UNIVERSITY OF CANBERRA | INSTITUTE FOR GOVERNANCE & POLICY ANALYSIS

NATSEM at the University of Canberra

2016 Census Small area Indicators of Wellbeing for Older Australians (IWOA)

TECHNICAL REPORT

JUNE 2018

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About NATSEM/IGPA

The National Centre for Social and Economic Modelling (NATSEM) was established on 1 January 1993, and supports its activities through research grants, commissioned research and longer term contracts for policy analysis and model development and maintenance.
In January 2014, the Institute for Governance and Policy Analysis (IGPA) at the University of Canberra was established to harness the research strengths of NATSEM and the ANZSOG Institute for Governance (ANZSIG). The aim of this Institute is to create and sustain an international class research institution for the study and practice of governance and public policy. The Institute has a strong social mission committed to the production of leading edge research and research driven education programs with genuine public value and, by implication, policy impact. The integration of ANZSIG and NATSEM has created exciting opportunities for the development of cutting edge research in public policy analysis through combining expertise in qualitative and quantitative methods, micro-simulation and policy modelling and evaluation.

NATSEM is one of three research centres within IGPA. NATSEM aims to be a key contributor to social and economic policy debate and analysis by undertaking independent and impartial research of the highest quality, including supplying valued commissioned research services. NATSEM is one of Australia's leading economic and social policy research centres and is regarded as one of the world's foremost centres of excellence for micro-data analysis, microsimulation modelling and policy evaluation. In keeping with IGPA's core mission, NATSEM's research activities aim to have significant policy impact and lead to social and economic change.

IGPA Director: Professor Mark Evans
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Acronyms

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ASGS	Australian Statistical Geography Standards
CSE	Child Social Exclusion
GCCSA	Greater Capital City Statistical Area
HES	Household Expenditure Survey
IGPA	Institute for Governance and Policy Analysis
IWOA	Index of Wellbeing for Older Australians
NATSEM	National Centre for Social and Economic Modelling
SA2	Statistical Areas Level Two
YSE	Youth Social Exclusion

INTRODUCTION

The Index of Wellbeing for Older Australians is an index developed by NATSEM for the Benevolent Society at small area level (SA2). The index is intended to be a tool for a range of stakeholders including policy-makers and planners in government, service providers and researchers. It will enable them to identify the wellbeing of the older population within local geographic areas and provide information to assist in the development and targeting of services. The small area unit we use is SA2 which is a general-purpose medium-sized area which aims to represent a community that interacts together socially and economically. SA2s generally have a population range of 3,000 to 25,000 persons. SA2s are aggregations of whole SA1s.

The main report shows the method for the modelling, a map of the index, a comparison with the ABS Socio-Economic Index for Areas (SEIFA) (Australian Bureau of Statistics, 2004), a discussion of the results, some policy implications, the limitations, and further work.

This technical report shows the data sources, definitions, the full results from the principal components analysis (PCA) for each domain, and a technical description of how the domains were combined to form the final index. We also include a section which discusses the validation of the indicators calculated from our modelling.

In this report, the results for each domain are shown in separate sections. The first table shown for each domain is the correlation table, which shows how each of the indicators are correlated with each other. Indicators that are highly correlated (greater than 0.95) can cause problems with the PCA analysis, and so one of the indicators is removed. We would hope to have reasonable correlations between indicators, and any with a low correlation will be removed in the next step. A full description of the PCA method can be found in (Dunteman, 1989).

For each domain, we then show the loadings (or weights) for the indicators against each of the first three components. Where loadings are less than 0.3, then the indicator with the lowest loading is removed, as it does not add much to the final index. This is the same cut-off used by the ABS for the SEIFA index (ABS, 2004), and NATSEM for the Child Social Exclusion index (Harding, McNamara, Daly, & Tanton, 2009).

Once an indicator is removed, the PCA is run again, and the indicator with the next lowest loading is removed. This iterative process continues until all indicators have loadings above 0.3.

Once all indicators have a loading above 0.3, there may be indicators that we try to reintroduce to test if the loading is now above 0.3. The reason for this is that some of the

indicators interact, so removing an indicator may now mean that another indicator previously removed now has a loading above 0.3.

We then looked at the eigenvalues, which show whether the first component is the best component, or whether the other components can be used. The eigenvalues are plotted using a scree plot, and we are looking for a sudden levelling of the eigenvalue. If the second component still explains a lot of the correlation, then this is a potential secondary index; whereas if the first index explains most of the correlation, and the scree plot levels out at the second component, then the second and further components can be eliminated as they are not explaining much of the correlation between the indicators.

This technique works well when all indicators are used for the PCA, and the different components identified through the PCA can then be split into domains like education, participation, etc. For this index, we have started from a theoretical construct which identified the domains, rather than letting the data and PCA identify the domains. This method then uses separate indicators for each domain, and runs a separate PCA for each domain, and then aggregates the first component of each domain as the index for that domain. So, the second and further components in each PCA are not used as they are less important and can be difficult to interpret.

The first component will always explain most of the correlation between the indicators, and traditionally this has been the component used for the index. The ABS follows this method in their Socio-Economic Index for Areas (SEIFA) and NATSEM has used it in their Child Social Exclusion indexes. Therefore, for this index, while the scree plots are shown for information, we have always used the first component in the PCA for the index.

Please note that we have excluded a not stated category from each indicator from both our numerator and denominator as we don't know what their real values are. We have also excluded any areas with a low population size of people aged 65 and above, which is fixed at a cut off of less than 30.

The rest of this paper first discusses the data and definitions of the indicators. The next section discusses the validation of selected variables which include the ones that are created by the spatial microsimulation technique. This is followed by the methodology section which describes how the index is created. We start with a discussion of the domains and present the results – the correlation matrix, the loadings as each indicator is removed, the final loadings and indicators used in the sub-index, and the scree plot for the eigenvalues. Note that the tables of loadings use the indicator mnemonics, and the full description of the indicator can be found in

the correlation matrix, the first table for each domain. This technical paper also outlines the method for bringing all the sub-indexes together.

DATA AND DEFINITION OF THE INDICATORS

We used a combination of data sources, which include data from (i) the 2016 Australian Bureau of Statistics (ABS) Census, (ii) modelled data from NATSEM' spatial microsimulation model SpatialMSM18 which uses the Household Expenditure Survey 2015/2016 and the Census of Population and Housing 2016 and (iii) administrative data provided by Australian Institute for Health and Welfare (AIHW). How the data are defined and constructed are explained below.

CENSUS 2016

All indicators used in this analysis are for people aged 65 and over. Treatment of Not Stated is to exclude from both the numerator and the denominator.

1. Labour force participation rates for those aged 65+ (Place of Usual Residence) (lbr_ptcp_r~s)

Variable name in Census: LFSP Labour Force Status

The categories available are:

- Employed, worked full-time
- Employed, worked part-time
- Employed, away from work
- Unemployed, looking for full-time work
- Unemployed, looking for part-time work
- Not in the labour force
- Not stated
- Not applicable

✓ **Numerator:** Number of people in the labour force aged 65 and over (Employed, worked full-time + Employed, worked part-time + Employed, away from work+ Unemployed, looking for full-time work + Unemployed, looking for part-time work)

✓ **Denominator:** Number of people aged 65 and over (Employed, worked full-time + Employed, worked part-time + Employed, away from work+ Unemployed, looking for full-time work + Unemployed, looking for part-time work+ Not in the labour force+ Not applicable)

2. **Employment to population ratio for those aged 65+ (Place of Usual Residence) (emp_rate_cns)**

Variable name in Census: LFSP Labour Force Status
For this indicator the following three variables are grouped-

- Employed, worked full-time
- Employed, worked part-time
- Employed, away from work

✓ **Numerator:** Number of people employed aged 65 and over (Employed, worked full-time + Employed, worked part-time + Employed, away from work)
✓ **Denominator:** Number of people aged 65 and over (Employed, worked full-time + Employed, worked part-time + Employed, away from work+ Unemployed, looking for full-time work + Unemployed, looking for part-time work+ Not in the labour force+ Not applicable)

3. **Unemployment to population ratio for those aged 65+ (Place of Usual Residence) (unemp_rate~s)**

Variable name in Census: LFSP Labour Force Status
For this indicator the following two variables are grouped as unemployed: -

- Unemployed, looking for full-time work
- Unemployed, looking for part-time work

✓ **Numerator:** Number of unemployed people aged 65 and over (Unemployed, looking for full-time work+ Unemployed, looking for part-time work)
✓ **Denominator:** Number of people aged 65 and over (Employed, worked full-time + Employed, worked part-time + Employed, away from work+ Unemployed, looking for full-time work + Unemployed, looking for part-time work+ Not in the labour force+ Not applicable)

4. **% of older people who had no access to a car to drive (Counting Persons, Places of Enumeration) (no_car_cns)**

Place of Enumeration as using household level data

Variable name in Census: VEHRD Number of Motor Vehicles (ranges)
The categories available are:

- No motor vehicles
- One motor vehicle
- Two motor vehicles
- Three motor vehicles
- Four or more motor vehicles
- Not stated
- Not applicable

- ✓ **Numerator:** Number of people aged 65 and over living with no Motor Vehicles
- ✓ **Denominator:** Number of people aged 65 and over living in dwellings with Motor Vehicle (1,2,3,4 or more) + with no motor vehicles

5. % of older people who are volunteers (Place of Usual Residence) (volunt_cns)

Variable name in Census: VOLWP Voluntary Work for an Organisation or Group
The categories available are:

- Not a volunteer
- Volunteer
- Not stated
- Not applicable

- ✓ **Numerator**: Number of people aged 65 and over who have volunteered
- ✓ **Denominator:** Number of people aged 65 and over who have volunteered + have not volunteered (in the last 12 months)

6. % of older people who do not have access to the internet in the house (Place of Usual Residence) (no_int_cns)

Variable name in Census: NEDD Dwelling Internet Connection
The categories available are:

- Internet accessed from dwelling
- Internet not accessed from dwelling
- Not Stated
- Not Applicable

- ✓ **Numerator**: Number of people aged 65 and over who did not have access to Internet from building
- ✓ **Denominator:** Number of people aged 65 and over who had internet and did not have internet access from building.

7. % of older people who can't speak English well or not at all (Place of Usual Residence) (not_well_e~s)

Variable name in Census: ENGLP Proficiency in Spoken English/Language

The categories available are:

- Speaks English only
- Speaks other language and speaks English: Very well
- Speaks other language and speaks English: Well
- Speaks other language and speaks English: Not well
- Speaks other language and speaks English: Not at all
- Not stated - both language (LANP) and proficiency (ENGP) not stated
- Not stated - language (LANP) stated, proficiency (ENGP) not stated

- ✓ **Numerator:** Number of people aged 65 and over who speaks other language and speaks English: Not well+ Speaks other language and speaks English: Not at all
- ✓ **Denominator:** Number of people 65 and over who speak English only+ Speaks other language and speaks English: Very well+ Speaks other language and speaks English: Well+ Speaks other language and speaks English: Not well+ Speaks other language and speaks English: Not at all

8. % Completed Year 12 (Place of Usual Residence) (cy12_cns)

Variable name in Census: HSCP Highest Year of School Completed

The categories available are:

- Year 12 or equivalent
- Year 11 or equivalent
- Year 10 or equivalent
- Year 9 or equivalent
- Year 8 or below
- Did not go to school
- Not stated
- Not applicable

- ✓ **Numerator:** Number of people 65 and over with Year 12 or equivalent
- ✓ **Denominator:** Number of people 65 and over with (Year 12 or equivalent+ Year 11 or equivalent+ Year 10 or equivalent+ Year 9 or equivalent+ Year 8 or below+ Did not go to school)

9. % Completed Year 10 (Place of Usual Residence) (cy10_cns)

Variable name in Census: HSCP Highest Year of School Completed
The categories available are:

- Year 12 or equivalent
- Year 11 or equivalent
- Year 10 or equivalent
- Year 9 or equivalent
- Year 8 or below
- Did not go to school
- Not stated
- Not applicable

- ✓ **Numerator:** Number of people 65 and over with highest Year of School Completed in Year 12 + Year 11 + Year 10 or equivalent
- ✓ **Denominator:** Number of people 65 and over with highest Year of School Completed in Year 12 + Year 11 + Year 10 + Year 9 or equivalents + Year 8 or below + Did not go to school

10. % with post school qualifications (Place of Usual Residence) (qual_cns)

Variable name in Census: QALLP - 1 Digit Level
The categories available are:

- Postgraduate Degree Level
- Graduate Diploma and Graduate Certificate Level
- Bachelor Degree Level
- Advanced Diploma and Diploma Level
- Certificate Level
- Level of education inadequately described
- Level of education not stated
- Not applicable

✓ **Numerator:** Number of people 65 and over with (Postgraduate Degree Level + Graduate Diploma and Graduate Certificate Level + Bachelor Degree Level+ Advanced Diploma and Diploma Level+ Certificate Level)
✓ **Denominator:** Number of people 65 and over with (Postgraduate Degree Level + Graduate Diploma and Graduate Certificate Level + Bachelor Degree Level+ Advanced Diploma and Diploma Level+ Certificate Level+ Not applicable)

11. % of older people who are still paying mortgages (Counting Persons, Places of Enumeration) (pay_mort_cns)

Variable name in Census: TEND Tenure Type

The categories available are:

The categories available are:

- Owned outright
- Owned with a mortgage
- Being purchased under a shared equity scheme
- Rented
- Being occupied rent-free
- Being occupied under a life tenure scheme
- Other tenure type
- Not stated
- Not applicable

For this indicator the following four variables are grouped-

- Owned with a mortgage
- Being purchased under a shared equity scheme

✓ **Numerator:** Number of people 65 and over who Owned with a mortgage+ Being purchased under a shared equity scheme

- ✓ **Denominator:** Number of people 65 and over who Owned outright+ Owned with a mortgage+ Being purchased under a shared equity scheme+ Rented+ Being occupied rent-free+ Being occupied under a life tenure scheme+ Other tenure type)

12. % of older people who are still renters (Counting Persons, Places of Enumeration) (rent_cns)

Variable name in Census: TEND Tenure Type
The categories available are:

- Owned outright
- Owned with a mortgage
- Being purchased under a shared equity scheme
- Rented
- Being occupied rent-free
- Being occupied under a life tenure scheme
- Other tenure type
- Not stated
- Not applicable

- ✓ **Numerator:** Number of people 65 and over who rented
- ✓ **Denominator:** Number of people 65 and over who Owned outright+ Owned with a mortgage+ Being purchased under a shared equity scheme+ Rented+ Being occupied rent-free+ Being occupied under a life tenure scheme+ Other tenure type)**.**

13. % of older people living in public housing (Counting Persons, Places of Enumeration) (pub_hous_cns)

Variable name in Census: TENLLD Tenure and Landlord Type

The categories available are:

- Owned outright
- Owned with a mortgage
- Rented: Real estate agent
- Rented: State or territory housing authority
- Rented: Person not in same household
- Rented: Housing co-operative, community or church group
- Rented: Other landlord type
- Rented: Landlord type not stated
- Other tenure type
- Tenure type not stated
- Tenure type not applicable

- ✓ **Numerator:** Number of people 65 and over who Rented: State or territory housing authority+ Rented: Housing co-operative, community or church group
- ✓ **Denominator:** Number of people 65 and over Living in Owned outright + Owned with a mortgage + Rented: Real estate agent + Rented: State or territory housing authority +

Rented: Person not in same household + Rented: Housing co-operative, community or church group + Rented: Other landlord type + Rented: Landlord type not stated + Other tenure type

14. % of older people who are homeless (Counting Persons, Places of Enumeration) (hmless_cns)

Variable name in Census: NPDD Type of Non-Private Dwelling

The categories available are:

- Hotel, motel, bed and breakfast
- Nurses' quarters
- Staff quarters
- Boarding house, private hotel
- Boarding school
- Residential college, hall of residence
- Public hospital (not psychiatric)
- Private hospital (not psychiatric)
- Psychiatric hospital or institution
- Hostel for the disabled
- Nursing home
- Accommodation for the retired or aged (not self-contained)
- Hostel for homeless, night shelter, refuge
- Childcare institution
- Corrective institution for children
- Other welfare institution
- Prison, corrective institution for adults
- Corrective institution for children
- Immigration detention centre
- Convent, monastery, etc.
- Other and non-classifiable
- Not stated
- Not applicable

Variable name in Census: STRD Dwelling Structure

The categories available are:

- Separate house
- Semi-detached, row or terrace house, townhouse etc. with one storey
- Semi-detached, row or terrace house, townhouse etc. with two or more storeys
- Flat or apartment in a one or two storey block
- Flat or apartment in a three storey block
- Flat or apartment in a four or more storey block
- Flat or apartment attached to a house
- Caravan
- Cabin, houseboat
- Improvised home, tent, sleepers out

- House or flat attached to a shop, office, etc.
- Not stated
- Not applicable

✓ **Numerator:** Number of people 65 and over who lived in Hostel for homeless, night shelter, refuge (NPDD) + Boarding house, private hotel (NPDD) + Other welfare institution (NPDD)+ Caravan, cabin, houseboat (STRD) +Improvised home, tent, sleepers out (STRD)

✓ **Denominator:** Number of people 65 and over living in Non- Private Dwelling (NPDD): Hotel, motel, bed and breakfast + Nurses' quarters + Staff quarters + Boarding house, private hotel + Boarding school + Residential college, hall of residence + Public hospital (not psychiatric) + Private hospital (not psychiatric) + Psychiatric hospital or institution + Hostel for the disabled + Nursing home + Accommodation for the retired or aged (not self-contained) + Hostel for homeless, night shelter, refuge + Childcare institution + Corrective institution for children + Other welfare institution + Prison, corrective institution for adults + Immigration detention centre + Convent, monastery, etc. and

+

on STRD variable: Separate house + Semi-detached, row or terrace house, townhouse etc with one storey + Semi-detached, row or terrace house, townhouse etc with two or more storeys + Flat, unit or apartment in a one or two storey block + Flat, unit or apartment in a three storey block + Flat, unit or apartment in a four or more storey block + Flat, unit or apartment attached to a house + Caravan, cabin, houseboat + Improvised home, tent, sleepers out + House or flat attached to a shop, office, etc.

15. % of Older People who need assistance with core activities (need_ass_cns)

Variable name in Census: ASSNP, Core Activity Need for Assistance
The categories available are:

- Has need for assistance with core activities
- Does not have need for assistance with core activities
- Not stated

✓ **Numerator:** Number of people aged 65 and over who have need for assistance with core activities

✓ **Denominator:** Number of people aged 65 and over (Have need for assistance with core activities **+** Does not have need for assistance with core activities)**.**

16. % of Older People who use aged care services (aged_care_cns)

Variable name in Census: NPDD Type of Non-Private Dwelling

The categories available are:

- Hotel, motel, bed and breakfast
- Nurses' quarters
- Staff quarters
- Boarding house, private hotel
- Boarding school

- Residential college, hall of residence
- Public hospital (not psychiatric)
- Private hospital (not psychiatric)
- Psychiatric hospital or institution
- Hostel for the disabled
- Nursing home
- Accommodation for the retired or aged (not self-contained)
- Hostel for homeless, night shelter, refuge
- Childcare institution
- Corrective institution for children
- Other welfare institution
- Prison, corrective institution for adults
- Corrective institution for children
- Immigration detention centre
- Convent, monastery, etc.
- Other and non-classifiable
- Not stated
- Not applicable

Variable name in Census: STRD Dwelling Structure

The categories available are:

- Separate house
- Semi-detached, row or terrace house, townhouse etc. with one storey
- Semi-detached, row or terrace house, townhouse etc. with two or more storeys
- Flat or apartment in a one or two storey block
- Flat or apartment in a three storey block
- Flat or apartment in a four or more storey block
- Flat or apartment attached to a house
- Caravan
- Cabin, houseboat
- Improvised home, tent, sleepers out
- House or flat attached to a shop, office, etc.
- Not stated
- Not applicable

- ✓ **Numerator:** Number of people 65 and over who lived in Nursing home (NPDD) + Accommodation for the retired or aged (not self-contained) (NPDD)
- ✓ **Denominator:** Number of people 65 and over living in Non- Private Dwelling (NPDD): Hotel, motel, bed and breakfast + Nurses' quarters + Staff quarters + Boarding house, private hotel + Boarding school + Residential college, hall of residence + Public hospital (not psychiatric) + Private hospital (not psychiatric) + Psychiatric hospital or institution + Hostel for the disabled + Nursing home + Accommodation for the retired or aged (not self-contained) + Hostel for homeless, night shelter, refuge + Childcare institution + Corrective institution for children + Other welfare institution + Prison, corrective institution for adults + Immigration detention centre + Convent, monastery, etc. and

+

on STRD variable: Separate house + Semi-detached, row or terrace house, townhouse etc with one storey + Semi-detached, row or terrace house, townhouse etc

with two or more storeys + Flat, unit or apartment in a one or two storey block + Flat, unit or apartment in a three storey block + Flat, unit or apartment in a four or more storey block + Flat, unit or apartment attached to a house + Caravan, cabin, houseboat + Improvised home, tent, sleepers out + House or flat attached to a shop, office, etc.

AIHW DATA

The data provided consist of (i) Home Care Packages Program services by level of care (high or low) and (ii) Commonwealth Home Support Program Services. The latter refers to a program which provides entry-level support services designed to help older people stay in their homes.

The data was provided in 2011 SA2s. A concordance was then used to convert the data into 2016 SA2's, which the 2016 Census data used.

1. % aged 65 and over with high care (high_care)

Variable name: Number of people aged 65 and over using Home Care Packages Program services*, by level of care and SA2, 2016–17.

The categories available are:

- Low care
- High Care

- ✓ **Numerator:** Number of people in high care in a SA2
- ✓ **Denominator:** Total population 65 and over in that SA2

*A program that supports older Australians with complex needs to remain living at home through a coordinated package of care and services to meet the individual needs of consumers.

2. % of low care within 65 and over (low_care)

Variable name: Number of people aged 65 and over using Home Care Packages Program services, by level of care and SA2, 2016–17

The categories available are:

- Low care
- High Care

- ✓ **Numerator:** Number of people in low care in a SA2
- ✓ **Denominator:** Total population 65 and over in that SA2

3. % of people aged 65 and over using Commonwealth Home Support Program services, by SA2, 2016–17 (com_support)

Variable name: people aged 65 and over using Commonwealth Home Support Program services, by SA2, 2016–17*

The categories available are:

- people aged 65 and over using Commonwealth Home Support Program services, by SA2, 2016–17

- ✓ **Numerator:** people aged 65 and over using Commonwealth Home Support Program services, by SA2, 2016–17, in a SA2
- ✓ **Denominator:** Total population 65 and over in that SA2

SPATIAL MICROSIMULATION ESTIMATES

NATSEM's spatial microsimulation model uses a technique that takes a survey and reweights it to small area Census data. SpatialMSM18 is the application of the NATSEM Spatial Microsimulation model using the ABS Household Expenditure Survey 2015/2016 and the 2016 Census of Population and Housing at the SA2 level.

SpatialMSM18 which uses 9 benchmarks as indicated in Table 1.

Table 1: 9 Benchmarks of Spatial Microsimulation

	Benchmark	Description
1	NPRD_2*HIND_2	Number of Persons Usually Resident in Dwelling by Total Household Income (weekly)
2	TENLLD_2*HIND_2	Tenure and Landlord Type by Total Household Income (weekly)
3	HCFMD_2*HIND_2	Family Household Composition by Total Household Income (weekly)
4	RNTRD_2*HIND_2	Rent (weekly) by Total Household Income (weekly)
5	MRERD_2*HIND_2	Mortgage repayments by Total Household Income (weekly)
6	AGE_2*HIND_2	Age of person (15+) by Total Household Income (weekly)
7	HIED_2*HIND_2	Equivalised Total Household Income (weekly) by Total Household Income (weekly)
8	LFSP_2*AGE_2	Labour Force Status by Age of person (15+)
9	QALLP_2	Non School Qualification

In SPATIALMSM18 we decided to:

- Use only households from the Greater Capital City Statistical Area (GCCSA) to populate the SA2 in that GCCSA. This means we only used households from Sydney to populate

SA2's in Sydney. Please note that in this release, the HES has separately identified the ACT population in the Confidentialised Unit Record Files (CURF) (in previous years, the NT and ACT were combined) but rural NT and Darwin still have the same identifier.

- Reduce the number of benchmarks if the model failed for an area. This is done according to the sequence in the table. The lower number of benchmarks means fewer constraints and a higher possibility of achieving an acceptable result. If the estimate is produced with less than 6 benchmarks, then the estimate is excluded from the overall database.

The indicators estimated from spatial microsimulation are as follows:

1. **Poverty Rate (pov_rate_dis)**

The poverty line is set at half of the median disposable equivalised household income. Although income is household income, the median is calculated based on the number of persons in the household at the national level. Given the differences between incomes in the Census and survey, the national weight is recalculated using the sum of weights from the spatial microsimulation result (Vidyattama et al. 2013). The numerator is then all people aged 65+ who lived in a household with income less than poverty line. The denominator is all persons aged 65 and over living in an occupied private dwelling.

- ✓ **Numerator:** All the person aged 65+ who lived in households with income less than poverty line.
- ✓ **Denominator:** All persons aged 65+ living in occupied private dwellings.

2. **Proportion of older people with the Age Pension as the major source of income (Age_pension~h)**

This indicator is based on income units. This means the number of older people in the numerator depends on whether the income unit has government pension as its major source of income and then establishing whether the government pension is age pension (PSRCSCU8=3 and PSINC=1). The denominator is all persons aged 65+ living in occupied private dwellings.

- ✓ **Numerator:** the number of older people in an income unit that has age pension as its major source of income
- ✓ **Denominator:** Total population 65 and over living in occupied private dwellings.

3. **Proportion of older people who live in the income unit that have no superannuation payments (No_super_sih)**

- ✓ **Numerator:** the number people aged 65+ living in an income unit where no older people receive a superannuation payment.
- ✓ **Denominator:** Total population aged 65+ living in occupied private dwellings.

4. **Proportion of older people who live in a household that could not raise $2000 in an emergency within a week (Not_raise~s)**

- ✓ **Numerator:** the number of people aged 65+ living in a family that could not raise $2000 in emergency money.
- ✓ **Denominator:** Total population aged 65+ living in occupied private dwellings.

5. **Proportion of older people who live in public/private rent dwelling and the household is in the bottom quintile of the equivalised household income distribution (Rent_botto~h)**

- ✓ **Numerator:** the number of people aged 65+ who live in a rented dwelling where the household income is also in the bottom quintile of the equivalised disposable household income distribution.
- ✓ **Denominator:** Total population 65 and over living in occupied private dwellings.

6. **Proportion of older people who live in housing stress (Hous_stres~h)**

This indicator is based on a standard 30/40 rule of housing stress (Nepal et al. 2010).

- ✓ **Numerator:** the number of people aged 65+ living in a household that pays more than 30% of their gross household income on a mortgage or rent and the household is in in the bottom quintile of the equivalised disposable household income distribution.
- ✓ **Denominator:** Total population aged 65+ living in occupied private dwelling

7. **Proportion of older people who receive rent assistance (Rent_Asst_~h)**

This indicator is based on income units. This means the number of older people in the numerator is not based on whether the person itself receives rent assistance, but instead on whether there is a person in an income unit that receives Commonwealth Rent Assistance. The denominator is all person 65+ living in occupied private dwelling.

- ✓ **Numerator:** the number of people aged 65+ living in an income unit that has one or more persons receiving commonwealth rent assistance.
- ✓ **Denominator:** Total population 65+ living in occupied private dwelling

VALIDATION OF SELECTED INDICATORS

ESTIMATED DATA FROM SPATIALMSM18

One of the factors we look at from our spatial microsimulation model is the percentage of areas that we get reasonable estimates for given a number of benchmarks. Areas where we cannot get reliable estimates are usually remote areas; or areas with very low population (eg, industrial areas or national parks). These results are shown in Table 2. It can be seen that for 9 benchmarks, we get reliable estimates for most of Sydney and Melbourne. Using 6 or more benchmarks gives us reliable estimates for most areas, although the NT is still very low due to remote areas in the reminder areas of the NT/ outside Darwin.

Table 2: Number of Benchmarks Used

	Number of Benchmarks used							
GCCSA	3	4	5	6	7	8	9	6 or more
1GSYD	0.00%	0.32%	1.28%	1.92%	3.53%	7.69%	85.26%	98.40%
1RNSW	0.00%	0.00%	1.52%	1.89%	12.88%	14.39%	69.32%	98.48%
2GMEL	0.32%	0.00%	0.32%	1.29%	0.97%	1.94%	95.15%	99.35%
2RVIC	0.00%	0.00%	1.31%	0.65%	3.92%	9.15%	84.97%	98.69%
3GBRI	0.00%	0.42%	0.85%	1.27%	4.66%	8.05%	84.75%	98.73%
3RQLD	0.00%	0.68%	2.40%	2.74%	11.64%	12.67%	69.86%	96.92%
4GADE	0.00%	0.00%	0.00%	1.82%	1.82%	13.64%	82.73%	100.00%
4RSAU	0.00%	0.00%	6.45%	11.29%	59.68%	8.06%	14.52%	93.55%
5GPER	0.00%	0.00%	1.73%	2.89%	0.58%	6.94%	87.86%	98.27%
5RWAU	1.27%	0.00%	12.66%	10.13%	48.10%	6.33%	21.52%	86.08%
6GHOB	0.00%	0.00%	0.00%	0.00%	8.57%	8.57%	82.86%	100.00%
6RTAS	0.00%	0.00%	0.00%	4.69%	65.63%	21.88%	7.81%	100.00%
7GDAR	0.00%	0.00%	0.00%	9.09%	27.27%	34.09%	29.55%	100.00%
7RNTE	4.17%	0.00%	54.17%	8.33%	8.33%	16.67%	8.33%	41.67%
8ACTE	0.00%	0.00%	3.82%	3.05%	32.06%	20.61%	39.69%	95.42%
Australia	0.13%	0.17%	2.40%	2.71%	12.15%	10.40%	71.98%	97.25%

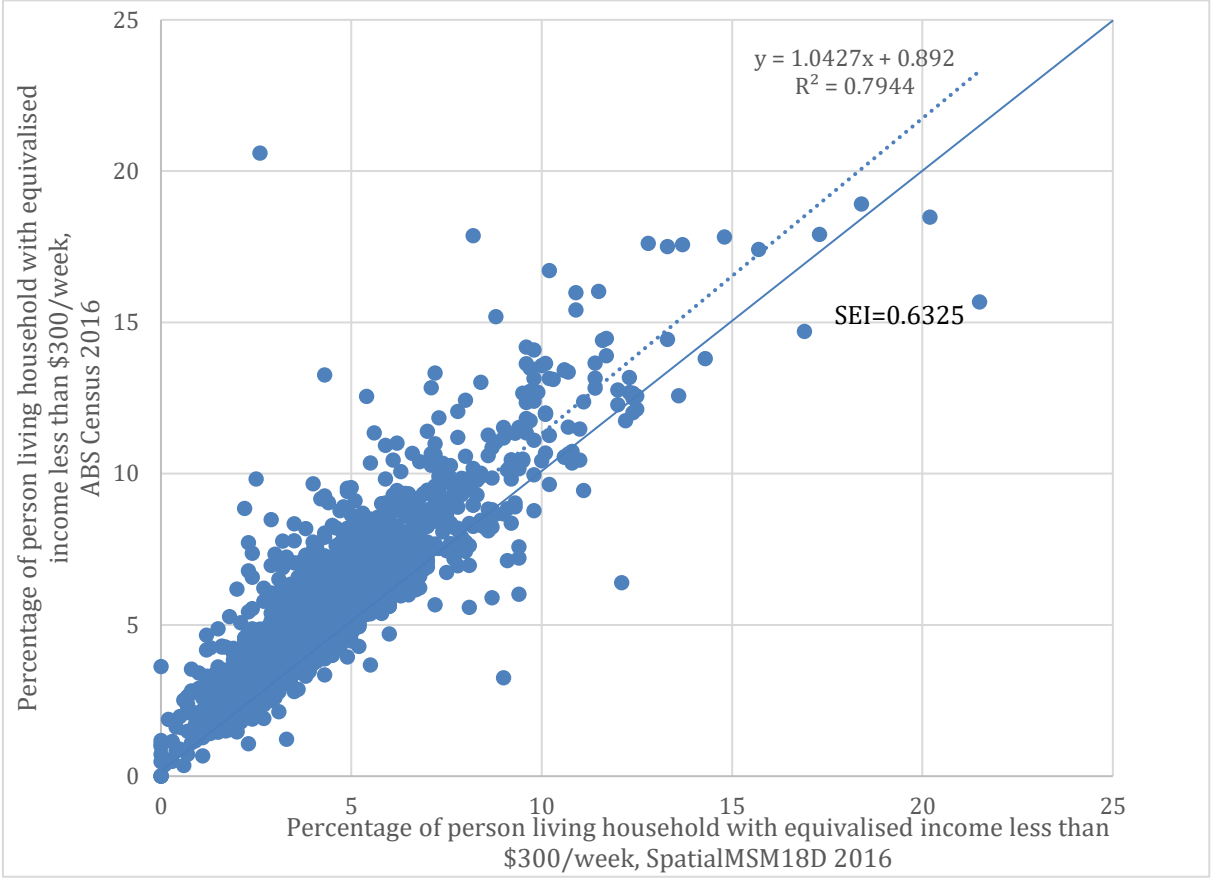
Note: G means Greater (Capital Cities Areas); R means the Remainder (of the State/Territory)

Based on this result we decided to use the estimate produced using 6 or more benchmarks. This means we can estimate 97.25 per cent of SA2's across Australia. Unfortunately, we cannot capture more than half of rural Northern Territory.

The other validation that is done is comparing the result from the spatial microsimulation model with SA2 level data that is defined in the same way as our modelled estimates. In this case, we have used the proportion of people living in a household with equivalised income less

than $300 a week. Figure 1 indicates that we have achieved a reasonably close estimate (0.7944 R square) especially when identifying which area has a high proportion of low income people.

Figure 1: Validation of proportion of persons living with equivalised income less than $300/week (SpatialMSM and Census data)



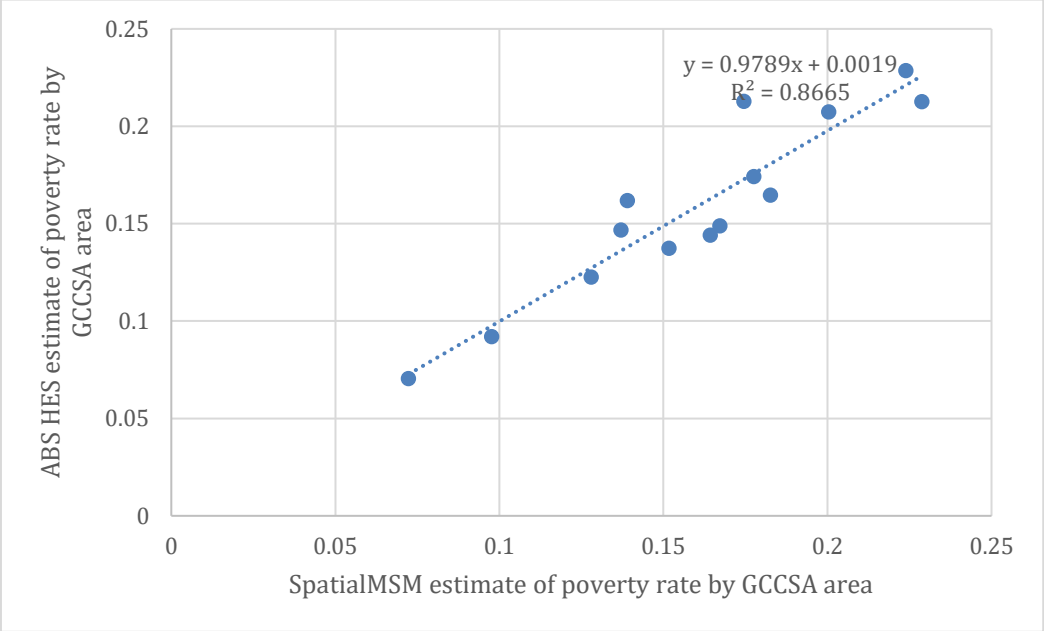
The next validation was to compare between the poverty rate estimate from the SpatialMSM and from the original HES data. This is done based on the equivalised gross weekly income. The poverty line for this poverty estimation is half of the median income. The spatialMSM and HES produced a different poverty line. This is due to the benchmarking process that the spatial microsimulation model makes against the Census data and is due to households commonly understating their income in the Census while in the HES the interviewer makes an effort to check the household income. The SpatialMSM18 showed $938.64/week as the median gross income while HES has a median income of $983.19/week. Using disposable income the median incomes are $850.41/week and $879.26/week for SpatialMSM and HES, respectively. Despite this difference, the poverty estimates between these two are quite similar, as seen in Table 3. Further explanation can be seen in Vidyattama et al. (2013).

Table 3: Validation of poverty rates, Australia, states, greater capital cities and rest of the states (SpatialMSM and HES)

	Poverty rate based on 50% median equivalised gross income for 15+		Poverty rate based on 50% median equivalised disposable income for 15+	
	SpatialMSM	HES	SpatialMSM	HES
Australia	15.6%	15.6%	10.1%	10.6%
Capital city	14.7%	14.2%	9.7%	9.6%
Rest of Australia	17.5%	18.3%	10.9%	12.4%
New South Wales	14.4%	15.5%	9.1%	10.2%
Victoria	17.3%	15.9%	11.5%	10.7%
Queensland	15.3%	15.5%	9.6%	10.3%
South Australia	19.3%	17.5%	12.9%	12.9%
Western Australia	14.5%	15.2%	9.8%	11.0%
Tasmania	19.2%	18.5%	11.2%	12.1%
Northern Territory	9.8%	9.2%	7.7%	8.2%
Australian Capital Territory	7.2%	7.0%	5.7%	5.7%
1GSYD	12.8%	12.3%	8.6%	7.9%
1RNSW	17.5%	21.3%	10.0%	14.3%
2GMEL	16.4%	14.4%	11.0%	9.9%
2RVIC	20.0%	20.7%	13.0%	12.9%
3GBRI	13.9%	16.2%	8.5%	10.5%
3RQLD	16.7%	14.9%	10.6%	10.1%
4GADE	18.3%	16.5%	12.5%	12.1%
4RSAU	22.9%	21.3%	14.3%	16.0%
5GPER	13.7%	14.7%	9.4%	10.5%
5RWAU	17.8%	17.4%	11.4%	12.9%
6GHOB	15.2%	13.7%	7.9%	8.7%
6RTAS	22.4%	22.9%	13.8%	15.2%
7GDAR & 7RNTE	9.8%	9.2%	7.7%	8.2%
8ACTE	7.2%	7.0%	5.7%	5.8%

The table also indicates that it is not only the overall poverty rate estimate from the SpatialMSM that is quite close to those directly calculated from the HES, but also the Greater Capital Cities and the rest of state areas have a close correlation. This is shown in Figure 2.

Figure 2: Validation of poverty rate by GCCSA (SpatialMSM and Census data)



The validation of SpatialMSM18 shows that the model is producing reasonable small area estimates, and excellent aggregated estimates. Therefore the model has been used to estimate several indicators for this report.

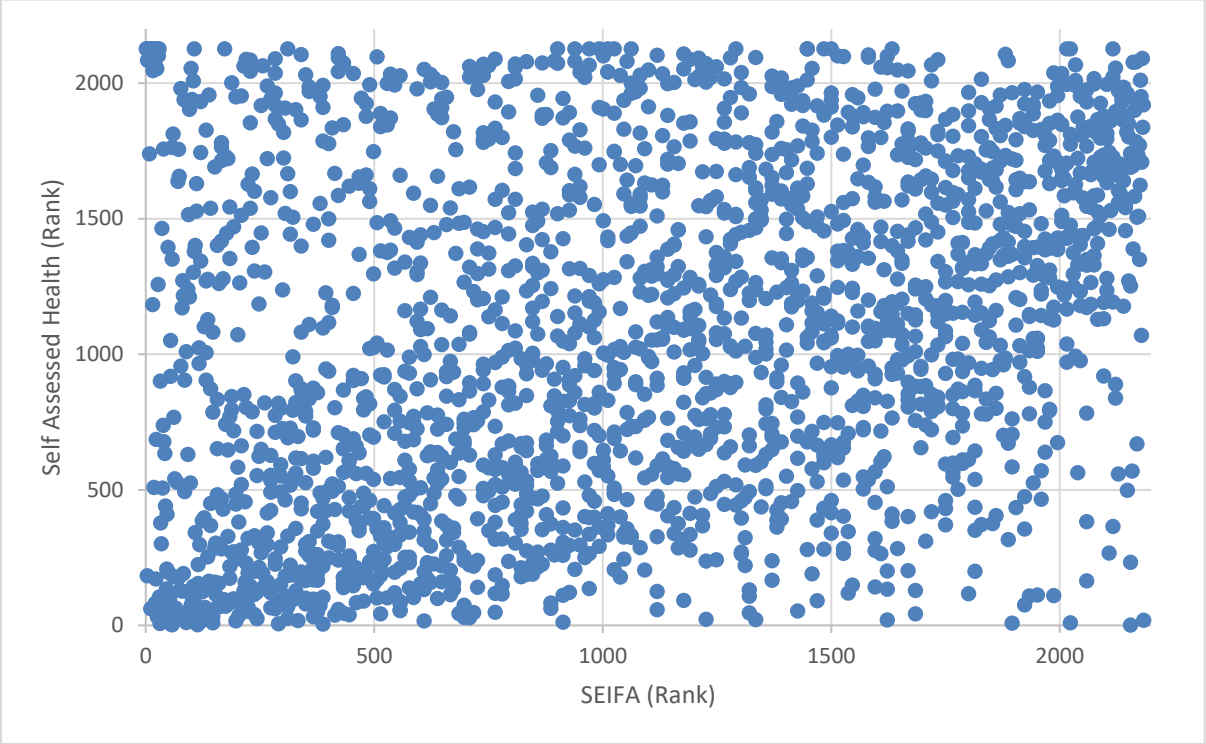
SELF-ASSESSED HEALTH

For this analysis, we also attempted to derive an estimate of self assessed health for the health domain. This was calculated using our spatial microsimulation and the HILDA survey. However, the validation has shown that the estimates are not sufficiently reliable so we decided not to use the indicator in the analysis. This section reports on this validation.

Validation was made against the 2016 Census SEIFA index, and small area estimates of self assessed health by the PHIDU published on the AURIN site.

We expected the estimate of self assessed health to be close to SEIFA, given that disadvantaged areas tend to have lower health status. Because SEIFA is an ordinal index, we compared ranks of SEIFA with ranks of self assessed health for the indicator % with self assessed health at the lowest level (5 in a scale of 1 to 5 where 5 is poor, and 1 is excellent health). A graph of the results at the SA2 level is shown in Figure 3. It can be seen that there is no relationship between the SEIFA rank and the self assessed health rank. The rank correlation coefficient was 0.33, again suggesting very weak correlation between them.

Figure 3: Validation of self assessed health (NATSEM) and SEIFA



Validation was also made against estimates of self assessed health calculated by the Public Health Information Development Unit (PHIDU) in South Australia, and held by the Australian Urban Research Infrastructure Network (AURIN). These were available by LGA for 2011 and were the % people in the area with self assessed health as fair to poor (4 and five on a 5 point scale where 5 is poor, and 1 is excellent health). This meant that we aggregated our 2016 SA2 estimates up to LGA level, and used the same cut-off for self assessed health (so % with scores of 4 or 5). We would expect some differences due to time differences, but the results should be similar. The results are shown in Figure 4. It can be seen that the two indicators are not highly correlated, with an R^2 value of 0.20.

Figure 4: Validation of self assessed health (PHIDU) and self-assessed health (NATSEM)

Overall, our estimates of health have not validated well against the SEIFA index and other small area estimates of health. We therefore decided not to use them in the IWOA and have continued the domain as a functional ability domain, using the data already available from the Census.

There is ongoing work at NATSEM looking at using imputation methods to derive small area estimates of health, which may in time provide better estimates of self-assessed health, but this goal is still a way off.

INDEX CONSTRUCTION

After selecting the indicators and validating the modelled indicators, the next step was to construct the index which consists of five domains; participation, education, resources, housing and functional ability.

PARTICIPATION DOMAIN

The correlations between the indicators for the Participation domain are shown in Table 4. It can be seen that there is a very high correlation between the labour force participation rate

and the employment rate. Because of this high correlation, we dropped the labour force participation rate and kept the employment and unemployment rates in the modelling.

Table 4: Correlation matrix for Participation domain

	lbr_pt~s	emp_ra~s	unemp_~s	no_car~s	not_we~s	volunt~s	no_int~s
lbr_ptcp_r~s	1.0000						
emp_rate_cns	0.9976	1.0000					
unemp_rate~s	0.1641	0.0960	1.0000				
no_car_cns	0.0776	0.0664	0.1706	1.0000			
not_well_e~s	-0.1217	-0.1258	0.0430	0.1790	1.0000		
volunt_cns	0.3949	0.4041	-0.0813	-0.2083	-0.4411	1.0000	
no_int_cns	-0.2482	-0.2390	-0.1645	0.2882	0.0282	-0.1120	1.0000

Note: lbr_ptcp_r~s=labour force participation rate; emp_rate_cns=employment rates for older people; unemp_rate~s= unemployment rates for older people; no_car_cns= % of older people who had no acccess to a car to drive; not_well_e~s= % of older people who cannot spak English well or not at all; volunt_cns= % of older people who volunteer; no_int_cns=% of older pople who have no access to internet from dwelling.

The principal components analysis (PCA) was run next, and the results are shown in Table 5. It can be seen that there is a very low weight for the unemployment rate (0.0381). This was because many areas had 0 unemployment rate for those older than 65, so this indicator was removed from the index.

Table 5: Results from PCA on participation domain with unemployment

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
emp_rate_cns	-0.4302	0.4439	0.2706	0.4982	0.0696	-0.5400	0
unemp_rate~s	0.0381	0.6857	-0.0594	-0.6277	0.3606	-0.0290	0
no_car_cns	0.3438	0.3775	0.6118	0.0835	-0.4793	0.3583	0
not_well_e~s	0.4736	0.2366	-0.2736	0.5783	0.4839	0.2760	0
volunt_cns	-0.5994	-0.0719	0.2861	0.0396	0.3680	0.6456	0
no_int_cns	0.3343	-0.3592	0.6263	-0.1217	0.5156	-0.2937	0

The final results are shown in Table 6, with all loadings are greater than 0.3.

Table 6: Results from PCA on participation domain without unemployment

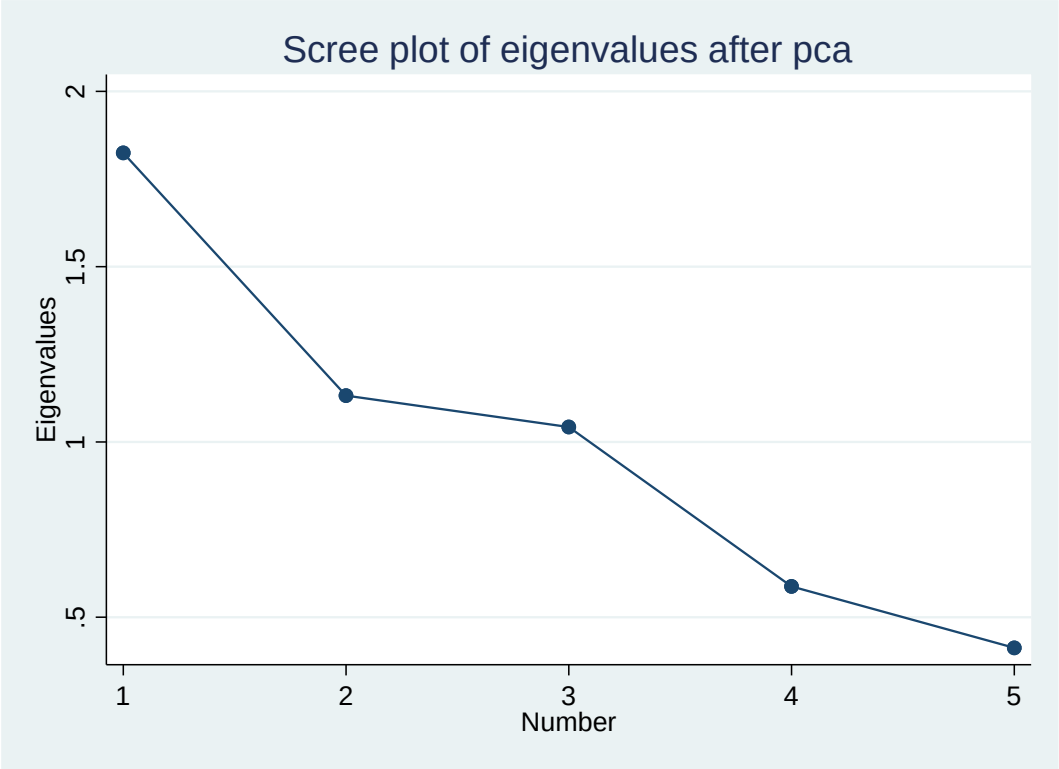
Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Unexplained
emp_rate_cns	-0.4365	0.3628	0.5863	0.2011	-0.5419	0
no_car_cns	0.3374	0.6754	0.3100	-0.4649	0.3432	0
not_well_e~s	0.4711	-0.2054	0.5325	0.6091	0.2852	0
volunt_cns	-0.5975	0.2670	-0.1255	0.3547	0.6558	0
no_int_cns	0.3416	0.5466	-0.5107	0.4965	-0.2776	0

The final index for the participation domain was one where a higher value signified lower participation or lower well-being. This means the index was inverted, so higher values signified greater wellbeing, which is what we wanted for our final index.

The scree plot for this domain is shown in Figure 5. It can be seen that there is a levelling out at component 2.

Figure 5: Scree plot for Participation domain



EDUCATION DOMAIN

The education domain had three indicators, and a correlation matrix is shown in Table 7. It can be seen that there are reasonably high correlations, with no correlation above 0.95 but all above 0.8.

Table 7: Correlation Matrix, Education domain

	cy12_cns	cy10_cns	qual_cns
cy12_cns	1.0000		
cy10_cns	0.8176	1.0000	
qual_cns	0.8703	0.8924	1.0000

Note: cy12_cns=% older people Completed Year 12; cy10_cns=% older people Completed Year 10; qual_cns=% older people with post school qualifications

The results from a principal components analysis on this domain are shown in Table 8. It can be seen that all the loadings are very high, so this domain was left as it is.

Table 8: Results from PCA on education domain

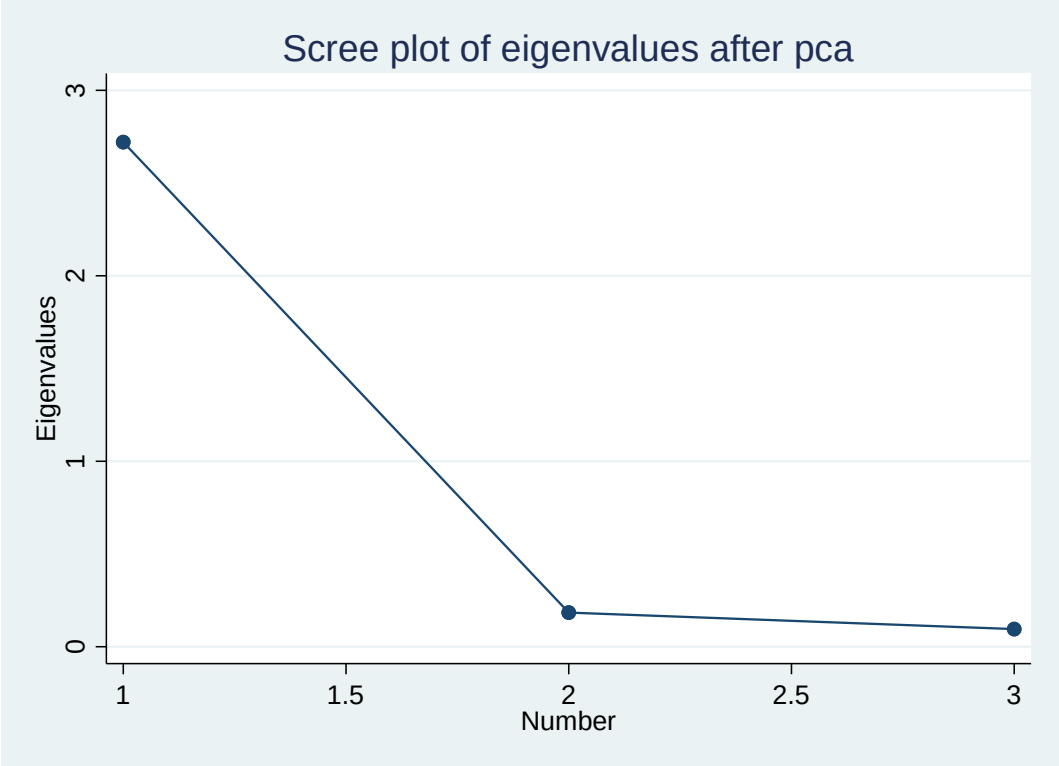
Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Unexplained
cy12_cns	0.5701	0.7615	0.3085	0
cy10_cns	0.5752	-0.6380	0.5119	0
qual_cns	0.5867	-0.1144	-0.8017	0

The results indicate that a higher value for the index is associated with higher education or greater well-being, so we did not transform the index as in other domains.

The scree plot is shown in Figure 6. There is a sudden levelling of the eigenvalues at component 2, so the components after the first add nothing to the index.

Figure 6: Scree plot for Education domain



RESOURCES DOMAIN

The next domain was the resources domain, and the correlation matrix is shown in Table 9. It can be seen that there are some low correlations with % of older people with age pension as the major source of income and the poverty rate.

Table 9: Correlation Matrix, Resources domain

	pov_ra~s	age_pe~h	no_sup~h	not_ra~s	rent_b~h
pov_rate_dis	1.0000				
age_pensio~h	0.0874	1.0000			
no_super_sih	0.5277	0.6583	1.0000		
not_raise_~s	0.3696	0.2064	0.4064	1.0000	
rent_botto~h	0.3110	0.2976	0.4688	0.5937	1.0000

Note: pov_rate_dis=Poverty rate for older people; age_pensio~h= % of older people with the Age Pension as the major source of income; no_super_sih= % of older people who have no superannuation payments; not_raise_~s= % of older people who could not raise $ 2000 in emergency within a week; rent_botto~h= % older people who pay public/private rent and are in the bottom income quintile of the equivalised household income distribution

The results from the PCA with all indicators is shown in Table 10. It can be seen that despite some low correlations, all indicators have a loading above 0.3, so this was the final index used for the resources domain.

Table 10: Results from a PCA on the Resources domain

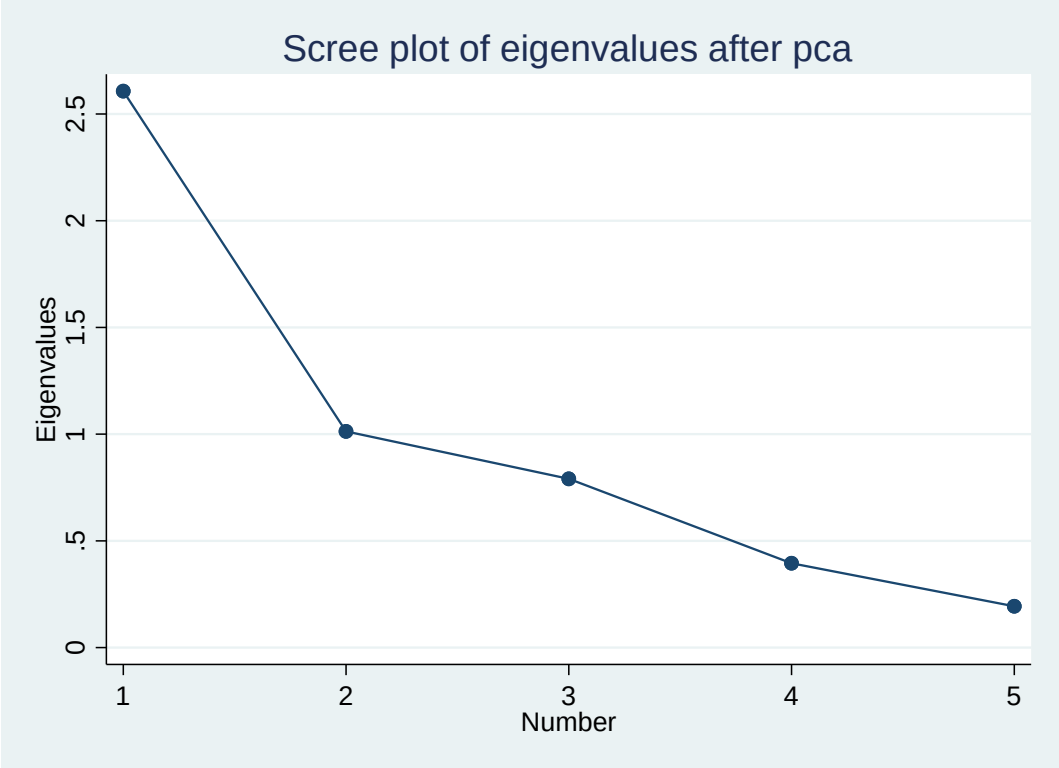
Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Unexplained
pov_rate_dis	0.3890	-0.3717	0.7402	-0.0633	0.3983	0
age_pensio~h	0.3835	0.7331	-0.1075	0.1440	0.5323	0
no_super_sih	0.5337	0.3036	0.2689	-0.0246	-0.7417	0
not_raise_~s	0.4461	-0.4177	-0.3791	0.6948	-0.0105	0
rent_botto~h	0.4667	-0.2404	-0.4738	-0.7014	0.0889	0

The results indicate that a higher value is associated with lower well-being, so this index was transformed so a higher value was associated with higher well-being.

The scree plot for this domain is shown in Figure 7. It can be seen that there is a levelling of eigenvalues at component 2.

Figure 7: Scree plot for Resources domain



HOUSING DOMAIN

The next domain was housing, and the correlation matrix is shown in Table 11. It can be seen that there were some very low correlations in this domain, particularly around the correlations between % of older people who are still paying a mortgage and other indicators, and between % of older people who are homeless and other indicators. Given these low correlations, we would expect that some indicators will be dropped from the PCA due to low loadings.

Table 11: Correlation Matrix, Housing domain

	pay_mo~s	rent_cns	pub_ho~s	hous_s~h	hmless~s	rent_a~h
pay_mort_cns	1.0000					
rent_cns	-0.0472	1.0000				
pub_hous_cns	-0.1396	0.8341	1.0000			
hous_stres~h	-0.1067	0.4577	0.2139	1.0000		
hmless_cns	-0.1702	0.0177	-0.0249	0.1212	1.0000	
rent_asst_~h	-0.1771	0.5844	0.3748	0.6192	0.1050	1.0000

Note: pay_mort_cns= % of older people who are still paying mortgages; rent_cns= % of older people who are still renters ; pub_hous_cns= % of older people living in public housing; hous_stres~h= % of older Australians in housing stress; hmless_cns=% of older people who are homeless; rent_asst_~h= % of older people receiving rent assistance.

The PCA with all indicators is shown in Table 12. We found that homelessness and paying mortgage indicators had very low loadings, so these indicators were removed. For the latter, this

may be because there were not many older people in this situation, so there were a lot of 0's across the country.

Table 12: Results from a PCA on the Housing domain with homelessness and paying the mortgage

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
pay_mort_cns	-0.1498	0.5457	0.6291	0.5167	0.0737	0.1077	0
rent_cns	0.5565	0.2590	-0.1270	0.2075	-0.0647	-0.7482	0
pub_hous_cns	0.4747	0.3150	-0.4574	0.2513	-0.1326	0.6209	0
hous_stres~h	0.4306	-0.2055	0.5397	-0.2547	-0.6295	0.1412	0
hmless_cns	0.0799	-0.6892	0.0219	0.7196	0.0108	0.0157	0
rent_asst_~h	0.5007	-0.1365	0.2953	-0.2100	0.7592	0.1511	0

The results after removing paying mortgage and homelessness are shown in Table 13.

Table 13: Results from a PCA on the Housing domain after homelessness and still paying mortgage indicators are removed.

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
rent_cns	0.5722	-0.3055	0.0896	-0.7558	0
pub_hous_cns	0.4844	-0.6018	0.1175	0.6240	0
hous_stres~h	0.4322	0.6259	0.6319	0.1491	0
rent_asst_~h	0.5011	0.3909	-0.7609	0.1312	0

It can be seen that all indicators now have high loadings. Some final testing on the paying mortgage and renters indicators showed that these two were measuring the same concept – so we have tried to replace pay renters with pay mortgage, but the PCA results do not improve (see Table 14). In the end, renting was left in the PCA and Table 13 shows our final results.

Table 14: Results from a PCA on the Housing domain after homelessness and renters indicators are removed.

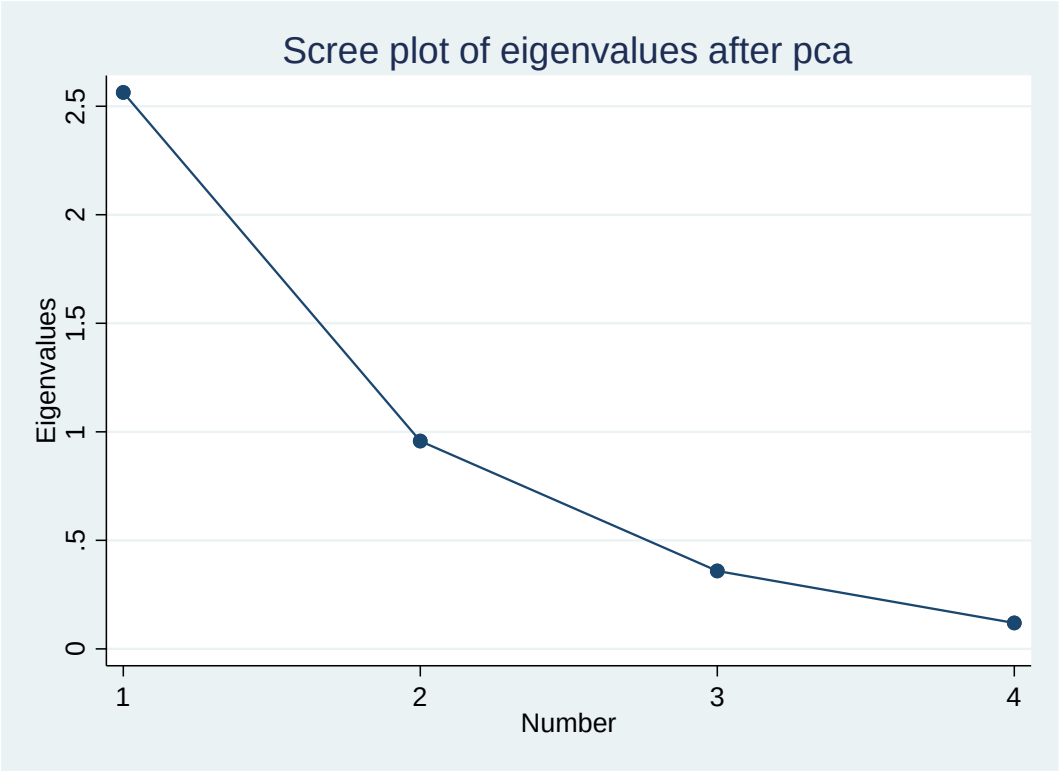
Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
pay_mort_cns	-0.2629	0.9206	0.2836	-0.0536	0
pub_hous_cns	0.4436	-0.1267	0.8621	0.2096	0
hous_stres~h	0.5755	0.3252	-0.4023	0.6334	0
rent_asst_~h	0.6348	0.1750	-0.1202	-0.7429	0

The results show that a higher value was associated with lower well-being, so the final index was transformed so that higher values represented higher well-being, consistent with what we wanted for the final index.

The scree plot for this domain is shown in Figure 8. It can be seen that for this domain, there is a slightly levelling out of the eigenvalues after component 1.

Figure 8: Scree plot for Housing domain



FUNCTIONAL ABILITY DOMAIN

The correlation matrix for the Functional Ability domain is shown in Table 15. It can be seen from Table 15, that there are no very high correlations, but many low correlations. Compared to the previous IWOA index, this functional ability domain has a fewer number of indicators due to unavailability of more recent data.

Table 15: Correlation matrix, Functional ability domain

	need_a~s	aged_c~s	com_su~t	low_care	high_c~e
need_ass_cns	1.0000				
aged_care_~s	0.5982	1.0000			
com_support	0.1746	-0.0213	1.0000		
low_care	0.1975	-0.0267	0.4205	1.0000	
high_care	-0.0138	-0.0803	-0.0310	0.4180	1.0000

Note: need_ass_cns=% of older people who need assistance with core activities; aged_care_~s= % of Older People who use aged care services; com_support=% of older people using Commonwealth Home Support Program services; high_care=% of older people who use high care Home Care Packages Program services; low_care=% of older people who use low care Home Care Packages Program services.

We included all the indicators in the PCA, and the results are shown in Table 16.

Table 16: Results from a PCA on the Functional Ability domain

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Unexplained
need_ass_cns	0.5857	-0.3824	0.0714	-0.2787	-0.6541	0
aged_care_~s	0.4281	-0.5571	0.2164	0.3307	0.5918	0
com_support	0.4127	0.2661	-0.6961	0.5172	-0.0825	0
low_care	0.5068	0.4912	0.0117	-0.5754	0.4131	0
high_care	0.2157	0.4810	0.6807	0.4630	-0.2109	0

Table 16 shows that high care ‘Home Care Packages Program services’ has a low loading which is less than 0.30, so we dropped this variable from the PCA. The new results are presented in Table 17.

Table 17: Results from a PCA on the Functional Ability domain without high care 'Home Care Packages Program Services'

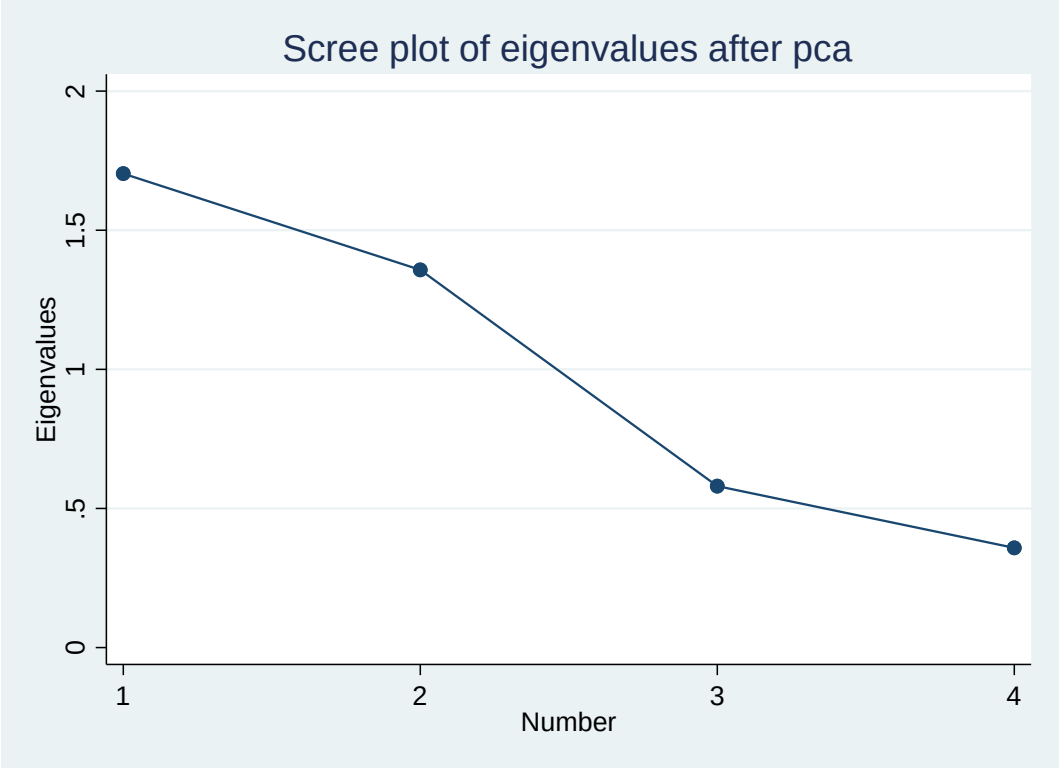
Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Unexplained
need_ass_cns	0.6525	-0.2617	-0.0396	-0.7100	0
aged_care_~s	0.5285	-0.5153	0.0484	0.6729	0
com_support	0.3786	0.5791	0.7158	0.0946	0
low_care	0.3893	0.5750	-0.6955	0.1846	0

It can be seen from Table 17, that all the loadings are now above 0.3, so this was the final index used for the Functional Ability domain. It can be seen that higher values were associated with lower well-being, so the index was transformed so that higher values represented higher well-being, consistent with what we wanted in the final index.

The scree plot for this domain is shown in Figure 9. Different from what we have seen with other domains, there is no levelling out of the eigenvalues after the first component. Nevertheless, due to the challenges in interpreting the components after the first component, we have used the first component as the index for this domain.

Figure 9: Scree plot for Functional Ability domain



METHOD FOR BRINGING THE SUB-INDEXES TOGETHER

The index for each domain was calculated using the loadings identified above, and then the domains were transformed using a log transformation which means they can then be averaged to create the final index. This log transformation is taken from (Noble et al., 2004). The log transformation is:

index_log_d1 = -23*log(1-index_prop*(1-exp(-100/23)))

where index_prop is the rank of the area scaled to the range [0,1]. The area with the lowest rank will have an index_prop of 1/n, and the area with the highest rank will have the value n/n (or 1), where n is the total number of areas being ranked.

Any missing values (ie, where data were not available for at least one of the domains) were removed as this transformation could not be calculated for these areas. The final index was then calculated by averaging the five domain index_log:

Index = (index_log_d1 + index_log_d2 + index_log_d3 + index_log_d4 + index_log_d5)/5.

Due to the way that the sub-indexes have been formulated, for the final index, higher scores represented higher wellbeing.

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