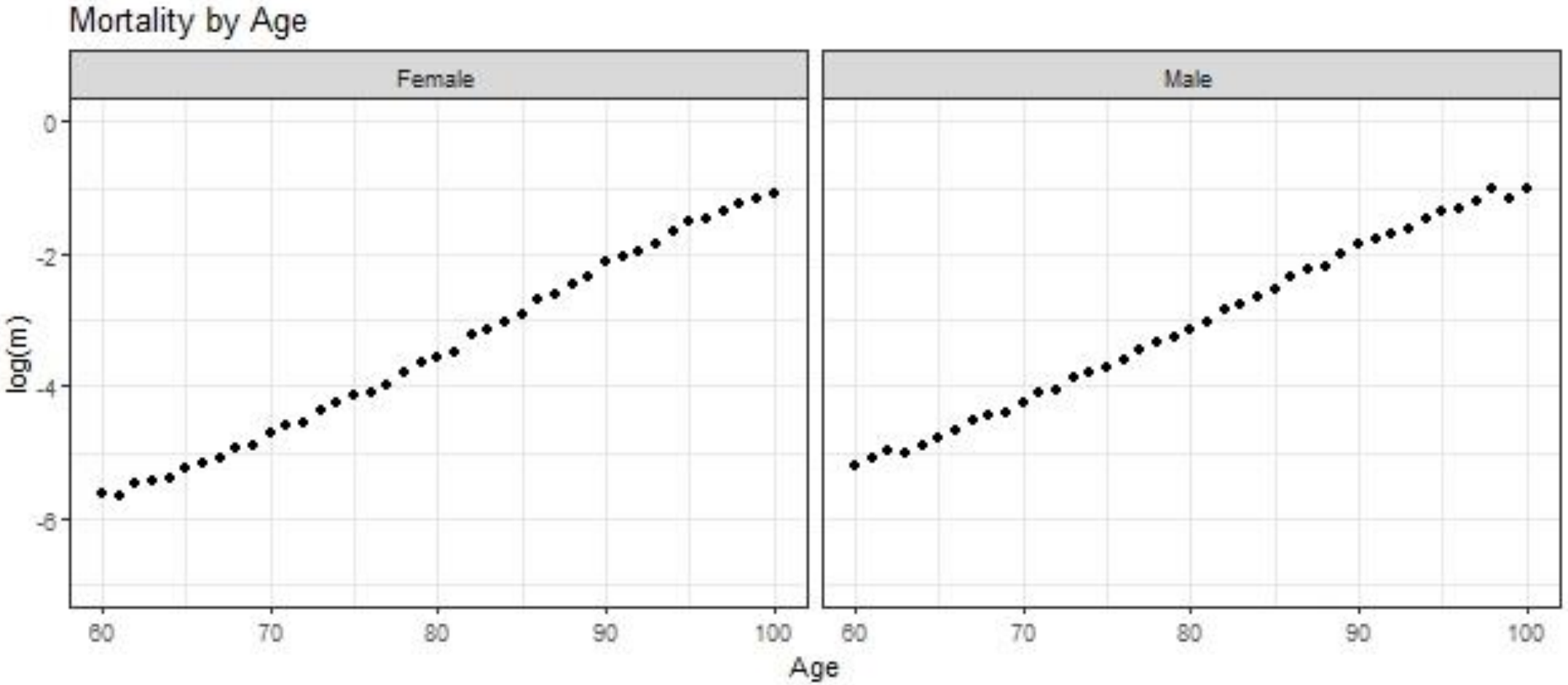
Appendix

Our sample

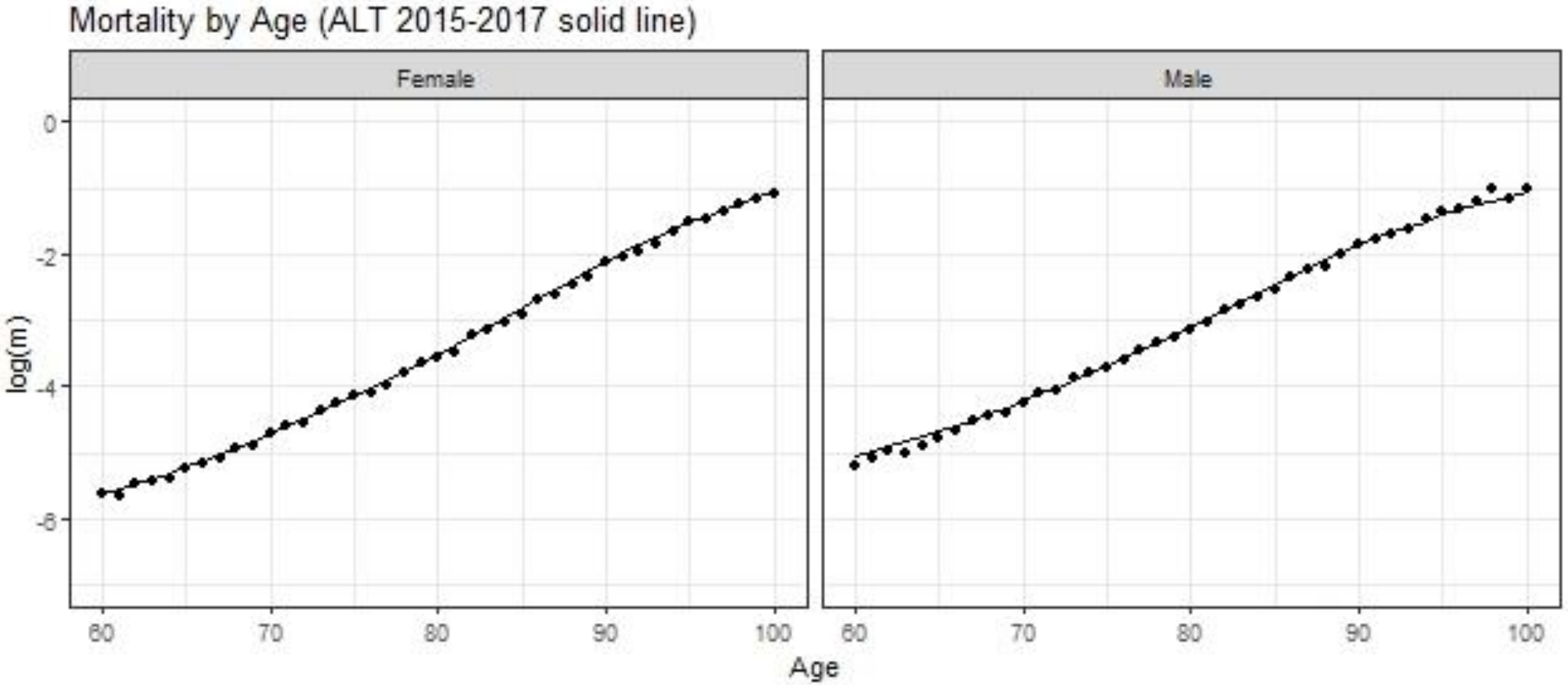
- Follow 2016 census population for a year from 1 September 2016 and 31 August 2017
  - Maximise covariate information
  - Minimise death underreporting
  - Avoid issues with seasonality

	Exposure		Deaths	
Age range	**Females**	**Males**	**Females**	**Males**
60-64	621046.63	584730.65	2518	3823
65-69	561972.25	534151.86	3603	5614
70-74	443133.38	417478.67	4915	7445
75-79	328190.86	292705.65	6472	9076
80-84	241294.20	193058.22	9077	10766
85-89	171998.74	116084.92	12701	11902
90-94	87037.82	44106.01	12346	7924
95-100	24408.87	8790.14	6044	2506
Total	2479082.75	2191106.11	57676	59056

Our sample



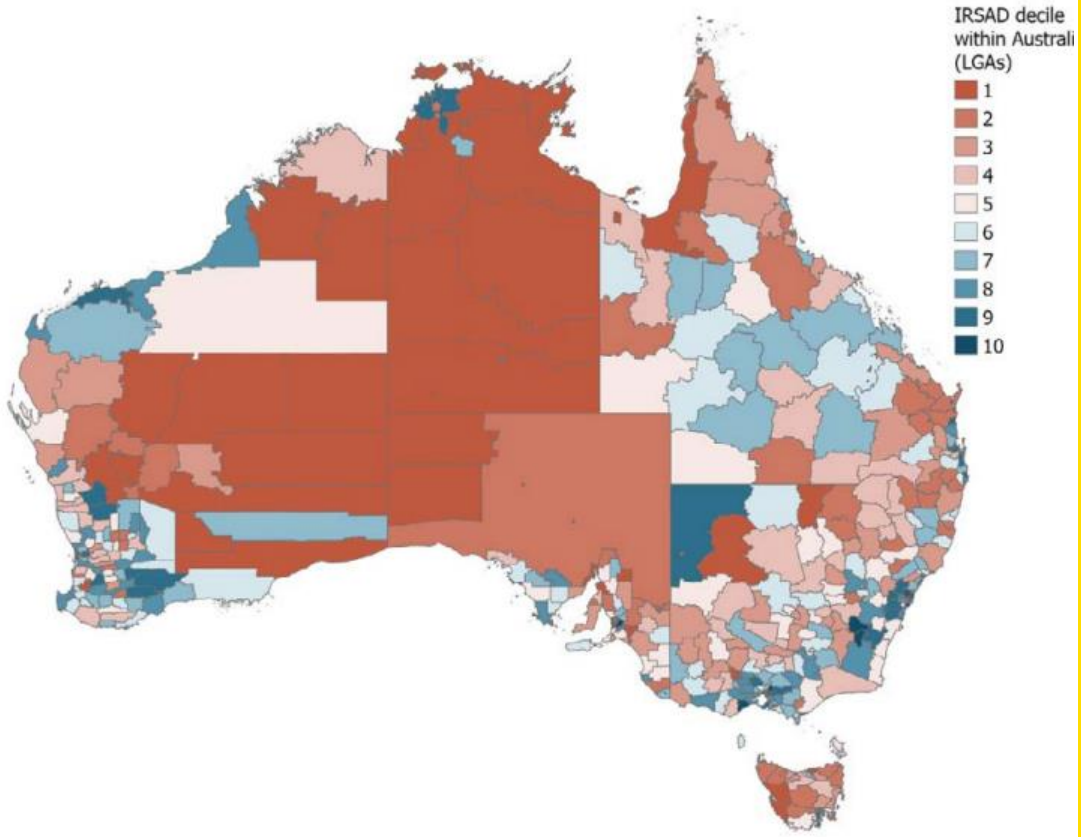
Our sample **matches ALT 2015-2017**



Index of Relative Socio-economic Advantage and Disadvantage (IRSAD)

- One of the SEIFA indices, summarises economic and social conditions in an area by measuring both advantage and disadvantage at SA1 level based on “SA1_IRSAD_2016” code of census.

- SA1_IRSAD_2016 provides 10 decile levels ranked from D1 (most disadvantaged) to D10 (most advantaged).



Source: BCARR analysis of the ABS Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), 2021.

Marital Status

Based on *Registered marital status (MSTP)* in 2016 Census

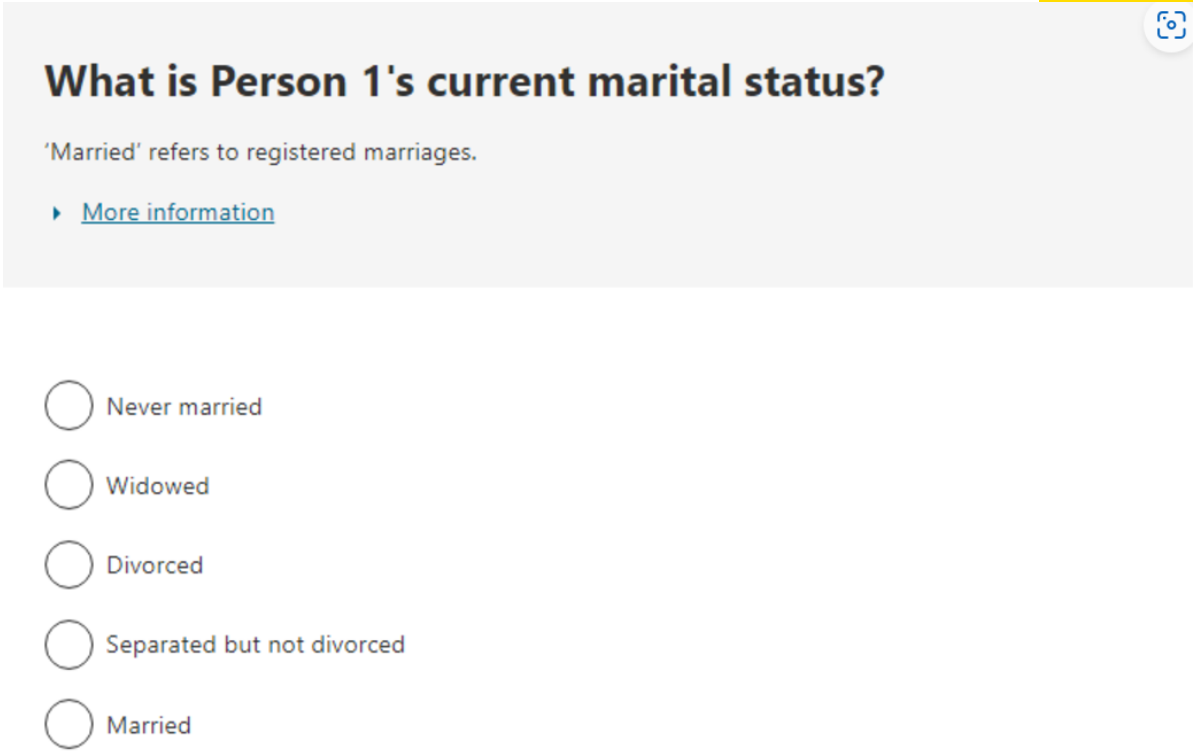
MSTP codes:

1. Never married
2. Widowed
3. Divorced
4. Separated
5. Married

@ Not applicable

For Modelling:

- Single: 1,2,3,4
- Married: 5



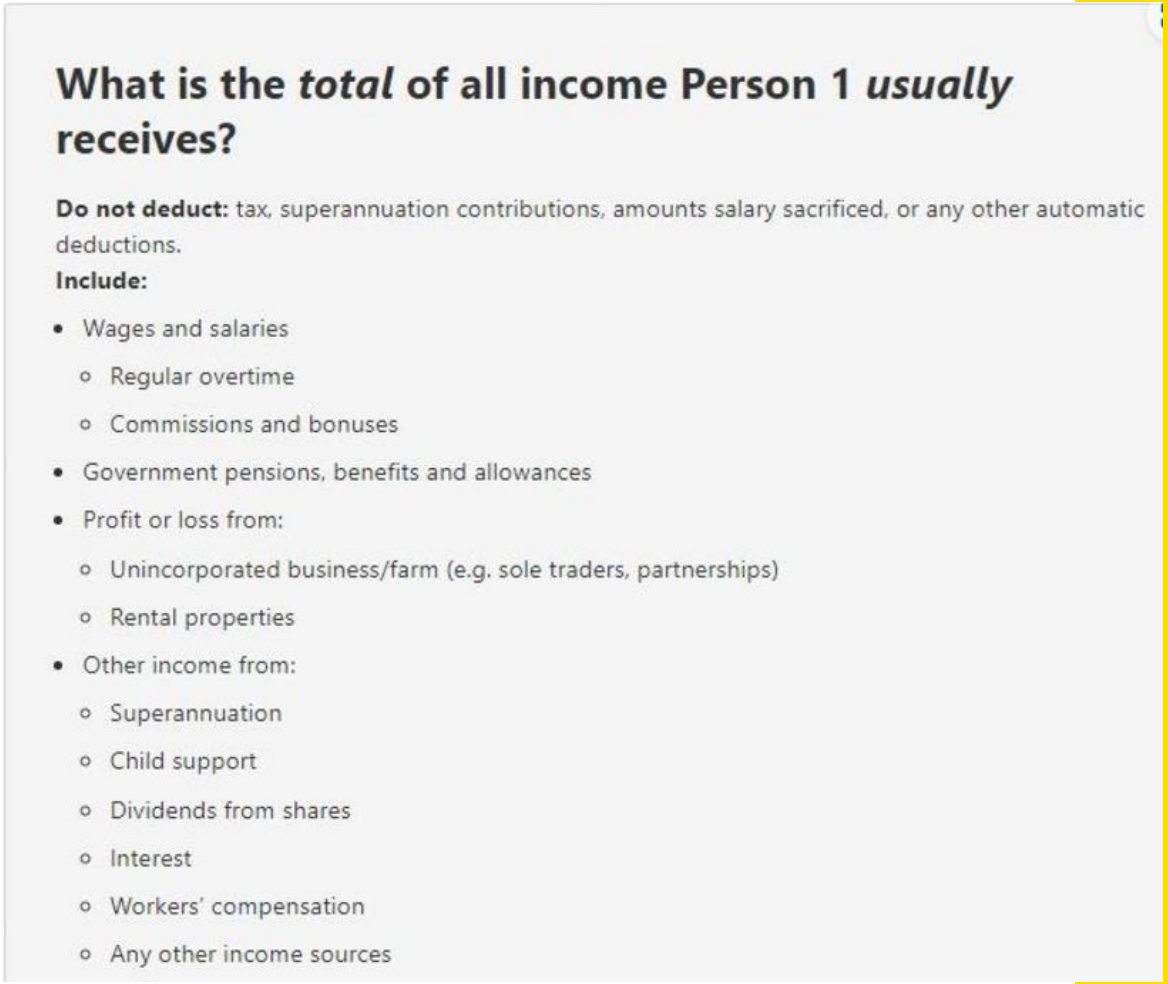
[Registered marital status (MSTP) | Australian Bureau of Statistics]

Income

Based on *Total personal income (weekly) (INCP)* on 2016 Census

INCP income groups for modelling:

1. <499$
2. 500-999
3. 1000$+
4. Missing



What is the *total* of all income Person 1 *usually* receives?

Do not deduct: tax, superannuation contributions, amounts salary sacrificed, or any other automatic deductions.

Include:

- Wages and salaries
  - Regular overtime
  - Commissions and bonuses
- Government pensions, benefits and allowances
- Profit or loss from:
  - Unincorporated business/farm (e.g. sole traders, partnerships)
  - Rental properties
- Other income from:
  - Superannuation
  - Child support
  - Dividends from shares
  - Interest
  - Workers' compensation
  - Any other income sources

[Total personal income (weekly) (INCP) | Australian Bureau of Statistics]

Homeownership

Two sources of data

- Tenure and landlord type (TENLLD) on 2016 Census
- Social Security Related Information (SSRI)

Homeownership categories for modelling:

1. Homeowner
2. Non-homeowner
3. Missing (for ages >=68)

- Homeownership information only usable before age 68
  - Census refers to location on census night and includes people in hospital and in age-cared facilities

Categories:	**1**	Owned outright
	2	Owned with a mortgage
	3	Rented: Real estate agent
	4	Rented: State or territory housing authority
	5	Rented: Person not in same household
	6	Rented: Housing co-operative, community or church group
	7	Rented: Other landlord type
	8	Rented: Landlord type not stated
	9	Other tenure type
	&	Tenure type not stated
	@	Tenure type not applicable
Number of categories:	**11**	

Not applicable (@) category comprises:

- Unoccupied private dwellings
- Non-private dwellings
- Migratory, off-shore and shipping SA1s

References

Australian Bureau of Statistics. “Person Level Integrated Data Asset (PLIDA), ABS DataLab.” *Findings Based on Use of PLIDA Data, Accessed 2023*.

Richards, Stephen J. 2020. “A Hermite-Spline Model of Post-Retirement Mortality.” Scandinavian Actuarial Journal 2020 (2): 110–27.

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- **MSTP codes**
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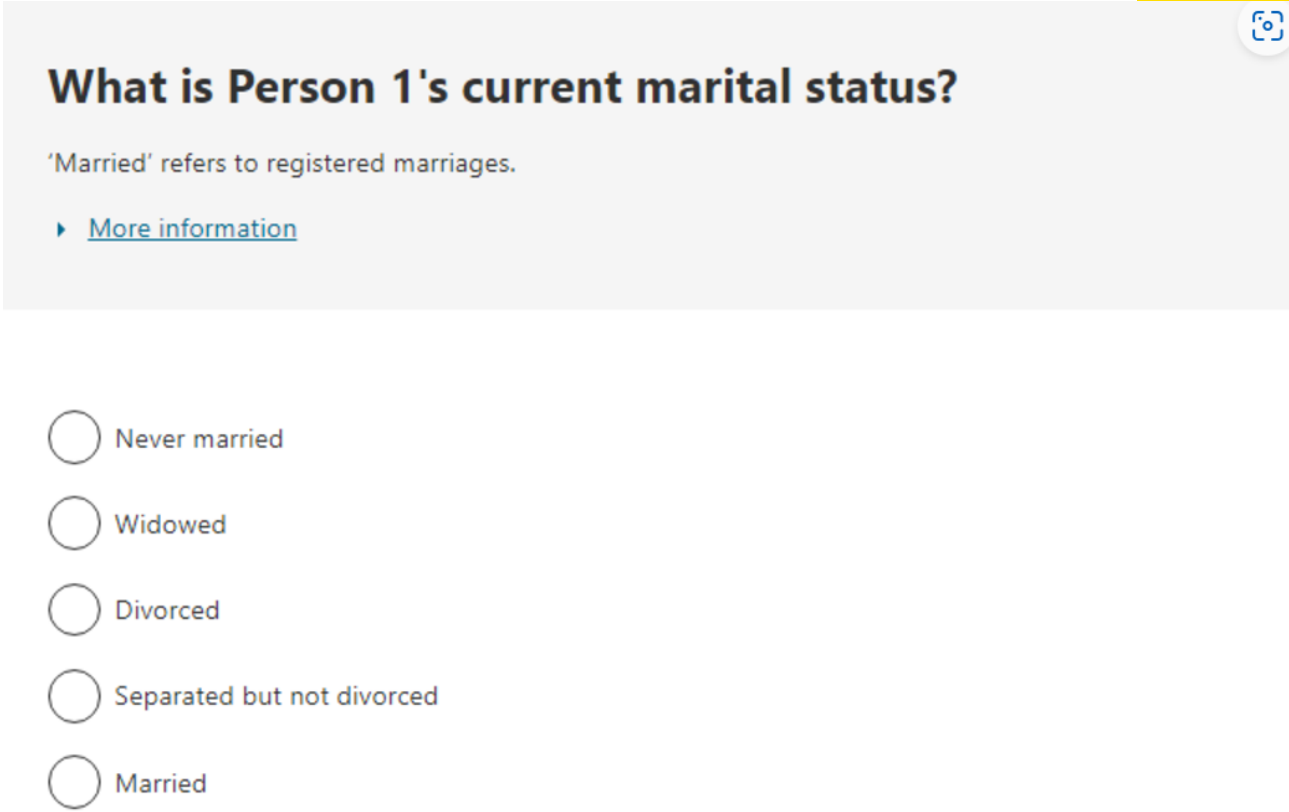
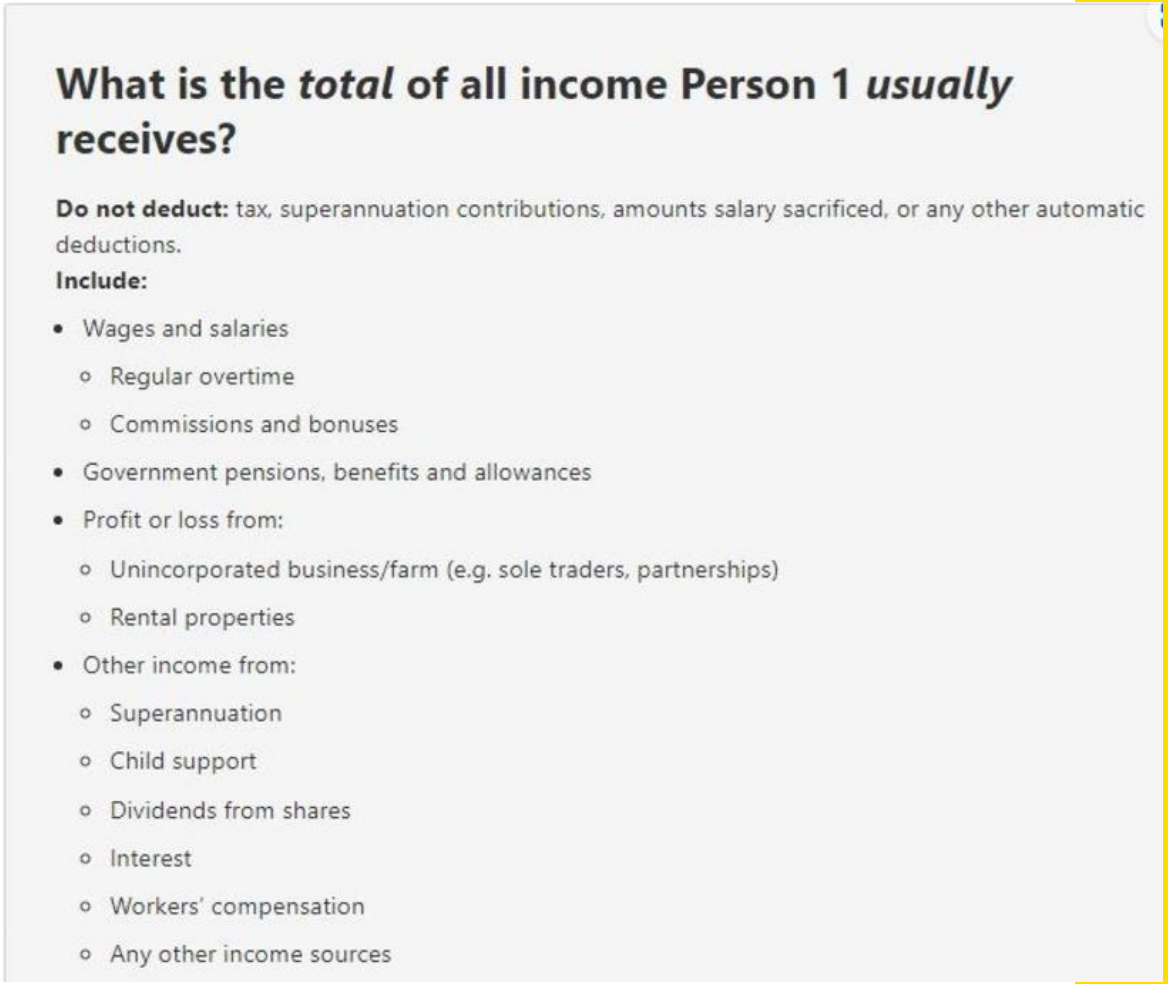
  - 2. Widowed
  - 3 Divorced
  - 4 Separated
  - 5 Married
  - @ Not applicable
- **Single:** 1,2,3,4
- **Married:** 5



Registered marital status (MSTP) | Australian Bureau of Statistics

Income

- Based on **Total personal income (weekly) (INCP) on** 2016 Census
- **Personal income group**
  - <499$
  - 500-999
  - 1000$+
  - Missing



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- Profit or loss from:
  - Unincorporated business/farm (e.g. sole traders, partnerships)
  - Rental properties
- Other income from:
  - Superannuation
  - Child support
  - Dividends from shares
  - Interest
  - Workers' compensation
  - Any other income sources

Total personal income (weekly) (INCP) | Australian Bureau of Statistics

Homeownership

- Two sources of data
  - **Tenure and landlord type (TENLLD) on** 2016 Census
  - **Social Security Related Information (SSRI)**
- **Homeownership**
  - Homeowner
  - Non-homeowner
  - Missing
- Homeownership information **only usable before age 68**
  - Census refers to location on census night and includes people in hospital and in age-cared facilities

Categories:	**1**	Owned outright
	2	Owned with a mortgage
	3	Rented: Real estate agent
	4	Rented: State or territory housing authority
	5	Rented: Person not in same household
	6	Rented: Housing co-operative, community or church group
	7	Rented: Other landlord type
	8	Rented: Landlord type not stated
	9	Other tenure type
	&	Tenure type not stated
	@	Tenure type not applicable
Number of categories:	**11**	

Not applicable (@) category comprises:

- Unoccupied private dwellings
- Non-private dwellings
- Migratory, off-shore and shipping SA1s

Period life expectancy at age 60 for representative profiles

Profile	Proportion of Population aged 60-65		Period Life Expectancy at age 60	
	Females	Males	Females	Males
P1. Single, Non-homeowner, <499 income, D1	1.92%	1.62%	23.86	18.67
P2. Married, Homeowner, <499 income, D1	2.24%	1.42%	28.04	24.06
P3. Married, Homeowner, <499 income, D7	2.90%	1.48%	30.10	26.27
P4. Married, Homeowner, 1000+ income, D4	0.84%	2.30%	31.90	29.09
P5. Married, Homeowner, 1000+ income, D10	2.46%	4.74%	32.98	30.20