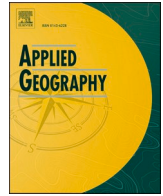




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# How will COVID-19 impact Australia's future population? A scenario approach

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## ARTICLE INFO

### Keywords:

Population scenarios  
COVID-19  
Migration  
Projections

## ABSTRACT

The impact of COVID-19 has been massive and unprecedented, affecting almost every aspect of our daily lives. This paper attempts to quantify the impact of COVID-19 on the future size, composition and distribution of Australia's population by projecting a range of scenarios. Drawing on the academic literature, historical data and informed by expert judgement, four scenarios representing possible future courses of economic and demographic recovery are formulated. Results suggest that Australia's population could be 6 per cent lower by 2040 in a *Longer* scenario than in the *No Pandemic* scenario, primarily due to a huge reduction in international migration. Impacts on population ageing will be less severe, leading to a one percentage point increase in the proportion of the population aged 65 and over by 2040. Differential impacts will be felt across Australian States and Territories, with the biggest absolute and relative reductions in growth occurring in the most populous states, Victoria and New South Wales. Given the ongoing nature of the crisis at the time of writing, there remains significant uncertainty surrounding the plausibility of the proposed scenarios. Ongoing monitoring of the demographic impacts of COVID-19 are important to ensure appropriate planning and recovery in the years ahead.

## 1. Introduction

Since its emergence in Wuhan, China in late 2019, Severe Acute Respiratory Syndrome Coronavirus (SARs CoV-2) and its associated disease (COVID-19) has spread rapidly, impacting more than 219 countries and territories (Worldometers, 2021). The effects of COVID-19 have been pervasive, impacting all economic, social and political domains, and causing 3.2 million deaths globally by the beginning of May 2021 (CSSE, 2020). COVID-19 is expected to affect the size, composition and distribution of national populations due to disruptions in long-term trends in mortality (Banerjee et al., 2020; Ferguson et al., 2020; Goldstein & Lee, 2020; Trias-Llimós & Bilal, 2020), fertility (Luppi, Arpino, & Rosina, 2020b; Stone, 2020a) and migration (Balbo et al., 2020). There is significant uncertainty with respect to the duration of the crisis, with many countries experiencing a third wave of infections (Henley, 2021) at the time of writing. There is additional uncertainty tied to the timing and equity of the global vaccination rollout (Science Alert, 2021).

Mortality and migration are likely to be most affected components of demographic change in the short-term term, but there is significant global variation in the magnitude of these impacts (Kontis et al., 2020).

As of the beginning of May 2021, Australia had experienced fewer than 1000 deaths due to COVID-19 (Australian Government Department of Health, 2021c). The disruption to the global migration system (Zambano, Bueermann, & Sullivan, 2020), however, is expected to substantially impact Australia's future population size and composition, exacerbated by Australia's ongoing international border closure (Australian Government Department of Health, 2021b). The distribution of Australia's population is likely to be affected by internal travel restrictions and lockdowns and the economic fallout which places downward pressure on internal migration rates (Levy, 2017). In concert, these demographic forces will produce very different futures than those forecast prior to the emergence of COVID-19.

Population projections are a fundamental tool for economic, social and regional planning. Assumptions underpinning projections are generally trend-based, derived from mathematical modelling and/or informed by the expert judgement of demographers. COVID-19 represents an unprecedented disruption to demographic behaviour, rendering existing projections unusable, and mathematical modelling of trends difficult. While there is a clear need to update projections for this new COVID-19 world, uncertainty as to the duration and scale of impacts as

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<https://doi.org/10.1016/j.apgeog.2021.102506>

Received 14 July 2020; Received in revised form 11 May 2021; Accepted 3 July 2021

Available online 6 July 2021

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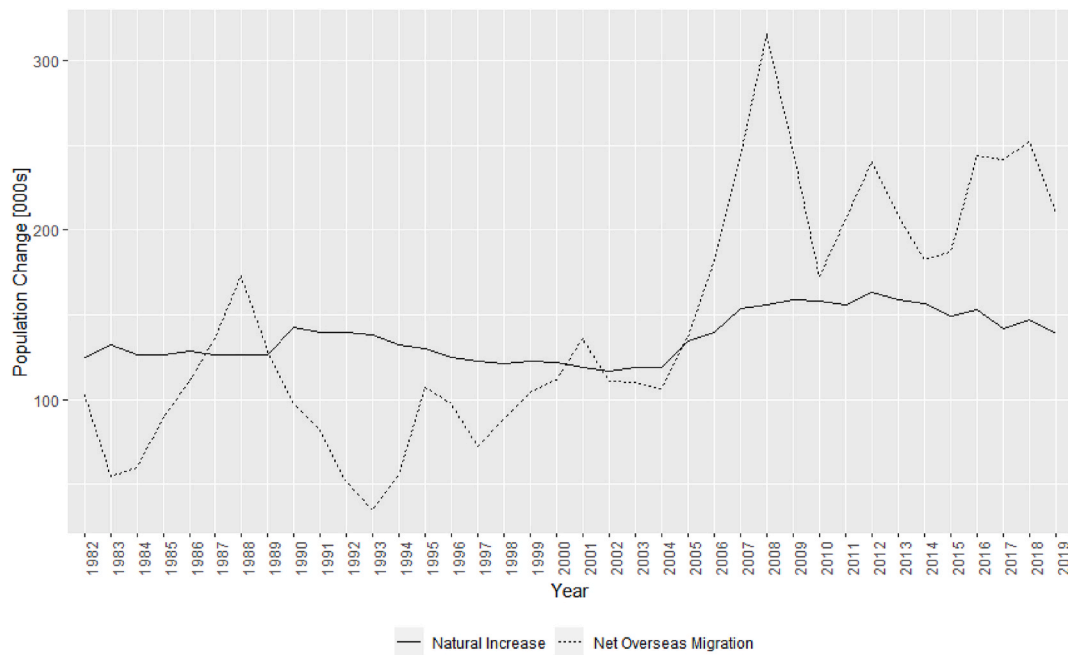


Fig. 1. Components of population growth, Australia 2000–2018  
Source: ABS, 2019a.

well as a lack of contemporaneous data, makes standard population forecasts unfeasible. The best option available to demographers is the development of scenarios which model a range of plausible population futures. This is the approach taken in this paper.

The paper presents a range of population scenarios to capture the potential impact of COVID-19 on the size, composition and distribution of Australia's population. We begin with some background on Australia's pre-COVID-19 population dynamics, before providing an overview of the COVID-19 restrictions expected to impact the components of demographic change in Australia. In Section 3, we describe the projection model and the data inputs. In Section 4, we outline the approach adopted to formulate our scenarios, including a survey of expert opinion, a targeted literature review and an assessment of historical equivalences. In Section 5, we report the results of our projections for Australia and its states and territories from 2019 out to 2040. In Section 6, we provide some discussion of our findings and recommendations for the on-going monitoring of population trends in the post-COVID-19 world.

## 2. Background

### 2.1. Trends in Australian population growth

Prior to the emergence of COVID-19, Australia had one of the fastest growing populations in the Organisation for Economic Co-operation and Development (OECD), with an annual growth rate of 1.5 per cent in 2018, behind only Iceland, Luxembourg and Israel (World Bank, 2020). As of the June 30, 2019, Australia had an estimated resident population of 25.4 million people. The population had increased by more than 380,000 from the year prior, with approximately two-thirds of this growth due to Net Overseas Migration (NOM). NOM has been the main contributor to Australia's population growth since the mid-2000s (Fig. 1), averaging 218,310 per annum between 2010 and 2019, equivalent to 59% of annual growth (ABS, 2020b). To be counted in NOM, a person must have spent 12 months in Australia during any 16 month period. As a consequence, NOM includes individuals on permanent and temporary visas, as well as returning and departing Australian citizens. In recent years, temporary migrants, most notably international

students, have been the largest single contributor, with an average contribution of 105,843 to NOM over the financial years 2017–18 and 2018–19, out of a total of 247,057 (ABS, 2020b). By contrast, natural increase (the excess of births over deaths) contributed roughly 154,455 people per annum to Australia's population between 2008 and 2018 (ABS, 2019a).

There have been differential impacts of population growth across Australian States and Territories driven in large part by the concentration of immigrants in the capital cities of Sydney and Melbourne, as well as an internal migration system that relocates population away from New South Wales and into Queensland and Victoria (Charles-Edwards, Bell, Cooper, & Bernard, 2018). Spatial differentials in fertility (ABS, 2019c) and mortality (ABS, 2019d) are also observed. In 2018, the highest fertility was observed in the Northern Territory (TFR = 2.03) while the lowest was observed in the Australian Capital Territory (TFR = 1.55) (ABS, 2019c). In 2016–18, the Northern Territory recorded the lowest life expectancy in Australia of 75.5 for males and 80.2 for females. Victoria recorded the highest life expectancy of 81.7 for males and 85.3 for females (ABS, 2019d).

### 2.2. Australia's responses to COVID-19 and its impacts on population components

#### 2.2.1. Net overseas migration (NOM)

Australia's first recorded case of COVID-19 was a passenger who flew into Melbourne on January 19, 2020 from Guangzhou, China. The Australian government responded by denying entry to anyone who had left or transited mainland China in the previous 14 days from February 1, 2020. An exception was made for Australian citizens and permanent residents who were placed in mandatory 14-day quarantine following their return. This travel ban coincided with one of the busiest months for international student arrivals, which fell by 34 per cent compared to the same month in the previous year (ABS, 2020a). Travel bans were later imposed for Iran (1st March), South Korea (5th March) and Italy (11th March), before a general travel ban was introduced on the 20th March, which banned travel to Australia for non-citizens and non-residents, and also restricted Australians from travelling overseas. The outcome of these unprecedented international border restrictions was a 99.3 per

cent drop in overseas arrivals in April 2020 compared to the previous year (ABS, 2020a). In January 2021, international arrivals remained 99 per cent lower than in January 2020 (ABS, 2021b). At the time of writing international borders remain closed and are unlikely to open until the Australian adult population has been vaccinated, which was originally estimated to occur around October 2021 (Zagon, 2021), but has experienced a setback due to issues with the AstraZeneca COVID-19 vaccine (Remeikis, 2021).

### 2.2.2. Net interstate migration (NIM)

Following the closure of the international border, Australian States and Territories introduced restrictions on interstate travel. Tasmania was the first to introduce border controls on March 19, 2020, followed by the Northern Territory, Western Australia and South Australia on 24th March, and then Queensland on 26th March. Controls varied between States and Territories with most involving a 14-day compulsory quarantine (Tasmania, Northern Territory, South Australia). Queensland and Western Australia enacted a ban on all non-resident visitors with exceptions for essential workers, on compassionate grounds, and new permanent residents. The two most populous states, New South Wales and Victoria, along with the Australian Capital Territory, initially kept their borders open, but did introduce strict travel restrictions for non-essential travel. In June 2020, Victoria experienced a surge of COVID-19 cases leading to an extended lockdown in Greater Melbourne. The lockdown ended in October 2020, after 112 days, making it one of the longest lockdowns in the world (BBC News, 2020). This led to the closure of the New South Wales border for the first time in 100 years (Khalil, 2020) as well as a travel bans from Victoria to other States and Territories. Since the end of 2020, there have been a few temporary State border closures in response to localised outbreaks and snap lockdowns, with Brisbane for example experiencing a three-day full lockdown in March 2021. These are expected to continue until the population is fully vaccinated. While these restrictions limit travel temporarily, with the exception of Western Australia, they do not prohibit moving to take up permanent residence in a new State or Territory. They do however restrict the ability for prospective migrants to take short-term trips for job interviews and other activities, which may serve as a precursor to migration.

### 2.2.3. Mortality and fertility

As of the beginning of May 2021, Australia had recorded about 30,000 cases of COVID-19 and about 900 deaths (Australian Government Department of Health, 2021c). Due to Australia's track record in limiting community transmission through widespread testing and contact tracing, community lockdowns as well strict quarantine measures (Stanaway, Irwig, Teixeira-Pinto, & Bell, 2020), it is not expected that COVID-19 will have a population-level impact on mortality in Australia. The commencement of Australia's vaccination program in February 2021 (Australian Government Department of Health, 2021d) provides further reason to believe that significant excess mortality may be avoided. However, at the time of writing the Federal Government had abandoned its original target of all eligible Australians being offered their first COVID-19 vaccine by October 2021.

Evidence of demographic response to shocks and economic recessions (Matysiak, Sobotka, & Vignoli, 2020) suggest that the pandemic is likely to negatively affect fertility. Indeed, research from Europe shows that COVID-19 has already affected fertility planning there, leading to a postponement of planned births (Aassve, Cavalli, Mencarini, Plach, & Bacci, 2020; Luppi et al., 2020b). While limited, evidence from Australia is mixed. Recent modelling of long-term fertility trend suggests that COVID-19 will exert a depressing effect on Australian fertility (McDonald, 2020), although there is evidence of a slight year-on-year increase in access to prenatal services between March and June 2020 (Moaven & Brown, 2021).

## 3. Projection model

Population projections were created by a program which incorporates cohort-component models using directional inward and outward migration flows at national and State/Territory geographical scales. The projection system is based on a movement population accounts framework (Rees, 1984) and uses a series of linked bi-regional models in place of data-hungry fully multiregional models to handle internal migration (Wilson & Bell, 2004). A minor adjustment is made to ensure that internal in-migration summed over all subnational geographical areas exactly matches total internal out-migration. The program outputs projected populations by sex and single years of age from age 0 to 110, together with projected demographic components of change with the same age-sex detail, for Australia and each of the States and Territories for each year of the projection horizon.

Overseas migration is modelled using immigration numbers and emigration rates, with an optional constraint to annual NOM assumptions, which was applied for this study. Interstate migration is projected via bi-regional in- and out-migration rates with an optional constraint to annual NIM numbers, which was also applied in this case.

The heart of the projection system comprises a set of population accounting equations. At the State and Territory scale, the population aged  $a+1$  at time  $t+1$  is calculated as:

$$P_{s,a+1}^i(t+1) = P_{s,a}^i(t) - D_{s,a \rightarrow a+1}^i + I_{s,a \rightarrow a+1}^i - E_{s,a \rightarrow a+1}^i + IM_{s,a \rightarrow a+1}^i - OM_{s,a \rightarrow a+1}^i \quad (1)$$

where  $P$  refers to population,  $i$  a State/Territory,  $t$  a point in time,  $s$  sex,  $a$  age group,  $a \rightarrow a+1$  the period-cohort aged  $a$  at time  $t$  and  $a+1$  at time  $t+1$ ,  $D$  deaths,  $I$  immigration,  $E$  emigration,  $IM$  interstate in-migration, and  $OM$  interstate out-migration. All demographic components in equation (1) cover the  $t$  to  $t+1$  projection interval, but explicit labelling is omitted to avoid clutter. For newly-born infants, the start-of-interval population consists of the number of babies born during the  $t$  to  $t+1$  projection interval. Each of the terms in equation (1) is obtained by multiplying occurrence/exposure demographic rates by populations at risk. A separate national scale projection is also calculated; State and Territory projections are made consistent with the national projections by constraining projected State/Territory births, deaths and overseas migration terms to those at the national scale each year.<sup>1</sup>

## 4. Projection assumptions

Future trends in the demographic components of change are generally determined by mathematical modelling and/or the expert judgment of demographers (ONS & Statistics Canada, 2014). Given the unprecedented nature of COVID-19, we adopted a multi-strand approach to inform our assumptions. First, we undertook a review of the academic literature on demographic responses to shocks including, natural disasters, economic recessions and pandemics. The second component was a review of historical data in Australia to understand the impact of past shocks on the various components of demographic change, such as the recessions of 1982–83 and 1990–91 and the global financial crisis (2007–09) as well as contemporary guidance on the likely economic impact of COVID-19 (RBA, 2020). The third dimension was a survey of Australian demographers to elicit their views on the likely impact of COVID-19 on international and internal migration. The survey sought to gauge opinion on future levels of NOM by visa category as well as NIM

<sup>1</sup> The impact of this top-down constraining is relatively minor. By the end of the projection horizon, constrained State and Territory Total Fertility Rates differed by 0.01–0.07 from the input data, with the exception of the Northern Territory where the difference was 0.12. For mortality, constrained life expectancy at birth for both males and females never differed by more than 0.1 years for any State or Territory.

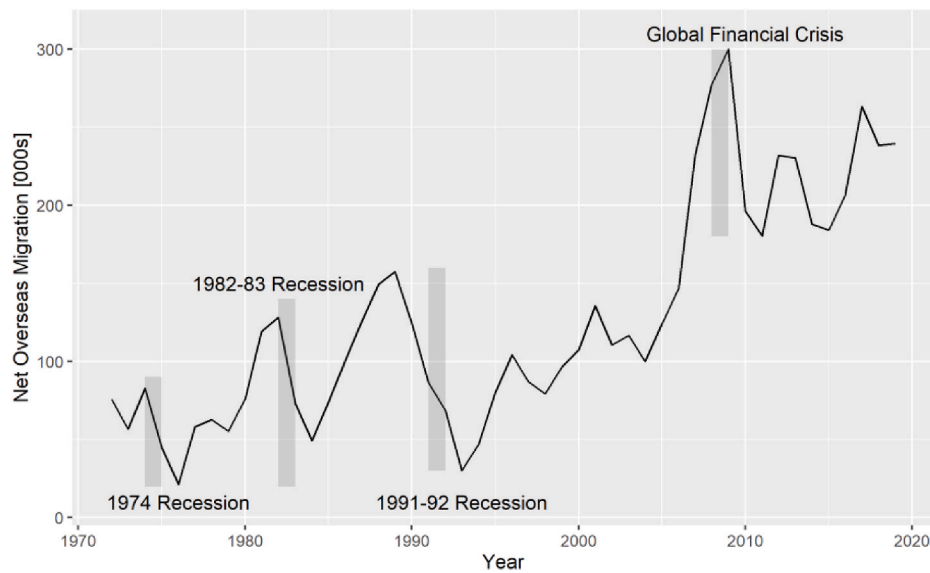


Fig. 2. Net overseas migration, 1971–2019.

Note: Since 1970 there have been only three technical economic recessions in Australia, defined as two consecutive quarters of negative real GDP growth. The Global Financial Crisis of 2007–09 led to an economic slowdown but not a recession.

Source: ABS, 2019b.

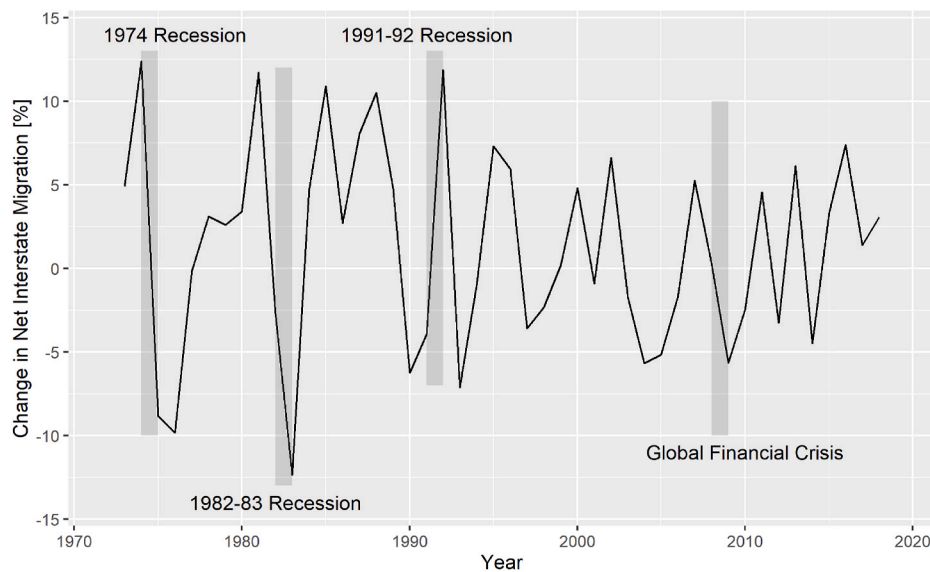


Fig. 3. Year-on-year change in interstate migration rates (%).

Source: ABS, 2019b.

for the financial years out to 2022–23, however the response rate was too low (5 responses out of 19 invitations) to use these to set assumptions directly. Responses were instead used to inform our judgement on likely scenarios.

#### 4.1. Overseas migration

Overseas migration is the most volatile component of population change both in Australia and globally. Overseas migration, particularly labour migration flows, are pro-cyclical, declining in periods of recession (Tilly, 2011). Evidence suggests, however, that declines in overseas migration tend to be smaller than expected and are followed by a relatively quick return to 'normal' (Beets & Willekens, 2009; Dobson, Latham, & Salt, 2009). Labour migration can be affected by a reduction in demand for labour at the destination as well as the introduction of

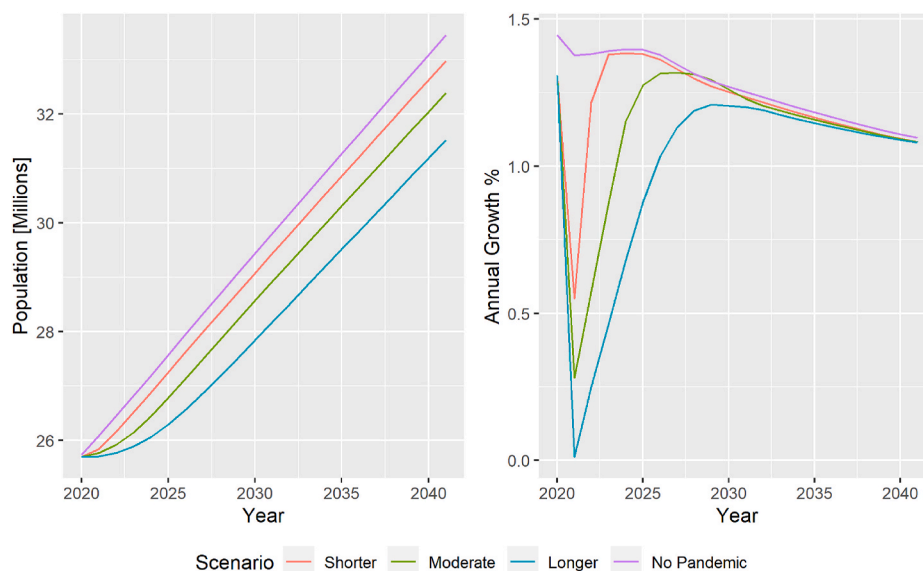
reactive migration policies during periods of recession, reducing immigration (Martin, 2009). At the same time, massive return migration of temporary workers tends not to occur, reducing the level of emigration, particularly from advanced economies (Dobson et al., 2009). Family migration is less sensitive to economic conditions, as are humanitarian flows (Papademetriou & Terrazas, 2009), however, resettlement processes may be slowed due to policy in receiving countries (Castles & Vezzoli, 2009). Student inflows are also sensitive to economic conditions and financial resources at origins and labour market opportunities at the destination, as many students support their studies through part-time work (Beets & Willekens, 2009; Papademetriou & Terrazas, 2009).

In Australia, NOM has fluctuated in line with the economic cycle, with substantial declines in the years following major economic recessions (Fig. 2). Since 1970 there have been only three technical economic recessions in Australia, defined as two consecutive quarters of

**Table 1**  
Summary of headline projection assumptions for each scenario.

	Scenario				Reference: No Pandemic
	Shorter	Moderate	Spatial Shift	Longer	
Fertility	TFR dips to 1.65 in 2020–21 before recuperating to 1.75 in the mid-2020s and settling at a long-run value of 1.70	TFR falls to 1.55 in 2020–21 before recuperating to 1.75 in the late 2020s and settling at a long-run value of 1.70		TFR drops to 1.45 in 2020–21 and takes a decade to recover to long-run value of 1.70	Same as for Shorter Impact scenario
Overseas migration	NOM drops to 0 in 2020–21 and recovers by 2023–24 to the long-run value of 210,000 per annum	NOM falls to –50,000 for 2020–21, increasing to a long-run value of 210,000 per annum by 2024–25		NOM falls to –100,000 for 2020–21 and recovers over many years reaching the long-run value of 210,000 per annum by 2028–29	NOM is 210,000 per annum from 2020–21 onwards
Interstate migration	Decline of 5% in 2020–21 then an increase in 2021–22 to +5% over 2018–19 levels then trend to 10-year average in 3 years	Decline of 10% in 2020–21 then 5% in 2021–22 then return to 10-year average in 3 years	Decline in 2020–21 pro-rated based on third quarter 2020 migration estimates <sup>a</sup> then uniform 5% decline in 2021–22 then returning to 10-year trend in 3 years.	Decline of 15% in 2020–21 then 25% in 2021–22 then return to 10-year trend after 5 years.	NIM returning to 10-year average 5 years after jump off
Mortality	Life expectancy at birth continues long-run increases, reaching 88.8 years for females and 86.3 years for males by 2040–41. Same assumptions used for all scenarios				

<sup>a</sup> This means greater net losses for New South Wales and Victoria and corresponding gains for Queensland and Western Australia than the Moderate scenario.



**Fig. 4.** Total population and average annual growth rates (%), Shorter, Moderate, Longer and No pandemic Scenarios, Australia, 2019–2040

negative real GDP growth. This makes it difficult to statistically model the impact of recessions on NOM due to a lack of data points. This is exacerbated by changes in the definition of NOM which occurred in 2006 breaking the data series (ABS, 2012). Another factor complicating the modelling of NOM is the shift in Australia’s migration program away from permanent settlement to temporary migration which accelerated in the first decade of this century (Hugo, Khoo, McDonald, & Voigt-Graf, 2003). Temporary migrants now account for approximately two-thirds of NOM, with international students, working holiday makers and New Zealand citizens, and short-term working visas the largest contributors. The shift to temporary migration adds a layer of complexity to NOM forecasting: while the number of permanent migration places is set annually by the federal government, temporary migration is demand driven (Wilson, 2017) and thus falls outside the direct control of the Australian Migration and Humanitarian Programmes. Temporary flows are differentially influenced by a range of Australian and international factors. For overseas students, factors such as the economic conditions at their country of origin as well as perceived quality of Australian universities, quality of life in Australia and pathways to permanency play a major role (Rafi & Lewis, 2013). For flows of New Zealand migrants, relative labour market conditions in Australia and New Zealand are a

major driver.

The survey of expert demographers asked participants for their views on the likely impact of COVID-19 on overseas migration to and from Australia for the financial years 2020–21, 2021–22, and 2022–23. Questions were asked about the possible future of immigration, emigration and NOM in 7 key visa/citizenship categories:

- permanent residence visa holders (part of the Migration program)
- permanent residence visa holders (part of Humanitarian Program)
- international students
- working holiday makers
- Temporary Work Skilled visa holders
- Australian citizens
- New Zealand citizens.

For each category we asked experts to estimate possible immigration, emigration and NOM numbers, and provide a brief summary of reasons for their responses. Undoubtedly this was a very challenging request to make, and many questions were answered with a range of values, and others were left unanswered. The overall finding was that a major drop in NOM was expected for the next 1–3 years by the survey participants.

**Table 2**  
Total population by scenario and difference with the No Pandemic scenario, selected years.

Scenario	2020		2025		2030		2040	
	Total population	Difference with the no pandemic scenario	Total population	Difference with the no pandemic scenario	Total population	Difference with the no pandemic scenario	Total population	Difference with the no pandemic scenario
No pandemic	25,732,381	na	27,569,219	na	29,436,029	na	33,089,100	na
Shorter	25,697,295	-35,087	27,251,897	-317,322	29,073,714	-362,315	32,627,382	-461,718
Moderate	25,697,295	-35,087	26,782,228	-786,991	28,568,497	-867,532	32,040,911	-1,048,188
Longer	25,697,295	-35,086	26,288,548	-1,280,671	27,840,447	-1,595,582	31,190,083	-1,899,017

A number of respondents emphasised the importance of international student migration to future NOM. If students were able to return relatively soon (under some sort of safe passage arrangement for example), the impacts on NOM would be reduced. The latest government advice suggests that large scale return of international students is unlikely to occur before 2022 (Hare, 2021). The most recent estimates indicate that in the year to June 2020, NOM declined by 19.4 per cent (ABS, 2021a), reflecting the early effects of COVID-19.

#### 4.2. Internal migration

Australia is one of the most migratory nations in the world (Bell et al., 2015), with nearly 40 per cent of the population changing address every five years. However, historical data shows significant volatility, with drops in the annual interstate migration rate that coincide with economic downturns (Fig. 3). These were all followed by significant rebounds in interstate migration, with the exception of the global financial crisis of 2007–09, which did not lead to a recession in Australia. Internal migration is well-known to be pro-cyclical (Saks & Wozniak, 2011). The level of internal migration varies in tandem with the business cycle as migrants respond to the labour and housing markets. Evidence from the United States suggest that the cyclicity of internal migration is not driven by variations in the geographic dispersion of economic opportunities but a reduction in the net benefits of migrating overall. Empirically this is manifested in the negative association of internal migration rates with unemployment (van der Gaag & van Wissen, 2008) and regional inequalities (Alvarez, Bernard, & Lieske, 2021). In Australia, the unemployment reached 7.1 per cent in May 2020 (ABS, 2020e), a 2 percentage point increase in just three months and the highest level since October 2001. By March 2021, the unemployment rate had decreased to 5.6 per cent, a better performance than the Reserve Bank of Australia forecast (RBA, 2020), although the effect of the withdraw of COVID-19 employment support packages by the Federal Government at the end of March 2021 is yet to be reflected employment statistics.

These short-term variations have occurred in the context of a long-term decline in internal migration that started in the mid-1990s (Bell, Wilson, Charles-Edwards, & Ueffing, 2017). While explanations have long revolved around changes in the composition of population, recent evidence suggests that the effect of population ageing has been fully counteracted by an increase in the share of more migratory groups, lone-households, renters and tertiary-educated individuals in particular (Kalemba, Bernard, Charles-Edwards, & Corcoran, 2020). This means that the downward trend in internal migration is the result of a secular, behavioural change in migration behaviour, possibly caused by a substitution with tele-working (Cooke & Shuttleworth, 2017) and long-distance commuting (Brown, Champion, Coombes, & Wymer, 2015). A trend analysis of reason-specific migration intensities has showed that all reasons for migrating interstate in Australia have declined over time (Bernard et al., 2020), which supports the idea of ‘rootedness’ or increased place attachment (Cooke, 2011). Alternatively, some individuals may simply be ‘stuck in place’ because they do not have the means to migrate in a context of stagnating wages (Foster, 2016). Some of these factors will continue to play out in the short-term and are likely to exert an additional downward pressure on interstate migration, even when state borders re-open.

A possible offset to the expected decline in internal migration, at least in the short term, is an increased rate of return migration. Large scale return migration has been observed in India and parts of Latin America, as urban migrant workers return to rural villages (World Bank, 2020). In Australia, there is some evidence of return to the parental home among young people, however, the intensity and pattern of these movements are unclear. One study suggests the up to 331,000 young adults have returned to their parental home during COVID-19, however this is a relatively small sample and includes overseas returnees (Hassan, 2020). It is also unclear whether these represent permanent or

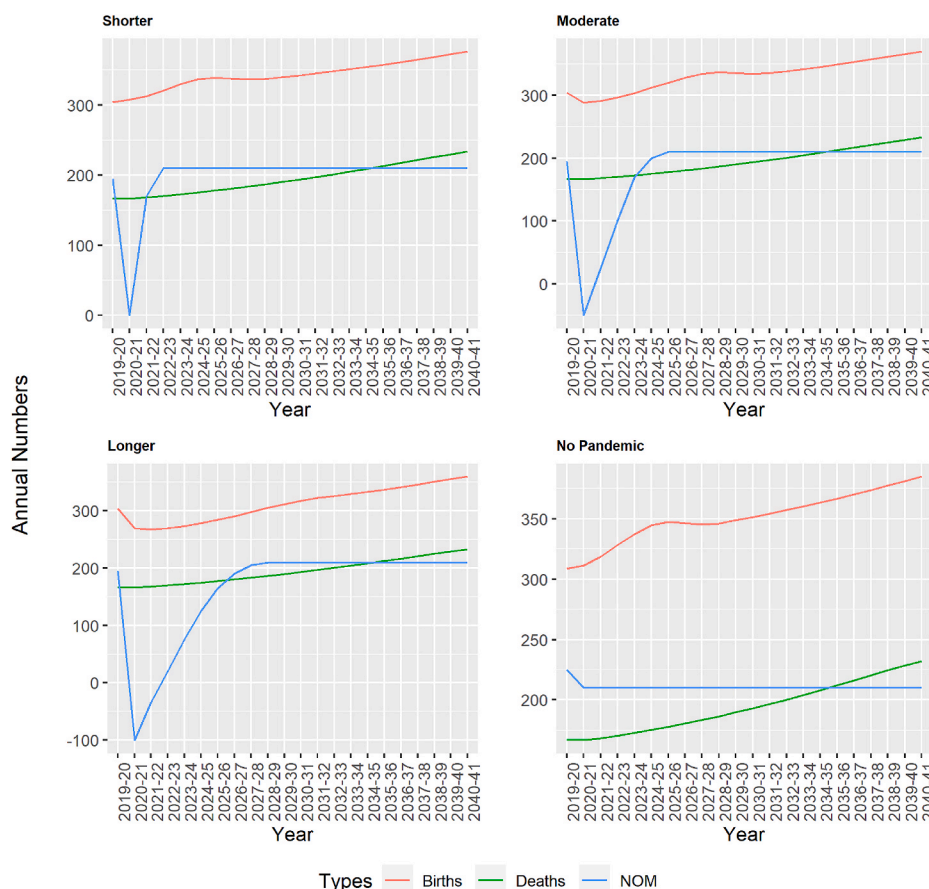


Fig. 5. Components of population growth, Australia, 2019–2040.

Note: The Spatial Shift scenario is not presented here separately as the assumptions on mortality, fertility and NOM are the same as for the Moderate scenario and have on a national level the same outcomes.

temporary returns, with four per cent of Australian’s reporting that one person had temporarily stayed in their household since the first of March due to COVID-19 (ABS, 2020c). The increase in work from home arrangements is another potential disrupter to the internal migration patterns. A number of media reports suggest that work from home arrangements may lead a resurgence in counter-urban flows (Goldlust, 2020), altering the pattern of internal migration in Australia. There is limited evidence for this at present.

The survey of Australian demographers elicited opinion on the likely impact of COVID-19 on internal migration in Australia for the next three financial years. Respondents were uniform in predicting a large decline in interstate migration in the year 2020–21, with drops ranging from 50 to 80 per cent of flows from the previous financial year, but largely recovering to pre COVID-19 levels by 2022–23. Associated commentary suggested that while the long-term outlook was good, the pace and pattern over the coming years was dependent upon economic recovery and the relative economic performance of Australian States and Territories. The scenarios proposed by experts in the survey are extreme by historical standard. The largest ever decrease year-on-year in interstate migration in Australia was –12.4 per cent following the economic recession of the early 1980s. The declines following the economic recession of the early 1990s and the Global Financial Crisis were smaller, at –7 per cent and –6 per cent respectively. Given that the closure of internal borders did not prohibit internal migration but only prevented temporary interstate movement, a more moderate set of assumptions were adopted. This is supported by the most recent data released by the ABS which suggested a 10 per cent drop in the level of interstate migration in the third quarter of 2020 compared to the previous quarter (ABS, 2021c).

### 4.3. Fertility

Fertility in Australia has been below replacement since the mid-1970s and has been steadily declining for the last decade (ABS, 2019a). In 2019 the Total Fertility Rate reached a new low of 1.66. However, this is still higher than many other Western industrialised countries (Gray & Evans, 2018). This trend is assumed to continue, with no recovery of fertility rates assumed in the near future (ABS, 2018). The COVID-19 pandemic will most likely further depress fertility in the short-term.

Evidence of the pandemic’s effect on fertility in Australia is currently limited due to the lag between conception and childbirth, and the lag between birth occurrences and the publication of statistics. When COVID-19 first struck Europe and lockdown measures were put in place, news speculated about a baby boom (Burke, 2020; Fordham, 2020; Graham-McLay, 2020). By now these thoughts have changed and more commentators expect a downturn in fertility (Bell, 2020; Murray, 2020). However, only one publication to date on the impact of COVID-19 on fertility has been published. It is based on a European Survey, considering fertility intentions. This study finds an overall intention to either delay or to forego having children due to COVID-19 (Luppi et al., 2020b).

To formulate assumptions on fertility for this study, we researched the impact on fertility induced by pandemics and economic downturns and also considered the impact of a change in the composition of the population due to a reduction in international migration. Research shows various pandemics lead to a clear decline in fertility (Stone, 2020b). The decline in fertility rates triggered by pandemics is often the result of high mortality, mortality of potential parents as well as unborn



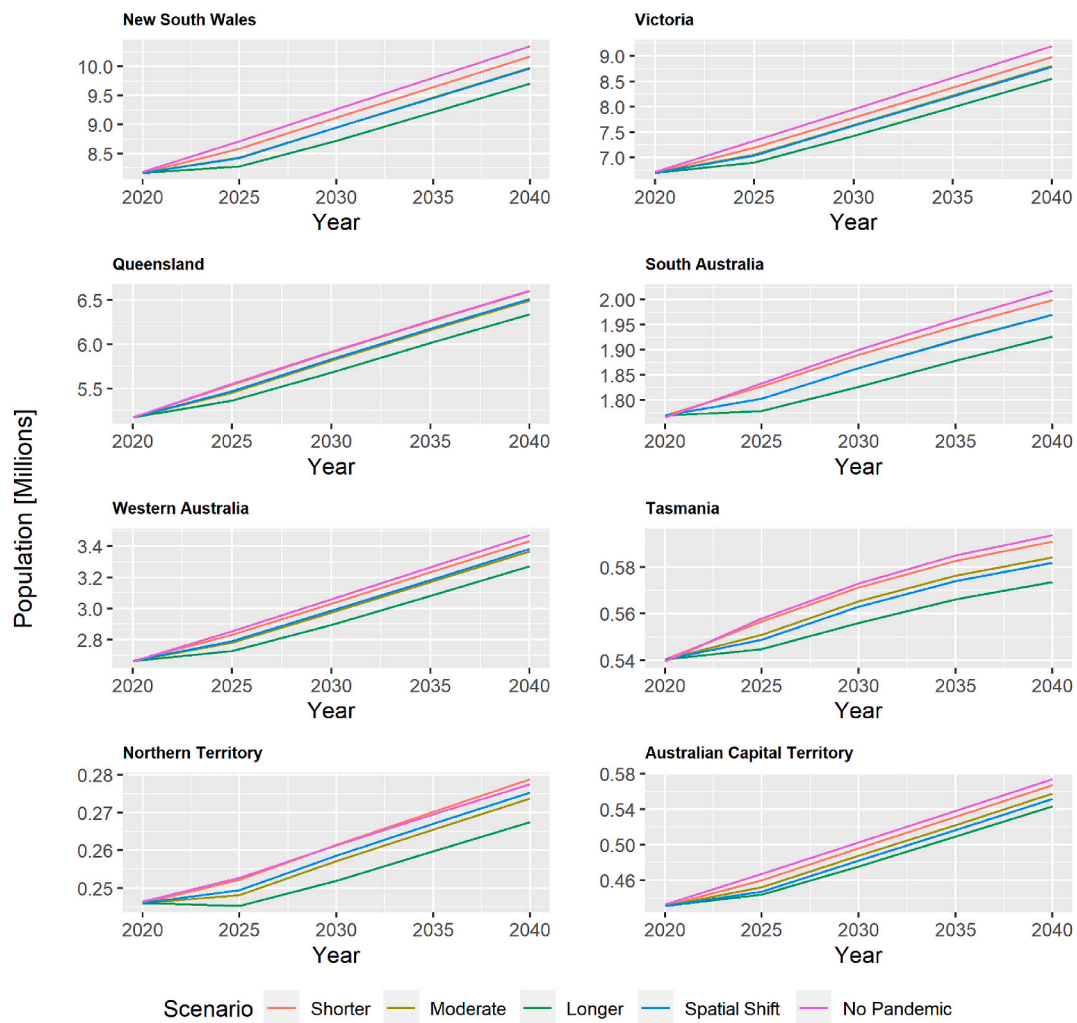


Fig. 6. Population totals, *Shorter*, *Moderate*, *Longer* and *No pandemic* Scenarios, Australian States and Territories, 2019–2040. Note: Population sizes differ so much between States and Territories that different scales for the y-axes needed to be used.

children, or as in the case of the Zika virus due to pregnancy avoidance. In Australia, low case numbers and deaths due to COVID 19 mean that mortality is unlikely to influence fertility. Declines in fertility due to economic downturns are also well documented (Sobotka, Skirbekk, & Philipov, 2011). In Australia, national and international lockdown regulations led to a considerable number of people losing their jobs, reduced working hours or being stood down (ABS, 2020d). Even though the Australian government put some measures in place – free child care, a job-keeper allowance, lower hurdles for job seeker allowance (ABS, 2020d) – to ease the impact of COVID-19 restriction on the economy, most of these measures are temporary. The reduction of immigration to Australia is expected to have a limited impact as women born abroad and in Australia have similar fertility rates (ABS, 2019a). With a reduction in international migration the overall number of births in Australia will be affected due to smaller childbearing-age populations, though the influence of overseas migration on fertility rates is thought to be small. For this reason, the reduction in international migration is not considered in our fertility assumptions.

#### 4.4. Mortality

At the time of writing (May 2021), about 900 deaths had been attributed to COVID-19 (Australian Department of Australian Government Department of Health, 2021c). Recent analysis of Australian deaths data shows a small increase excess deaths in Australia during the

first half of 2020, however it is not clear whether these are due to population growth or are in fact COVID-related (Bennett, 2020). Excess deaths are relatively few based on current data. The impacts of COVID-19 on mortality may reach beyond deaths directly attributable to COVID-19, including delays in elective surgery, suicide due to financial uncertainty and domestic violence. The available evidence at the time of writing suggests that the impact on mortality in Australia is likely to be minimal.

#### 4.5. Headline assumptions

For this study we developed scenarios based on the assumed demographic and economic recovery process from the COVID-19 pandemic in Australia. As of May 2021, many restrictions imposed across States and Territories have been lifted and Australia’s vaccination program has commenced. However, recovery may not be straightforward. This is highlighted Australia’s second wave of COVID-19 in June 2020 following the virtual elimination of community transmission following the first wave (Milne et al., 2020). According to the recovery process we assume the pandemic to have different levels of impact on population behaviour affecting demographic indicators. We set out five scenarios – one reference scenario assuming *No Pandemic* and four scenarios each considering a different speed of recovery and extent of impact. Table 1 summarises the key ‘headline’ demographic indicators of these four scenarios the national scale as well as the interstate

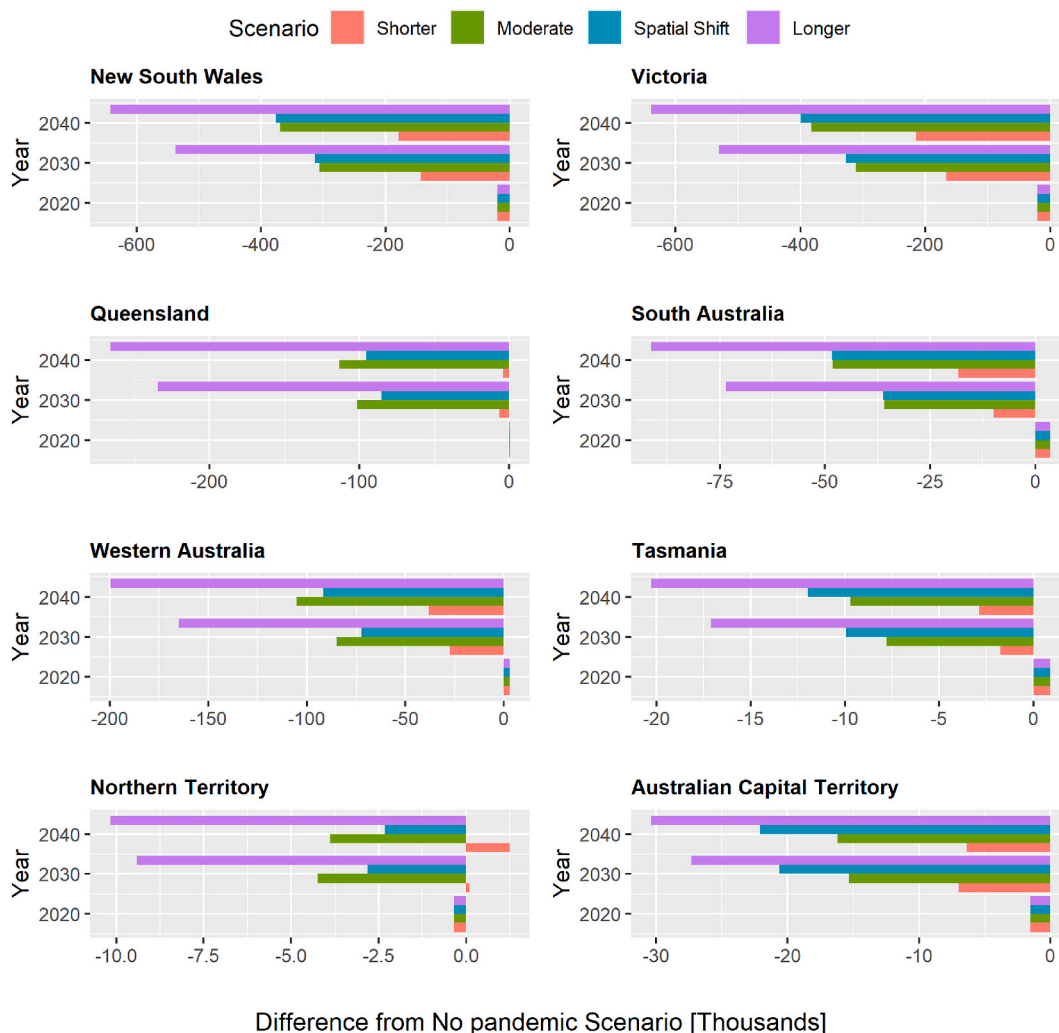


Fig. 7. Difference in population totals between *Shorter*, *Moderate*, *Longer* and *No pandemic* Scenarios, Australian States and Territories, 2019–2040.

**Table 3**  
Distribution of population by States and Territories, 2019 and 2040, *No pandemic*, *Shorter*, *Moderate*, *Spatial shift* and *Longer* Scenarios (per cent).

	2020	2040				
		No pandemic	Shorter	Moderate	Spatial shift	Longer
New South Wales	31.8%	31.3%	31.2%	31.1%	31.1%	31.1%
Victoria	26.1%	27.8%	27.5%	27.5%	27.4%	27.4%
Queensland	20.1%	20.0%	20.2%	20.3%	20.3%	20.3%
South Australia	6.9%	6.1%	6.1%	6.1%	6.1%	6.2%
Western Australia	10.3%	10.5%	10.5%	10.5%	10.6%	10.5%
Tasmania	2.1%	1.8%	1.8%	1.8%	1.8%	1.8%
Northern Territory	1.0%	0.8%	0.9%	0.9%	0.9%	0.9%
Australian Capital Territory	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
Total	100%	100%	100%	100%	100%	100%

migration assumptions.

In the *Moderate* scenario the pandemic reduces fertility to a TFR of 1.55 in the 2020–21 financial year before a recovery over the next few years, followed by a minor increase which represents a modest tempo effect of previously delayed births. In all scenarios the assumed long-run

TFR is 1.70, which is in line with current TFR assumptions of the official ABS population projections. In the *Shorter* impact scenario the economic impact of the pandemic is less severe than originally envisaged and quite short, and the TFR hardly falls before recovering. This situation corresponds to a better economic recovery than anticipated. In the *Longer* impact scenario, the serious and long-lasting economic consequences of the pandemic drives fertility sharply down to 1.45 before a slow recovery over many years. Net Overseas Migration in the *Moderate* scenario falls substantially to –50,000 in the 2020–21 year before recovering over the next few years and maintaining 210,000 per annum in the long-run. The *Shorter* scenario assumes international migration resumes quickly in late 2020 and early 2021, resulting in NOM of 0 in 2020–21 before quickly increasing over the following year. This situation is conceivable in the event of mass vaccination by the end of 2021 followed by the re-opening of international borders. In contrast, the *Longer* scenario sees NOM plummet to –100,000 and take eight years to increase to the long-run level of 210,000 per annum, as a result of a slower economic recovery and protracted international border restrictions. In all scenarios life expectancy at birth is assumed to continue its long-run upward trajectory, and no mortality differentials between scenarios are included.

At the State and Territory scale, both fertility and life expectancy at birth assumptions are tied to the national level assumptions. State/Territory TFRs are assumed to follow the national TFR assumption plus or minus average differentials of the last decade. Similarly, State/Territory life expectancies are tied to national life expectancy assumptions

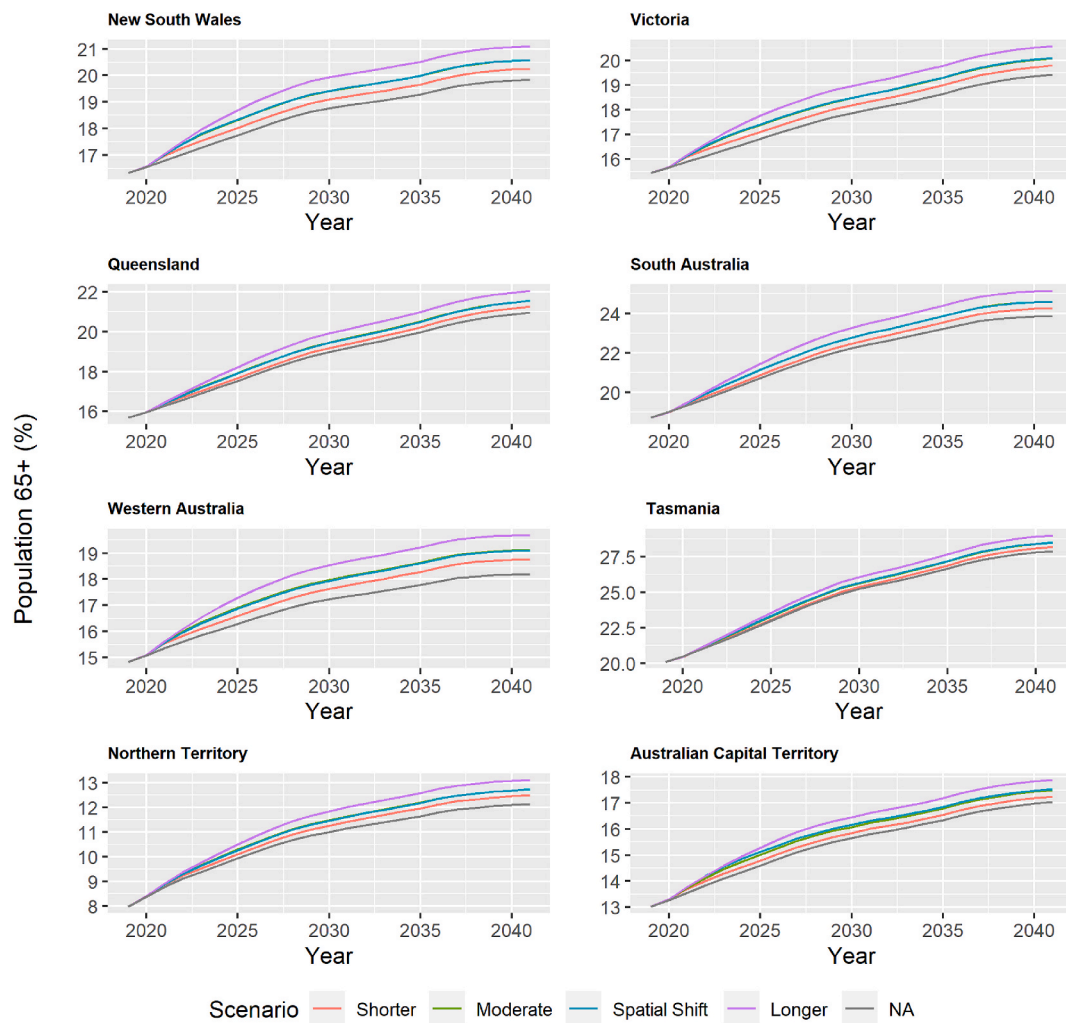


Fig. 8. Population aged 65+ (%), Shorter, Moderate, Longer and No pandemic Scenarios, Australia, 2019–2040.

plus or minus average differentials of the last decade. National projections of immigration and emigration totals are distributed to States and Territories using immigration and emigration distributions of the last decade. Interstate migration assumptions in the *Moderate*, *Shorter* and *Longer* scenarios are limited to changes in the overall level of migration, with the pattern and age structure to remain unchanged. In the *Shorter* scenarios, the level of interstate migration is assumed to drop 5 per cent in 2020–2021, before rebounding +5 per cent on 2021–22. This assumes that, while some moves were postponed during the initial response to COVID-19, they are recovered in the following year. The *Longer* scenario has NIM dropping by 15 per cent in 2020–2021 and then by a further 25 per cent in 2020–21. This assumes that a significant level of foregone moves, due to deteriorating economic conditions. The decline in the *Longer* scenario is considerably smaller than proposed by the experts. A judgement was made to moderate the decline due to a number of factors: the first is the potential for a significant number returns to the parental home; the second is that many moves already in train would likely have occurred. The scale of the decline in the *Longer* scenario is still more than twice the maximum decline in Australian interstate migration Australia since the 1970s. A fourth scenario (*Spatial Shift*) was developed based on a single quarter of interstate migration data released by the ABS in February 2021 and reflects observed changes in pattern of interstate migration flows (ABS, 2021c), with larger net losses for New South Wales and Victoria and corresponding gains for Queensland and Western Australia than the *Moderate* scenario.

## 5. Results

### 5.1. National-level results

In this section we present scenario results of the most important population measures from the projections. For each scenario we analyse total populations, population growth rates and population ageing for Australia and for States and Territories. Fig. 4 shows the total projected population of Australia from 2020 to 2040 for the five scenarios as well as annual average growth rates. The reference *No Pandemic* scenario has Australia’s population reaching 27.6 million by 2025, 29.4 million by 2030 and 33.1 million by 2040. Totals from the *No Pandemic* scenario are lower than the ABS’s current Series B projection which reaches 33.6 million by 2040. Based on the modelled scenarios, COVID-19 is expected to have a measurable and persistent impact on Australia’s population. Under the *Shorter*, *Moderate* and *Longer* scenarios, Australia’s population by 2040 is, respectively, 0.46 million, 1 million and 1.90 million lower than in the *No Pandemic* scenario (Table 2). The impacts of COVID-19 are felt most strongly in the short term with annual population growth dropping to 0.55 per cent in the *Shorter* scenario, 0.28 per cent in the *Moderate* scenario, and just 0.01 per cent in the *Longer* scenario. For historical context, Australia’s annual population growth last dropped below the projected rates in 1916 at which time growth was negative (ABS, 2019b). The impacts on Australia’s growth rates are persistent for the *Moderate* and *Longer* scenarios, with annual growth not returning to *No Pandemic* levels until the late 2020s in the late 2030s for the *Longer*

scenario. The boost in annual growth rates in the *Moderate* scenario in 2027–28 is due to the return to pre-COVID levels of migration and fertility.

### 5.2. Components of change

The projected demographic components of change reveal which processes drive population change. These are illustrated for each scenario in Fig. 5.

COVID-19 has the potential to exert a profound impact on the number of births in Australia over the next 30 years. Compared to the reference scenario, close to 860,000 fewer babies born if the *Longer* scenario comes to pass, about 420,000 less if we assume a *Moderate* recovery period and close to 180,000 fewer under a *Short* recovery scenario. Even though in each scenario the TFR converges to 1.7, the resulting number of births does not because of differences in the number of females of reproductive age. In the last projection period of 2040–41, there are still about 25,000 fewer babies born in the *Longer* scenario, about 15,000 fewer in the *Moderate* scenario and about 8,500 fewer in the *Shorter* scenario compared to the reference scenario. By affecting the size of successive birth cohorts, the demographic reach of COVID-19 is expected to be long-lasting.

There is little difference in the number of deaths between scenarios. This is largely due to the use of identical mortality assumptions across the scenarios. The annual number of deaths in each scenario increases from about 170,00 to about 230,000 over the projection horizon because of the rapid growth of population at the oldest ages where death rates are highest.

Even though NOM is assumed to converge back to long-term trends after a maximum of 10 years in all scenarios, there is a substantial variation in total NOM across the projection horizon. In the *Longer* Scenario, overall NOM is over a million people lower compared to *No Pandemic*. The difference reduces in line with the speed of recovery. In the *Moderate* scenario, NOM is about 640,000 fewer and in the *Shorter* scenario is 280,000 fewer compared to the *No Pandemic* scenario, which highlights the strength of the demographic effect of COVID-19 through international border closures.

Our results suggest the impact of COVID-19 on population ageing to be relatively modest at the national level. This reflects the fact that NOM impacts projections more than any other component of change. While migration does exert some influence on age structure, the magnitude is less than for fertility. Under the *No Pandemic* scenario the proportion of Australians aged 65 and over is expected to increase from 15.9 per cent in 2020 to 20.0 per cent by 2040, this is only one percentage point less in 2040 than in the *Longer* scenario.

### 5.3. State variation

Due to differences in international and internal migration levels and pattern, the demographic impacts of COVID-19 will vary across Australian States and Territories. Fig. 6 illustrates the total population growth for States and Territories, while Fig. 7 reports differences between the *Shorter*, *Moderate* and *Longer* scenarios and the reference scenario. Most States and Territories will experience less population growth due to the pandemic out to 2040. The largest absolute impacts will be felt in the two most populous states, New South Wales and Victoria, reflecting the importance of NOM to growth in these two states, followed by Queensland and Western Australia. If the pandemic has the longer impact assumed in our scenarios, then the population of New South Wales will be 642,416 fewer at the end of the projection horizon compared to if the pandemic had not taken place, while in Victoria the population is 638,451 lower. For Queensland, the population is 266,175 lower under the *Longer* scenario, while in Western Australia it is 199,745.

In contrast, the absolute impacts of the *Shorter* scenario range from a difference of –178,313 in New South Wales relative to the reference

scenario to a small positive value of +1,247 in the Northern Territory. In relative terms, the largest impact out to 2040 in the *Longer* Scenario is in Victoria, which will have a population 7.5 per cent smaller than in the *No Pandemic* scenario followed by New South Wales (6.7 per cent smaller). The relative impact will be much smaller in the Northern Territory and Tasmania, with the *Longer* scenario leading to populations 3.8 per cent and 3.5 per cent smaller respectively than under the *No Pandemic* scenario.

The impact of COVID-19 on the distribution of Australia's population by State and Territory is relatively small under the current scenarios, with the *Longer scenario* leading a slight reduction in the relative share of Victoria's population in 2040 and a slight gain in Queensland (Table 3). This does however have a number of potential impacts including the relative distribution of tax revenue and the apportionment of seats in the Australian House of Representatives (Corr, 2016).

The population in all states and territories will age under each of the scenarios (Fig. 8). Compared to the reference scenario, the population of Western Australia will age more under the *Longer* scenario, with the percentage of the population aged 65 and over 1.5 percentage points higher by 2040 than in the *No Pandemic* scenario. The impact on ageing is smallest in the Australian Capital Territory (0.86 percentage point higher). This reflects the relatively small contribution of net overseas migration (the component of change most affected by the pandemic) to population change in that jurisdiction.

## 6. Discussion and conclusion

The impacts of COVID-19 have been substantial and pervasive and will ultimately be reflected in the demography of national and sub-national populations. While in early stages, much of the focus of demographers has been on mortality and morbidity, attention is now turning to other components of demographic change, and ultimately the cumulative impact of COVID-19 on population size, structure and distributions. Population projections are the obvious and appropriate tool to scope these impacts. In normal times, projections are informed by recent data, extrapolative models of fertility, mortality and migration, as well as expert views as to likely demographic futures. Creating projections in a period of unprecedented global upheaval, with limited data and the potential for long lasting changes in demographic behaviour, is fraught. However there is a clear need to try and quantify the potential impact, which we attempt here via a number of scenarios.

To formulate our assumptions, we synthesised academic research on the impact of external shocks on the various components of demographic change, used past data to establish meaningful limits and a survey of experts to garner a range of views. These were informed by the economic forecasts produced by the Reserve Bank of Australia and framed as *Shorter*, *Moderate*, *Spatial Shift* and *Longer*. Ultimately, the scenarios represent our informed view as to plausible futures for Australia's population and thus will be subject to error, especially in view of the pandemic still ongoing, no officially specified end in sight of an end to international travel restrictions and Australia's vaccination program still in early stages at the time of writing. However, we have to start planning for life after the pandemic now and decision makers need data to start this process sooner rather than later. The modelled scenarios suggest the potential for significant and long-lasting impacts on the size of Australia's population, but a relatively modest impact on population ageing (see Wilson, Temple, & Charles-Edwards, 2021 for a fuller discussion). The scale of the expected impact differs across Australia's States and Territories, with New South Wales and Victoria experiencing the greatest decrease in population in absolute terms, while Victoria is most impacted in relative terms. The impact on the spatial distribution of the Australia's population across state and territories is minor under the current scenarios. If shifts in internal migration patterns emerge due to differences in the relative economic recovery of states and territories or other yet unknown factors, greater differences in spatial patterns may occur.

Broader questions emerge from this exercise with respect to how population projections are created and used in response to shocks and crises. In this study we focused on the impact of COVID-19. However, over the same period Australia was subject to other environmental, political and economic forces likely to impact the components of demographic change. These include Australia's extreme bushfire season of 2019–2020 (Bradstock et al., 2021), potentially impacting internal migration flows, and rising tensions with China which could affect international student flows in the coming years (Foster, 2021). There is clear value in developing more complex scenarios incorporating a fuller range of influences, although this falls outside the scope of the current study (Amran, 2019; Rees et al., 2010).

Population projections inevitably contain a degree of error, which propagates as the projection timeline increases and the size of the area decreases. Probabilistic approaches have increasingly been used to quantify the degree of uncertainty in demographic futures, however, when uncertainty is so high bounds may be less useful. Scenario approaches may provide more targeted ranges, however, they still are only as good as their input data, which has the potential to shift rapidly in response to policies such as large scale border closures. Perhaps a more fruitful approach would be a dynamic projection system which produces regular and high frequency outputs. This requires significant investment in both statistical infrastructure but also in academic research into the nowcasting of demographic events. There are significant opportunities in this space, as recent research on digital demography has shown (Cesare, Lee, McCormick, Spiro, & Zagheni, 2018), however there is some way to go before leading indicators of demographic change are identified and validated. This would allow for a shift in the conceptualization of projections from looking backwards to look forwards, to a contemporary picture of plausible population futures.

## Author statements

Elin Charles-Edwards: Conceptualization, Data curation; Formal analysis, Writing - Original Draft; Writing - Review & Editing; Supervision.

Tom Wilson: Conceptualization, Data curation; Formal analysis, Writing - Original Draft; Writing - Review & Editing.

Aude Bernard: Conceptualization, Writing - Original Draft; Writing - Review & Editing.

Pia Wohland: Conceptualization, Writing - Original Draft; Writing - Review & Editing.

## References

- Aassve, A., Cavalli, N., Mencarini, L., Plach, S., & Bacci, M. L. (2020). The COVID-19 pandemic and human fertility Birth trends in response to the pandemic will vary according to socioeconomic conditions. *Science*, 369(6502), 370–371. <https://doi.org/10.1126/science.abc9520>
- ABS. (2012). 3412.0 - migration, Australia, 2010-11, explanatory notes. In *Australian Bureau of statistics, Canberra*. <https://www.abs.gov.au/ausstats/abs@.nsf/lookup/3412.0explanatory+notes12010-11>.
- ABS. (2018). 3222.0 - population projections, Australia, 2017 (base) - 2066. [https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3222.0Main+Features12017%20\(base\)%20-%202066?OpenDocument](https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3222.0Main+Features12017%20(base)%20-%202066?OpenDocument).
- ABS. (2019a). In 3101.0 Australian demographic statistics. Canberra: Australian Bureau of Statistics. <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3101.0Jun%202019>.
- ABS. (2019b). In 3105.0.65.001 Australian historical population statistics. Canberra: Australian Bureau of Statistics. <https://www.abs.gov.au/statistics/people/population/historical-population/latest-release>.
- ABS. (2019c). In 3301.0 births, Australia, 2018. Canberra: Australian Bureau of Statistics.
- ABS. (2019d). In 3302.0.55.001 life Tables, states, territories and Australia, 2016-2018. Canberra: Australian Bureau of Statistics.
- ABS. (2019a). In 3401.0 overseas arrivals and Departures, Australia, Feb 2020. Canberra: Australian Bureau of Statistics. <https://www.abs.gov.au/statistics/industry/tourism-and-transport/overseas-arrivals-and-departures-australia/latest-release>.
- ABS. (2020b). In 3412.0 migration, Australia, 2018-19. Canberra: Australian Bureau of Statistics.
- ABS. (2020c). In 4940.0 household impacts of COVID-19 survey, 12-15 may 2020. Canberra: Australian Bureau of Statistics. <https://www.abs.gov.au/statistics/people/people-and-communities/household-impacts-covid-19-survey/latest-release>.
- ABS. (2020d). In 6202.0 - labour force, Australia, may 2020. <https://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6202.0Main+Features1May%202020?OpenDocument>.
- ABS. (2020e). In 6202.0 labour force. Canberra: Australian Bureau of Statistics.
- ABS. (2021a). Migration, Australia. In A. B. o. Statistics. Canberra <https://www.abs.gov.au/statistics/people/population/migration-australia/latest-release#net-overseas-migration>.
- ABS. (2021b). In A. B. o. Statistics (Ed.), *Overseas arrivals and Departures, Australia* (Vol. 2021). Canberra <https://www.abs.gov.au/statistics/industry/tourism-and-transport/overseas-arrivals-and-departures-australia/latest-release>.
- ABS. (2021c). In *Regional internal migration estimates, provisional - Provisional statistics on internal migration at state/territory and capital city levels* (Vol. 2021). <https://www.abs.gov.au/statistics/people/population/regional-internal-migration-estimates-provisional/latest-release>.
- Alvarez, M., Bernard, A., & Lieske, S. N. (2021). Understanding internal migration trends in OECD countries. *Population, Space and Place*, Article e2451. <https://doi.org/10.1002/psp.2451>. n/a (n/a).
- Amran, G. B. A., Conte, A., Gailey, N., Ghio, D., Grapsa, E., Jensen, K., et al. (2019). In L. W (Ed.), *Demographic scenarios for the EU - migration, population and education*. Luxembourg: Publication Office of the European Union. <https://doi.org/10.2760/590301>.
- Australian Government Department of Health. (2021b). In *Coronavirus (COVID-19) advice for international travellers* (Vol. 2021). <https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/coronavirus-covid-19-restrictions/coronavirus-covid-19-advice-for-international-travellers>.
- Australian Government Department of Health. (2021c). In *Coronavirus (COVID-19) current situation and case numbers* (Vol. 2021). <https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/coronavirus-covid-19-current-situation-and-case-numbers>.
- Australian Government Department of Health. (2021d). In *First COVID-19 vaccinations in Australia*. <https://www.health.gov.au/news/first-covid-19-vaccinations-in-australia>.
- Balbo, N., Kashnitsky, I., Melegaro, A., Meslé, F., Mills, M. C., de Valk, H., et al. (2020). Demography and the coronavirus pandemic. In *Population and policy brief* (Vol. 25). Population Europe.
- Banerjee, A., Pasea, L., Harris, S., Gonzalez-Izquierdo, A., Torralbo, A., Shallcross, L., et al. (2020). Estimating excess 1-year mortality associated with the COVID-19 pandemic according to underlying conditions and age: A population-based cohort study. *The Lancet*, 395(10238), 1715–1725. [https://doi.org/10.1016/S0140-6736\(20\)30854-0](https://doi.org/10.1016/S0140-6736(20)30854-0)
- BBC News. (2020). *Covid in Australia: Melbourne to exit 112-day lockdown*. In BBC (Ed.). 2021. <https://www.bbc.com/news/world-australia-54686812>.
- Beets, G., & Willekens, F. (2009). The global economic crisis and international migration: An uncertain outlook. *Vienna Yearbook of Population Research*, 7, 19–37. [www.jstor.org/stable/23025522](http://www.jstor.org/stable/23025522).
- Bell, T. (2020). No baby boom in the time of corona. In *The Guardian*. <https://www.theguardian.com/commentisfree/2020/jun/14/no-baby-boom-in-the-time-of-corona>.
- Bell, M., Charles-Edwards, E., Ueffing, P., Stillwell, J., Kupiszewski, M., & Kupiszewska, D. (2015). Internal migration and development: Comparing migration intensities around the world. 41(1), 33–58. <https://doi.org/10.1111/j.1728-4457.2015.00025.x>
- Bell, M., Wilson, T., Charles-Edwards, E., & Ueffing, P. (2017). Australia: The long-run decline in internal migration intensities. In T. Champion, T. J. Cooke, & I. Shuttleworth (Eds.), *Internal migration in the developed world: Are we becoming less mobile?* (pp. 147–172). Abingdon, United Kingdom: Routledge. <https://doi.org/10.4324/9781315589282-7>.
- Bennett, C. (2020). *Have there been uncounted coronavirus deaths in Australia? We can't say for sure, but the latest ABS data holds clues in the Conversation*. <https://theconversation.com/have-there-been-uncounted-coronavirus-deaths-in-australia-we-cant-say-for-sure-but-the-latest-abs-data-holds-clues-141363>.
- Bernard, A., Charles-Edwards, E., Alvarez, M., Wohland, P., Loginova, J., & Kalembe, S. (2020). *Anticipating the impact of COVID-19 on international migration*. Canberra, Australia: Centre for Population, Federal Department of Treasury.
- Bradstock, R., Clarke, H., Collins, L., Clarke, M., Nolan, R. H., & Penman, T. (2021). A staggering 1.8 million hectares burned in 'high-severity' fires during Australia's Black Summer. In *The Conversation*. <https://theconversation.com/a-staggering-1-8-million-hectares-burned-in-high-severity-fires-during-australias-black-summer-157883>.
- Brown, D. L., Champion, T., Coombes, M., & Wymer, C. (2015). The Migration-commuting nexus in rural England. A longitudinal analysis. *Journal of Rural Studies*, 41, 118–128. <https://doi.org/10.1016/j.jrurstud.2015.06.005>
- Burke, D. (2020). Coronavirus: 2020 baby boom predicted as world goes into lockdown. In *Workshop Guardian*. <https://www.workshopguardian.co.uk/health/coronavirus/coronavirus-2020-baby-boom-predicted-world-goes-lockdown-2503886>.
- Castles, S., & Vezzoli, S. (2009). The global economic crisis and migration: Temporary interruption or structural change? *Paradigms*, 2, 68–75.
- Cesare, N., Lee, H., McCormick, T., Spiro, E., & Zagheni, E. (2018). Promises and pitfalls of using digital traces for demographic research. *Demography*, 55(5), 1979–1999. <https://doi.org/10.1007/s13524-018-0715-2>
- Charles-Edwards, E., Bell, M., Cooper, J., & Bernard, A. (2018). Population shift: Understanding internal migration in Australia. In 2071.0 - *Census of population and housing: Reflecting Australia - Stories from the Census, 2016*. Canberra: Australian Bureau of Statistics.
- Cooke, T. J. (2011). It is not just the economy: Declining migration and the rise of secular rootedness. 17(3), 193–203. <https://doi.org/10.1002/psp.670>
- Cooke, T. J., & Shuttleworth, I. (2017). *Migration and the Internet Migration Letters*, 14(3), 331–342. <https://doi.org/10.33182/ml.v14i3.347>

- Corr, P. (2016). Democracy and dollars: Use of demography in distribution. In T. Wilson, E. Charles-Edwards, & M. Bell (Eds.), *Demography for planning and policy: Australian case studies*. Cham: Springer.
- CSSE. (2020). In *COVID-19 Dashboard in. Center for systems Science and Engineering (CSSE)*. Baltimore, Maryland: Johns Hopkins University.
- Dobson, J., Latham, A., & Salt, J. (2009). *On the move? Labour migration in times of recession*. London: Policy Network.
- Ferguson, N., Laydon, D., Nedjati-Gilani, G., Imai, N., Ainslie, K., Baguelin, M., et al. (2020). *Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand*. London, UK: Imperial College London. <https://doi.org/10.25561/77482>
- Fordham, E. (2020). Will coronavirus cause a baby boom?. In *FOXBusiness*. <https://www.foxbusiness.com/lifestyle/coronavirus-baby-boom-covid-19-1>.
- Foster, T. B. (2016). *Rooted or stuck? The Causes and consequences of American Mobility decline*. Washington State: University of Washington.
- Foster, A. (2021). China takes aim at Australian universities with latest boycott. In *news.com.au*. <https://www.news.com.au/finance/business/other-industries/china-takes-aim-at-australian-universities-with-latest-boycott/news-story/7ac39c1990c7fa44b98ddaf36e6a5aa3>.
- van der Gaag, N., & van Wissen, L. (2008). Economic determinants of internal migration rates: A comparison across five European countries. *Tijdschrift voor Economische en Sociale Geografie*, 99(2), 209–222. <https://doi.org/10.1111/j.1467-9663.2008.00454.x>
- Goldlust, R. (2020). Is there a rush of tree changers on the way?. In *The Canberra times, Canberra*. [https://www.canberratimes.com.au/story/6801494/is-there-a-rush-of-tree-changers-on-the-way/#\\$cs.tab=0](https://www.canberratimes.com.au/story/6801494/is-there-a-rush-of-tree-changers-on-the-way/#$cs.tab=0).
- Goldstein, J. R., & Lee, R. D. (2020). *Demographic Perspectives on mortality of Covid-19 and other Epidemics in NBER working paper No. 27043*. Cambridge, MA: National Bureau of Economic Research.
- Graham-McLay, C. (2020). Sex toy sales triple during New Zealand's coronavirus lockdown. In *The Guardian*. <https://www.theguardian.com/world/2020/apr/09/sex-toy-sales-triple-during-new-zealands-coronavirus-lockdown>.
- Gray, E., & Evans, A. (2018). Geographic variation in parity progression in Australia. *Population, Space and Place*, 24(2), Article e2080. <https://doi.org/10.1002/psp.2080>
- Hare, J. (2021). International students won't return until 2022. In *Financial review*. <https://www.afr.com/work-and-careers/education/international-students-won-t-return-until-2022-20210330-p57fa>.
- Hassan, B. (2020). "Boomeranging" generation moves home due to COVID-19. In *Finder*. <https://www.finder.com.au/press-release-may-2020-boomeranging-generation-moves-home-due-to-covid-19>.
- Henley, J. (2021). Lockdowns return or are extended as third wave of Covid sweeps Europe. In *The Guardian*. <https://www.theguardian.com/world/2021/mar/22/lockdowns-return-extended-third-wave-covid-europe>.
- Hugo, G., Khoo, S.-E., McDonald, P., & Voigt-Graf, C. (2003). Temporary skilled migration to Australia: The 457 visa sub-class. *People and Place*, 11(4), 27–40.
- Kalemba, S. V., Bernard, A., Charles-Edwards, E., & Corcoran, J. (2020). *Decline in internal migration levels in Australia: Compositional or behavioural effect?*, Article e2341. <https://doi.org/10.1002/psp.2341>
- Khalil, S. (2020). Coronavirus: Australia to close Victoria-New South Wales border. In *British Broadcasting Company*. <https://www.bbc.com/news/world-australia-53303317>.
- Kontis, V., Bennett, J. E., Rashid, T., Parks, R. M., Pearson-Stuttard, J., Guillot, M., et al. (2020). Magnitude, demographics and dynamics of the effect of the first wave of the COVID-19 pandemic on all-cause mortality in 21 industrialized countries. *Nature Medicine*, 26(12). <https://doi.org/10.1038/s41591-020-1112-0>
- Levy, B. L. M. T., & Daniel Perez, A. (2017). Why did people move during the great recession? *The Role of Economics in Migration Decisions. The Russell Sage Foundation Journal of the Social Sciences*, 3(3), 100–125. <https://doi.org/10.7758/rsf.2017.3.3.05>
- Luppi, F., Arpino, B., & Rosina, A. (2020b). *The impact of COVID-19 on fertility plans in Italy, Germany, France, Spain and UK SocArXiv*. <https://doi.org/10.31235/osf.io/wr9jb>. May 22.
- Martin, P. (2009). *Recession and Migration: A New Era for Labor Migration?* (Vol. 43, pp. 671–691). <https://doi.org/10.1111/j.1747-7379.2009.00781.x>, 3.
- Matysiak, A., Sobotka, T., & Vignoli, D. (2020). The great recession and fertility in Europe: A sub-national analysis. *European Journal of Population*. <https://doi.org/10.1007/s10680-020-09556-y>
- Milne, G., Xie, S., Poklepovich, D., O'Halloran, D., Yap, M., & Whyatt, D. (2020). *Effectiveness of second wave COVID-19 response Strategies in Australia*. <https://doi.org/10.1101/2020.11.16.20232843>. medRxiv, 2020.2011.2016.20232843.
- Moaven, L., & Brown, J. (2021). COVID-19 "baby boom". *Medical Journal of Australia*. <https://doi.org/10.5694/mja.2.51010>. n/a (n/a).
- Murray, A. (2020). A COVID-19 baby boom? More like a baby bust. In C. G. T. Network (Vol. 2020). <https://newseu.cgtn.com/news/2020-06-20/A-COVID-19-baby-boom-More-like-a-baby-bust-RsvSpJsKYM/index.html>.
- ONS, & Statistics Canada. (2014). In-depth review of population projections. In *Conference of European Statisticians*. Geneva, Switzerland: United Nations Economic Commission for Europe.
- Papademetriou, D., & Terrazas, A. (2009). Immigrants and the current economic crisis: Research evidence, policy challenges, and implications. In *Migration policy Institute, Washington DC*.
- Rafi, B., & Lewis, L. (2013). Indian higher education students in Australia: Their patterns and motivations. *Australian Journal of Education*, 57(2), 157–173. <https://doi.org/10.1177/0004944113485837>
- RBA. (2020). Statement on Monetary policy, may 2020. In *Reserve Bank of Australia, Sydney*. <https://www.rba.gov.au/publications/smp/2020/may/>.
- Rees, P. (1984). Spatial population analysis using movement data and accounting methods: Theory, models, the 'MOVE' program and examples. In *Working paper 404/Computer manual 23*. UK: University of Leeds.
- Rees, P., Boden, P., Dennett, A., Stillwell, J., Jasińska, M., Jong, A.d., et al. (2010). Demographic and migratory flows affecting European regions and cities. Applied research project 2013/1/3. Annex D6 report on scenarios and a database of scenario drivers, Annex D7 regional population dynamics: A report assessing the effects of demographic developments on regional competitiveness and cohesion. In T. E. Programme (Ed.), *Luxemburg*. <https://www.espon.eu/demifer>.
- Remeikis, A. (2021). Australia plans staggered reopening of international borders in second half of year. In *The Guardian, Australia*. <https://www.theguardian.com/australia-news/2021/apr/18/australia-plans-staggered-reopening-of-international-orders-in-second-half-of-year>.
- Saks, R. E., & Wozniak, A. (2011). Labor reallocation over the business cycle: New evidence from internal migration. *Journal of Labor Economics*, 29(4), 697–739. <https://doi.org/10.1086/660772>
- Science Alert. (2021). In *There's one really Shameful aspect of the global vaccine rollout, says UN Chief*. <https://www.sciencealert.com/un-chief-criticizes-wealthy-countries-for-se-ishly-stockpiling-vaccines-to-everyone-s-detriment>.
- Sobotka, T., Skirbekk, V., & Philipov, D. (2011). Economic recession and fertility in the developed world. *Population and Development Review*, 37(2), 267–306. [www.jstor.org/stable/23043283](http://www.jstor.org/stable/23043283).
- Stanaway, F., Irwig, L. M., Teixeira-Pinto, A., & Bell, K. J. (2020). COVID-19: How many Australians might have died if we'd had an outbreak like that in England and Wales? *Medical Journal of Australia* (Preprint).
- Stone, L. (2020a). Short-run fertility responses to mortality events: A look to the past. *Applied Demography, Special Issue on COVID-19*.
- Stone, L. (2020b). Will the coronavirus spike births?. In *Institute for Family studies (IFS)*. <https://ifstudies.org/blog/will-the-coronavirus-spike-births>.
- Tilly, C. (2011). The impact of the economic crisis on international migration: A review. *Work, Employment & Society*, 25(4), 675–692. <https://doi.org/10.1177/0950017011421799>
- Trias-Llimós, S., & Bilal, U. (2020). Impact of the COVID-19 pandemic on life expectancy in Madrid (Spain). *Journal of Public Health*, 10.1093/pubmed/fdaa087.
- Wilson, T. (2017). Can international migration forecasting be improved? The case of Australia. *Migration Letters*, 14(2), 285–299. <https://doi.org/10.33182/ml.v14i2.333>
- Wilson, T., & Bell, M. (2004). Comparative empirical evaluations of internal migration models in subnational population projections. *Journal of Population Research*, 21(2), 127–160. <https://doi.org/10.1007/BF03031895>
- Wilson, T., Temple, J., & Charles-Edwards, E. (2021). Will the COVID-19 pandemic affect population ageing in Australia? *Journal of Population Research*, 1–15.
- World Bank. (2020). COVID-19 crisis through a migration lens. In *Migration and development brief* (Vol. 21) (World Bank, Washington D.C.).
- Worldometers. (2021). In *Worldometers Coronavirus updates* (Vol. 2021). Delaware, U.S. A: Dover. <https://www.worldometers.info/coronavirus/#countries>.
- Zagon, C. (2021). International travel could resume by October if Australia's vaccine rollout goes to plan. In *9News*. <https://www.9news.com.au/national/coronavirus-international-travel-could-resume-by-october-australia-vaccine-rollout-plan/8735248-bca0-4b7e-8c8b-3a651deb6fc6>.
- Zambrano, E., Bueermann, G., & Sullivan, D. (2020). Travel restrictions, points of entry, and mobility data: Impact in COVID-19 data models and needed solutions for proximity, location and mobility data. In *Migration policy Practice* (Vol. X, pp. 60–64), 2.