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ORIGINAL RESEARCH

Decomposing the differences in healthy life expectancy between migrants and natives: the 'healthy migrant effect' and its age variations in Australia

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Abstract

Whether the 'healthy migrant effect' exhibits different patterns in mortality and morbidity and how such patterns change during the life course have not been adequately understood in the literature. Using the datasets of the Australian Bureau of Statistics, this study presents an in-depth investigation of the healthy migrant effect and its age variations in Australia. Specifically, this study estimates life expectancy (LE) and healthy life expectancy (HLE) of the Australia-born and overseas-born populations, as well as eight Australian migrant groups, and decomposes the HLE differences into mortality and morbidity differences from three dimensions: age, gender and country of birth. The results reveal that compared with the Australia-born population, the overseas-born population enjoys a prominently longer LE; however, they suffer a similar or lower HLE after age 65 and a lower HLE/LE ratio throughout all ages. Young overseas-born adults manifest a more significant health advantage in both mortality and morbidity than early-life and older overseas-born individuals; however, the morbidity advantage of young migrants, particularly those who are female and originated from culturally different countries, declines dramatically with ageing. The results suggest that overall, migrants do not have the same advantage in morbidity as they do in mortality and that health advantages of migrants decreases with time in both dimensions of health and more rapidly for morbidity. The results suggest that pertinent policies are needed to reduce acculturation-related challenges and to mitigate the decline in migrants' health in the post-migration environment to ensure better quality of life outcomes of migrants.

Keywords Healthy migrant effect · Life expectancy · Healthy life expectancy · Age-decomposition algorithm · Morbidity

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Introduction

A great deal of research has provided evidence for the 'healthy migrant effect', which refers to migrants tending to have a better health status than natives (Cunningham et al., 2008; Anikeeva et al., 2010; Garcia & Chiu, 2016; Mehta et al., 2016; Zur Nieden & Sommer, 2016; Vang et al., 2017). The phenomenon of migrants experiencing a health advantage is puzzling given that migrants often have relatively limited knowledge of and access to health care services in the host society because of linguistic, cultural and financial barriers. Migrants may also undergo negative experiences during the acculturation process (e.g. discrimination), which are associated with poor health outcomes (Bruxner et al., 1997; Dey & Lucas, 2006; Fennelly, 2007; Cunningham et al., 2008; Anikeeva et al., 2010; Vang et al., 2017). However, despite most international evidence supporting the healthy migrant effect, some scholars argue that migrants might not be healthier than natives in specific health indices (Cunningham et al., 2008; Anikeeva et al., 2010; Lee, 2019). There are also doubts over the existence of the healthy migrant effect, with a few researchers claiming that findings of a health advantage in migrants is an artificial phenomenon caused by systemic problems related to the delay in registering the deaths of migrants returning to home country (Uitenbroek & Verhoeff, 2002; Smith & Bradshaw, 2006) or migrants' reporting bias (Antman et al., 2020). This inconsistent understanding of the heathy migrant effect poses challenges for policymakers and health care service providers in improving the allocation of health care resources for the growing migrant communities.

Another factor related to the healthy migrant effect that has not been adequately understood is whether and how this effect changes over time when migrants acculturate and age in the host society (Cho et al., 2004; Vang et al., 2017). The process of acculturation results in multidimensional changes, from the physical and social environment to individual values and behaviours, that have profound consequences on migrants' health outcomes (Jass & Massey, 2004; Berry et al., 2006). Existing research indicates that despite migrants having a prominent health advantage on arrival, the healthy migrant effect tends to wear off during migrants' acculturation process (Vang et al., 2017) and that some migrant groups even suffer worse health outcomes than native-born residents in later life despite their relative healthy status at young age (McDonald & Kennedy, 2004; Biddle et al., 2007). These findings indicate that compared with native-born residents, migrants' health and wellbeing might deteriorate more rapidly during the acculturation process in the host country and that acculturation might be stressful and health-threatening for many migrants. However, there is a dearth of research on changes in migrants' health status when migrants acculturate and age in the host society, and how different migrant subpopulations experience different changes.

To obtain a more nuanced understanding of the healthy migrant effect, it is necessary to conduct a study combining the two dimensions of mortality and morbidity, alongside the post-migration trajectories of migrant health over the life course. Healthy life expectancy (HLE), which refers to the average number of remaining years spent in good health at a certain age given certain patterns of mortality and morbidity, is a powerful measure that can be employed to achieve greater understanding of the healthy migrant effect (Stiefel et al., 2010; Jagger & Robine, 2011). Therefore,

this study presents an in-depth investigation of migrants' life expectancy (LE) and HLE and the differences in LE and HLE between migrants and natives in the context of Australia, a major migration destination country. More specifically, this study estimates the age-specific LE and HLE for the Australia-born and overseas-born populations, as well as for eight major Australian migrant groups, and decomposes the differences in HLE between migrants and natives into differences in mortality and differences in morbidity. The results from this study provide new understanding on the health inequalities within the growing and increasingly diverse migrant communities in Australia. The nuanced understanding amongst the groups included in this study can better inform policies and practices that enable enhanced assessment of the health care needs of migrant communities for migrants in Australia and elsewhere.

Literature review

Inconsistent evidence for the healthy migrant effect in mortality and morbidity

The strongest and most consistent evidence of migrants' health advantage is the finding of migrants' lower mortality, which has been observed in most migration destination countries around the world, including the United States (Dupre et al., 2012; Preston & Elo, 2014; Lariscy et al., 2015; Mehta et al., 2016), Germany (Carnein et al., 2014; Zur Nieden & Sommer, 2016), Canada (Quan et al., 2007; Trovato & Odynak, 2011), Australia (Page et al., 2007), Netherlands (Uitenbroek & Verhoeff, 2002), England and Wales (Reus-Pons et al., 2017) and Israel (Ott et al., 2009). Migrants' mortality advantage has been found regardless of age (Quan et al., 2007), gender (Zur Nieden & Sommer, 2016), race (Dupre et al., 2012), country of origin (Mehta et al., 2016) and age of migration (Garcia & Chiu, 2016). Migrants' lower mortality is particularly prominent among migrants within ten years after migration (Ng, 2011) and among migrants originating from countries with strong religious beliefs (Anikeeva et al., 2010; Huijts & Kraaykamp, 2012) and countries geographically distant from the destination country (Huijts & Kraaykamp, 2012).

However, the existing findings of the healthy migrant effect in morbidity are largely inconsistent and are often contradictory. While some studies indicate that migrants have a lower prevalence of several chronic diseases, for example, cardiovascular disease (Singh & Siahpush, 2001; Gray et al., 2007), asthma (Ponsonby et al., 2008; Siddiqi et al., 2013), overweight/obesity (Abraido-Lanza et al., 2005) and some types of cancers (including colon, prostate and breast cancers) (Mills & Yang, 1997; McDermott et al., 2011), most research reports contradictory findings for the different health outcomes between migrants and natives in many other health indicators, for example, mental health (Bzostek et al., 2006; Aglipay et al., 2013; Constant & Milewski, 2021), perinatal health (Kelaher & Jessop, 2002; Shah et al., 2011), self-rated health (Franzini & Fernandez-Esquer, 2004; Gagnon et al., 2013), disability (Gray et al., 2007; Prus et al., 2010), suicide (Burvill, 1998; DesMeules et al., 2005) and arthritis (Vang et al., 2017). In addition, migrants are consistently found to suffer worse health outcomes in some health indices, for example, injuries (Dobson et al., 2004; Trajkovski & Loosemore, 2006), infectious diseases (e.g. acquired immunode-

ficiency syndrome) (Forna et al., 2003; DesMeules et al., 2005) and diabetes (Hodge et al., 2004; Araneta & Barrett-Connor, 2005).[1] The inconsistency of the findings for the healthy migrant effect in the existing literature between mortality and morbidity and for the different indices of morbidity suggests that this effect does not apply to all aspects of health and might have different patterns for morbidity and mortality.

Given that previous research on the healthy migrant effect tends to measure mortality and morbidity separately or focuses only on outcomes of specific diseases, emerging research has begun to examine mortality and morbidity concurrently by using HLE as a new measure to better explore the health status of migrants. The findings of these studies indicate that migrants have longer LE than the native-born host population, but their HLE is overall similar and even lower than that of natives (Eschbach et al., 2007; Garcia & Chiu, 2016; Garcia et al., 2017, 2018, 2019; Reus-Pons et al., 2017). The results of such pioneering research suggest that migrants live longer but might not be healthier than natives. However, thus far, evidence about migrant health from the dimension of HLE remains scarce and is limited to the context of the United States and several Western European countries, hindering a more comprehensive and nuanced understanding of migrant health in other contexts, such as Australia.

The puzzling 'wearing off' of the healthy migrant effect over time

Acculturation refers to a dynamic process in which cultural and psychological changes occur in the individuals as a result of living in the context of two distinct cultural groups coming into continuous first-hand contact (Herskovits et al., 1936; Berry, 2005). The multifaceted changes that occur during the acculturation process, particularly changes in food consumption and dietary habits and in the physical and social environment, have a profound effect on migrants' physical and mental health outcomes (Jass & Massey, 2004; Berry & Hou, 2017; Fox et al., 2017).

Existing research has found that when migrants are gradually acculturated and integrated in the host society, the healthy migrant effect tends to wear off over time and even disappears sometime after migration (Cho et al., 2004; McDonald & Kennedy, 2004; Vang et al., 2017). For example, a Canadian study compared the mortality rates of migrants and the Canadian-born population, finding that the age-standardised mortality rate is 720 per 100,000 persons among male migrants in Canada within ten years after their arrival; however, this figure increases to 913 per 100,000 persons for male migrants in Canada with residency from 10 to 20 years and to 1,054 per 100,000 persons for male migrants in Canada with residency of more than 20 years. In comparison, for Canadian-born men, the average mortality rate is 1,305 per 100,000 persons (Ng, 2011). Similarly, a study examining patterns of chronic disease in Australia found that the probability of having chronic disease among migrants on arrival (approximately 15–25%) is significantly lower than that of the Australia-

[1] Some of the references in this paragraph used mortality rather than the prevalence of a certain health indicator (e.g. infectious diseases). Using cause of certain health conditions can reflect the health level of a certain group and the health disparities by place of birth. However, such practices might not be efficient to reflect the differences by place of birth of some long-term chronic conditions that tend to be not fatal but affect quality of life in the long run.

born individuals (approximately 35–42%). However, approximately 20 years after migration, the probability of migrants having chronic diseases significantly increases and eventually approaches the same level as experienced for Australia-born people (Biddle et al., 2007).

Some explanations are available to interpret this puzzling decline in migrants' health status with prolonged residency. These explanations attribute the deterioration in migrants' health outcomes to migration- and acculturation-related challenges as well as the behavioural changes that occur during the acculturation process, including trauma-causing negative experiences during or before the migration process (e.g. exposure to war and conflicts) (Jasso et al., 2005), psychological stress from adaption to new environment (Jasinskaja-Lahti et al., 2006; Safi, 2009; Huijts & Kraaykamp, 2012), limited knowledge of and access to health care resources in the new host society (Dey & Lucas, 2006) and low socioeconomic status in the host society (Fennelly, 2007). For example, migrants in Western societies might follow an unhealthy lifestyle characterised by tobacco, alcohol and drug use and might adapt to unhealthy local dietary habits, such as consumption of sweetened drinks and over-fried food (Myers et al., 1996; Abraido-Lanza et al., 2005; Akresh, 2007; Fennelly, 2007; Fullin & Reyneri, 2011; Vang et al., 2017). However, despite such explanations, it is not sufficiently understood how acculturation affects migrants' health trajectory over time and the differences in such effects between different migrant subpopulations.

To address these gaps identified in the existing literature, this study provides a comprehensive investigation of migrant health in the context of Australia from the less-examined perspective of HLE. The results from this study provide a more complete picture of the healthy migrant effect and contribute to better understanding of the changes in migrants' health outcomes over the life course.

Data and methods

Data

The study uses several databases sourced from the Australian Bureau of Statistics (ABS) to estimate LE and HLE for the Australia-born and overseas-born populations in 2016. Specifically, data on the size of the total Australian population are derived from the ABS's annual publications of estimated resident population,[2] while the size of the Australia-born and overseas-born populations are derived from the Census of Population and Housing (CPH),[3] adjusted by the ratio of the estimated resident population to the population size of the CPH (for five-year-age-group adjusted results, see Table 1 or for age-specific adjusted results, see Supplementary Material 1). Information about the health status of Australian populations is also captured from the CPH, while data on the number of deaths by place of birth are obtained from the annual

[2] ABS: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3101.0Jun 2018?OpenDocument.

[3] ABS: https://www.abs.gov.au/statistics/microdata-tablebuilder/available-microdata-tablebuilder/census-population-and-housing#using-the-basic-curf.

Table 1 Population size of the Australia-born and Overseas-born populations by Age Group and Country of Birth, Census of Population and Housing, 2016

Age	Australia-born population			Overseas-born population										
	Total	Male	Female	Total	Male	Female	Selected eight major countries of birth							
							UK	Germany	Italy	Greece	Lebanon	China	India	South Africa
1–4	1,070,080	549,976	520,105	118,475	60,525	57,944	-	-	-	-	-	-	-	-
5–9	1,293,163	663,560	629,607	209,474	107,492	101,986	-	-	-	-	-	-	-	-
10–14	1,157,292	594,194	563,081	239,894	123,441	116,474	-	-	-	-	-	-	-	-
15–19	1,117,394	572,550	544,840	304,199	155,120	149,084	-	-	-	-	-	-	-	-
20–24	1,080,442	549,397	531,058	486,345	246,032	240,307	-	-	-	-	-	-	-	-
25–29	1,017,647	510,412	507,231	646,961	313,679	333,301	-	-	-	-	-	-	-	-
30–34	976,967	484,851	492,101	726,886	354,971	371,935	-	-	-	-	-	-	-	-
35–39	917,081	453,632	463,455	644,610	319,498	325,098	-	-	-	-	-	-	-	-
40–44	994,270	489,601	504,667	588,989	288,100	300,884	-	-	-	-	-	-	-	-
45–49	994,539	487,683	506,858	586,923	285,485	301,427	94,997	5,960	4,531	2,976	9,206	33,124	22,637	18,058
50–54	925,800	455,477	470,327	597,752	293,477	304,270	119,176	6,497	8,439	4,780	9,736	36,438	17,879	14,291
55–59	902,773	442,056	460,714	551,564	267,057	284,494	105,987	5,964	11,351	6,595	8,612	28,593	14,260	11,255
60–64	801,427	391,527	409,902	497,974	240,823	257,146	92,555	7,410	15,955	8,546	7,264	24,746	12,102	9,118
65–69	697,347	338,532	358,806	491,651	242,698	248,960	110,804	18,281	25,962	12,037	6,272	15,835	9,680	7,480
70–74	516,520	246,823	269,698	371,194	184,502	186,691	93,915	12,560	20,891	14,890	4,188	9,808	7,547	5,045
75–79	361,454	166,244	195,194	291,205	141,195	150,026	70,504	8,893	24,320	15,742	2,822	8,294	4,845	3,286
80–84	252,770	108,111	144,670	207,775	95,917	111,851	46,696	5,646	22,308	12,202	1,653	7,047	3,378	1,922
85–90	178,086	67,321	110,760	130,880	56,173	74,702	27,026	4,564	14,248	5,859	977	3,796	2,055	1,104
90–94	81,178	25,796	55,366	59,223	21,032	38,207	12,943	1,857	5,413	1,586	369	1,541	768	403
95+	21,965	5,634	16,312	15,519	4,384	11,148	3,918	345	937	277	66	511	221	138
Total	15,358,195	7,603,377	7,754,752	7,767,493	3,801,601	3,965,935	778,521	77,977	154,355	85,490	51,165	169,733	95,372	72,100

statistics of deaths published by the ABS.[4] Given that the ABS only publishes annual statistics of death by place of birth in ten-year age group from age 5 years onwards (i.e. 0 year, 1–4 years, and ten-year age groups from 5 to 14 years to 75–84 years, and 85 years and older), this study uses the Penalized Composite Link Model, proposed by Rizzi et al. (2015), to ungroup the annual statistics of death into age-specific level (for ungrouped age-specific death number, see Supplementary Material 2).

Complete life tables (with the open-ended age interval set as ≥95) were constructed to compute LE and HLE for the Australia-born and overseas-born populations and migrants originating from the eight overseas countries (United Kingdom [UK], Germany, Greece, Italy, Lebanon, China, India and South Africa). Following the recent studies in estimating migrants' LE (Hendi & Ho, 2021; Wallace et al., 2022), this study computes LE and HLE from age one rather than at birth. This is because LE at birth is not a suitable measure of the overseas-born population since immigration is generally unlikely to occur at age zero (i.e. before reaching the first birthday), as evident in the literature (Hendi & Ho, 2021). Notably, when estimating the LE and HLE for migrants born in the eight selected overseas countries, the study does not compute HLE for ages younger than 45, given that mortality data for individuals under the age of 45 are incomplete or sparsely distributed for migrants originating from certain overseas countries in age groups younger than age 45.

Measurement of health

In CPH, health is measured by whether people need help or assistance in three core activities: self-care, mobility and communication. Self-care is defined as the ability to conduct daily activities independently (e.g. eating, showering, dressing and toileting); mobility is defined as the ability to conduct body movements (e.g. getting out of bed and moving around at home or in places away from home); and communication is defined as the ability to understand or be understood by others.[5] If respondents need help or assistance in any of these three core activities and it is caused by disability, a long-term health condition (lasting longer than six months) or old age, they are considered unhealthy. Respondents having no difficulty in conducting any types of core activity are considered healthy. It should be noted that if respondents require assistance in any core activities, but the cause is a short-term health condition (lasting fewer than six months such as a temporary sporting injury) and difficulty with English language or other reasons, they are considered healthy.

The CPH measures health according to individuals' care needs, which are essential in estimating the demand for healthcare services as populations age. The inclusion of communication in the health measure improves the assessment of individuals' care needs, which are importantly affected by the care recipient's communication ability, which in turn is a crucial indicator of health conditions (Threats & Worrall, 2004).

[4] ABS: Source: mortality data in 2016, https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3302.02016?OpenDocument; mortality data in 2011, https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3302.02011?OpenDocument; mortality data in 2006, https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3302.02006?OpenDocument.

[5] Note that communication difficulties caused by English language improficiency are not considered a cause of poor health.

In addition, the CPH identifies the reason of being unhealthy, which assists to better assess individuals' health conditions and care needs in a longer period. Moreover, the health measure used in this paper comprehensively reflects the consequences of the health outcomes and better measures the quality of life, which is the essence of the indicator of HLE.

Methods

This study uses the period life table method proposed by Chiang (1979) to estimate LE and the Sullivan method developed by Sullivan (1971) to estimate HLE. The age-decomposition algorithm proposed by Andreev et al. (2002) is also adopted to decompose the differences in HLE between the Australia-born and overseas-born populations. The use of the former two methods (i.e. the period life table method and the Sullivan method) is because they have been widely used in the existing research to estimate LE and HLE and are highly practicable (requiring cross-sectional data only). The adoption of the age-decomposition algorithm developed by Andreev et al. (2002) is because this approach is able to decompose the differences of HLE of two populations into differences due to mortality and differences due to morbidity, enabling comparison of health disparities by place of birth from the two key aspects of health. The procedure for using the period life table method for estimating LE can be found in Chiang (1979), and the procedures of the Sullivan method and the decomposition technique of HLE can be found in Jagger et al. (2014) and Andreev et al. (2002), respectively. Estimation of the confidence interval (CI) of LE is based on the method proposed by Chiang (1979), while the estimation of the CI of HLE is based on the method proposed by Jagger et al. (2014).

Decomposition of the differences in healthy life expectancy

The period life table method and the Sullivan method are well-established in the existing literature, thus, here we briefly describe the age-decomposition algorithm developed by Andreev et al. (2002).

The differences in HLE between two populations can be decomposed into the corresponding differences in mortality and morbidity. Let $i=1, 2$ represent two different populations and $(HLE_x^2 - HLE_x^1)$ denote the differences in HLE between the two populations at age group x. According to the age-decomposition algorithm proposed by Andreev et al. (2002), $(HLE_x^2 - HLE_x^1)$ can be decomposed into two element components: λ_x (contribution due to differences in mortality at age x) and γ_x (contribution due to differences in morbidity at age x). The decomposition process follows Eq. (1) to (3) below.

$$\lambda_x{=}00.25 \times (l_x^1 + l_x^2) \times (R_x^2 - R_x^1) \times (\pi_x^1 + \pi_x^2) + 0.5 \times (HLE_{x+1}^1 \times l_x^2 + HLE_{x+1}^2 \times l_x^1) \times (q_x^1 - q_x^2) \quad (1)$$

$$\gamma_x = 0.25 \times (l_x^1 + l_x^2) \times (R_x^2 + R_x^1) \times (\pi_x^2 - \pi_x^1) \quad (2)$$

$$HLE_x^2 - HLE_x^1 = \sum_{j=x}^{\omega} \lambda_x + \sum_{j=x}^{\omega} \gamma_x \quad (3)$$

In these equations, ${}_n\pi_x$ is the proportion of unhealthy people at age x, $q_x^i (i = 1, 2)$ denotes the probability of death for age x of population i; $R_x^i (i = 1, 2)$ is the ratio of L_x^i (i.e. the number of person years lived in age x) to l_x^i (i.e. the number of surviving persons at age x); and $\sum_{j=x}^{\omega} \lambda_x$ and $\sum_{j=x}^{\omega} \gamma_x$ are the total contribution due to differences in mortality and the total contribution due to differences in morbidity.

Results

Life expectancy and healthy life expectancy of the Australia-born and overseas-born populations

The results show that the overseas-born population enjoyed a significantly longer LE at age one in 2016 than did the Australia-born population from almost all the three dimensions, age, gender and country of birth. As shown in Table 2, LE at age one of the overseas-born population (84.70 years [95% CI: 84.68, 84.72]) exceeded that of the Australia-born population (80.57 years [95% CI: 80.55, 80.59]) by 4.13 years; and this margin remained at least three years from birth to age 55 and was then kept at least one year until age 85. Additionally, LE at age one of male migrants (82.73 years [95% CI: 82.70, 82.76]) was greater than for Australia-born men (78.44 years [95% CI: 78.42, 78.47]) by 4.29 years, while LE at age one for female migrants (86.68 years [95% CI: 86.65, 86.71]) was also greater than that of Australia-born women (82.69 years [95% CI: 82.67, 82.72]), but by a smaller gap of 3.99 years. Similarly, LE at age 45 of China-born (42.9 years [95% CI: 42.77, 43.03]), India-born (40.93 years [95% CI: 40.77, 41.09]) and South Africa-born migrants (41.42 years [95% CI: 41.21, 41.63]) exceeded that of the Australia-born population of the same age by 4.99, 3.02 and 3.51 years, respectively; the LEs at the same age of the other five migrant groups were also longer than the LE at age 45 of the Australia-born population by a margin ranging from 0.48 to 1.94 years, except Lebanon-born migrants whose LE at age 45 was lower than that of the Australia-born population with a small margin of 0.04 years (see Table 3).

While the overseas-born population had a clearly longer LE at age one than the Australia-born population, the HLE at age one of migrants was only longer than that of the Australia-born population before age 65. After this age, the HLE of the overseas-born population was similar or even lower than that of the Australia-born population. Specifically, compared with the Australia-born population, the overseas-born population had a longer HLE at age one (77.18 years [95% CI: 77.17, 77.20] vs. 74.83 years [95% CI: 74.82, 74.84]) by 2.35 years; however, this margin gradually decreased as age increases, and eventually disappeared after age 65. In addition, the decline in migrants' HLE was more rapid among female migrants. That is, female migrants' HLE, which stood higher than that of the Australia-born females at age one (77.70 years [95% CI: 77.67, 77.72] vs. 76.43 years [95% CI: 76.41, 76.45]), became lower than the HLE of Australia-born women after age 54, while the margin of HLE

between male migrants and the Australian-born males was maintained until age 90. Moreover, Italy-born (32.82 years [95% CI: 32.75, 32.88]), Greece-born (31.40 years [95% CI: 31.30, 31.49]) and Lebanon-born migrants (27.42 years [95% CI: 26.26, 26.58]) also had a notably lower HLE at age 45 than that of their Australia-born counterparts (33.26 years [95% CI: 33.25, 33.27]); however, HLE at the same age of UK-born (34.20 years [95% CI: 34.17, 34.23]), Germany-born (33.87 years [95% CI: 33.79, 33.95]), India-born (34.57 years [95% CI: 34.45, 34.69]), China-born (34.08 years [95% CI: 33.99, 34.18]) and South Africa-born migrants (36.82 years [95% CI: 36.67, 36.97]) was higher than that of the Australia-born population but to different extents.

Given that the overseas-born population has a considerably longer LE at all ages but only a moderately longer HLE before age 65, this group has a lower HLE/LE ratio than that of the Australia-born population across all ages. Specifically, the HLE/LE ratio of the overseas-born population (87.48%) was lower than that of the Australia-born population (89.16%) by 1.68% at age one, which broadened to 3.64% at age 35 and to 6.12% at age 65 before peaking at 11.15% at age 79. The gap in the HLE/LE ratio between migrants and natives was more significant for female migrants, whose HLE/LE ratio was lower than that of Australia-born females in a range from 2.68 to 13.06%, which was substantially larger than that of the difference between male migrants and Australia-born males (from 0.67 to 9.37%). The lower HLE/LE ratio of migrants than the Australia-born population was also clear among Italy-born (by 5.15–17.28%), Greece-born (by 8.57–22.05%), Lebanon-born (by 17.25–30.34%), China-born (by 7.94–22.68%) and India-born migrants (by -1.24–9.60%), while UK-born (by 0.08–2.59% before age 94), Germany-born (by -1.15–0.47% before age 75) and South Africa-born migrants (by -0.23–2.51%) had a similar or slightly higher HLE/LE ratio than did the Australia-born population.

Age decomposition of the differences in healthy life expectancy

The results of the age-decomposition algorithm reveal that the differences in mortality (between migrants and natives) and the differences in morbidity (between migrants and natives) contributed differently to the HLE differences between the Australia-born and overseas-born populations. As presented in Fig. 1, migrants' longer HLE at age one was largely attributable to migrants' overall lower mortality, while the corresponding contribution due to differences in morbidity was negative and partly offset the positive contribution arising from migrants' lower mortality. For example, the HLE at age one of the overseas-born population (77.18 years [95% CI: 77.17, 77.20]) exceeded that of the Australia-born population (74.83 years [95% CI: 74.82, 74.84]) by 2.35 years, which was a net effect of a gain of 2.65 years due to migrants' lower mortality and a loss of 0.30 years due to migrants' overall higher prevalence of morbidity. The negative contribution by migrants' higher morbidity was more prominent among female migrants, whose overall reduction in HLE at age one due to their higher morbidity reached 0.97 years (see Fig. 2b). A loss of HLE at age 45 due to their relatively high morbidity were also observed among Italy-born (1.71 years), Greece-born (3.08), China-born (2.05), India-born (0.63) and Lebanon-born migrants (6.84) (see Fig. 3). Conversely, the overall contribution due to morbidity difference

Table 2 LE, HLE and LE/HLE Ratio of the Australia-born and Overseas-born Populations by Selected Ages and Gender, 2016

	LE (95%CI)			HLE (95%CI)			Ratio of HLE/LE (%)		
	AUB	OVB	Gap	AUB	OVB	Gap	AUB	OVB	Gap
				Total					
1	80.57(80.55,80.59)	84.70(84.68,84.72)	-4.13	74.83(74.82,74.84)	77.18(77.17,77.20)	-2.35	89.16	87.48	1.68
5	76.63(76.61,76.65)	80.72(80.70,80.74)	-4.09	70.94(70.93,70.95)	73.24(73.22,73.26)	-2.3	88.88	87.11	1.77
15	66.69(66.67,66.71)	70.79(70.76,70.81)	-4.1	61.37(61.36,61.38)	63.47(63.45,63.49)	-2.1	88.34	86.08	2.26
25	56.94(56.92,56.95)	60.93(60.91,60.96)	-3.99	51.88(51.86,51.89)	53.69(53.68,53.71)	-1.81	87.47	84.59	2.88
35	47.33(47.31,47.34)	51.09(51.07,51.11)	-3.76	42.45(42.44,42.46)	43.89(43.87,43.91)	-1.44	86.12	82.48	3.64
45	37.91(37.89,37.93)	41.35(41.32,41.37)	-3.44	33.26(33.25,33.27)	34.25(34.24,34.27)	-0.99	84.21	79.53	4.68
55	28.80(28.78,28.82)	31.88(31.85,31.90)	-3.08	24.43(24.42,24.44)	25.01(24.99,25.02)	-0.58	81.43	75.31	6.12
65	20.21(20.19,20.23)	22.85(22.83,22.87)	-2.64	16.18(16.17,16.19)	16.40(16.38,16.42)	-0.22	76.87	68.89	7.98
75	12.41(12.39,12.43)	14.66(14.64,14.69)	-2.25	8.75(8.74,8.76)	8.72(8.71,8.74)	0.03	67.72	57.1	10.62
85	6.31(6.29,6.33)	8.05(8.02,8.07)	-1.74	3.13(3.12,3.14)	3.19(3.17,3.21)	-0.06	47.6	38.05	9.55
95	3.19(3.17,3.21)	3.27(3.26,3.29)	-0.08	0.79(0.77,0.80)	0.69(0.67,0.71)	0.1	23.66	20.15	3.51
				Male					
1	78.44(78.42,78.47)	82.73(82.70,82.76)	-4.29	73.27(73.25,73.29)	76.70(76.68,76.72)	-3.43	89.67	89	0.67
5	74.50(74.48,74.53)	78.76(78.73,78.79)	-4.26	69.40(69.38,69.41)	72.77(72.75,72.79)	-3.37	89.42	88.7	0.72
15	64.57(64.55,64.60)	68.83(68.80,68.86)	-4.26	59.96(59.95,59.98)	63.05(63.03,63.07)	-3.09	89.14	87.94	1.2
25	54.91(54.88,54.93)	59.03(59.00,59.06)	-4.12	50.61(50.59,50.62)	53.34(53.32,53.36)	-2.73	88.48	86.75	1.73
35	45.40(45.38,45.43)	49.23(49.20,49.26)	-3.83	41.31(41.29,41.32)	43.59(43.57,43.61)	-2.28	87.34	85	2.34
45	36.13(36.10,36.15)	39.53(39.50,39.56)	-3.4	32.25(32.23,32.26)	33.99(33.97,34.01)	-1.74	85.69	82.54	3.15
55	27.18(27.16,27.20)	30.16(30.13,30.19)	-2.98	23.57(23.56,23.59)	24.81(24.79,24.84)	-1.24	83.26	78.98	4.28
65	18.84(18.82,18.87)	21.33(21.30,21.36)	-2.49	15.58(15.56,15.59)	16.35(16.33,16.37)	-0.77	79.37	73.6	5.77
75	11.37(11.34,11.39)	13.45(13.42,13.48)	-2.08	8.55(8.54,8.57)	8.96(8.93,8.98)	-0.41	72.23	63.92	8.31
85	5.73(5.71,5.76)	7.24(7.20,7.27)	-1.51	3.31(3.29,3.33)	3.51(3.49,3.54)	-0.2	55.43	46.58	8.85
95	3.26(3.23,3.29)	2.61(2.58,2.64)	0.65	1.15(1.11,1.19)	0.78(0.75,0.82)	0.37	33.93	28.87	5.06
				Female					
1	82.69(82.67,82.72)	86.68(86.65,86.71)	-3.99	76.43(76.41,76.45)	77.70(77.67,77.72)	-1.27	88.73	86.05	2.68
5	78.74(78.72,78.76)	82.70(82.67,82.73)	-3.96	72.51(72.50,72.53)	73.74(73.72,73.77)	-1.23	88.41	85.6	2.81

Table 2 (continued)

	LE (95%CI)			HLE (95%CI)			Ratio of HLE/LE (%)		
	AUB	OVB	Gap	AUB	OVB	Gap	AUB	OVB	Gap
15	68.79(68.77,68.81)	72.75(72.72,72.78)	-3.96	62.80(62.79,62.82)	63.91(63.88,63.93)	-1.11	87.64	84.33	3.31
25	58.94(58.92,58.96)	62.84(62.81,62.87)	-3.9	53.16(53.14,53.17)	54.06(54.03,54.08)	-0.9	86.58	82.59	3.99
35	49.21(49.18,49.23)	52.94(52.91,52.97)	-3.73	43.60(43.59,43.62)	44.21(44.18,44.23)	-0.61	85.07	80.16	4.91
45	39.64(39.62,39.67)	43.15(43.12,43.18)	-3.51	34.26(34.25,34.28)	34.53(34.51,34.56)	-0.27	82.97	76.82	6.15
55	30.36(30.33,30.38)	33.57(33.54,33.60)	-3.21	25.28(25.26,25.30)	25.22(25.19,25.24)	0.06	79.95	72.1	7.85
65	21.47(21.45,21.50)	24.34(24.31,24.37)	-2.87	16.77(16.75,16.78)	16.47(16.44,16.49)	0.3	74.96	64.94	10.02
75	13.28(13.26,13.31)	15.76(15.73,15.79)	-2.48	8.93(8.92,8.95)	8.51(8.49,8.54)	0.42	64.56	51.86	12.7
85	6.67(6.65,6.69)	8.64(8.61,8.67)	-1.97	2.99(2.97,3.00)	2.94(2.92,2.97)	0.05	43.01	32.7	10.31
95	4.05(4.03,4.07)	3.46(3.44,3.48)	0.59	0.84(0.81,0.86)	0.60(0.57,0.62)	0.24	19.83	16.65	3.18

Note: AUB: Australian born; OVB: overseas born

	LE (95%CI)			**HLE (95%CI)**			**Ratio of HLE/LE (%)**		
	AUB	**OVB**	**Gap**	**AUB**	**OVB**	**Gap**	**AUB**	**OVB**	**Gap**
				Total					
1	80.51(80.5,80.53)	84.69(84.66,84.71)	-4.18	74.77(74.75,74.78)	77.16(77.14,77.17)	-2.39	89.15	87.46	1.69
5	76.57(76.56,76.59)	80.71(80.69,80.73)	-4.14	70.88(70.87,70.89)	73.21(73.2,73.23)	-2.33	88.86	87.08	1.78
15	66.64(66.62,66.65)	70.78(70.76,70.8)	-4.14	61.31(61.3,61.32)	63.44(63.43,63.46)	-2.13	88.33	86.05	2.28
25	56.9(56.88,56.91)	60.94(60.91,60.96)	-4.04	51.83(51.82,51.84)	53.68(53.66,53.69)	-1.85	87.45	84.56	2.89
35	47.31(47.3,47.33)	51.1(51.08,51.12)	-3.79	42.43(42.42,42.44)	43.88(43.87,43.9)	-1.45	86.09	82.45	3.64
45	37.92(37.9,37.93)	41.37(41.34,41.39)	-3.45	33.25(33.24,33.26)	34.25(34.24,34.27)	-1	84.18	79.49	4.69
55	28.82(28.8,28.84)	31.9(31.88,31.93)	-3.08	24.43(24.42,24.45)	25.01(25,25.03)	-0.58	81.39	75.27	6.12
65	20.24(20.23,20.26)	22.89(22.87,22.91)	-2.65	16.2(16.19,16.21)	16.41(16.4,16.43)	-0.21	76.81	68.83	7.98
75	12.45(12.44,12.47)	14.71(14.69,14.73)	-2.26	8.78(8.76,8.79)	8.74(8.72,8.76)	0.04	67.65	57.03	10.62
85	6.34(6.33,6.36)	8.08(8.06,8.1)	-1.74	3.14(3.13,3.15)	3.2(3.18,3.22)	-0.06	47.55	38.01	9.54
95	3.21(3.2,3.23)	3.3(3.28,3.31)	-0.09	.79(.77,.81)	.69(.67,.71)	0.1	23.65	20.14	3.51
				Male					
1	78.3(78.28,78.33)	82.66(82.63,82.69)	-4.36	73.14(73.13,73.16)	76.63(76.61,76.65)	-3.49	89.67	89	0.67

Table 2 (continued)

	LE (95%CI)			HLE (95%CI)			Ratio of HLE/LE (%)		
	AUB	OVB	Gap	AUB	OVB	Gap	AUB	OVB	Gap
5	74.37(74.34,74.39)	78.69(78.65,78.72)	-4.32	69.27(69.26,69.29)	72.7(72.68,72.73)	-3.43	89.42	88.7	0.72
15	64.44(64.41,64.46)	68.76(68.73,68.79)	-4.32	59.84(59.82,59.85)	62.98(62.96,63)	-3.14	89.15	87.94	1.21
25	54.79(54.77,54.82)	58.97(58.94,59)	-4.18	50.5(50.49,50.52)	53.28(53.26,53.31)	-2.78	88.48	86.74	1.74
35	45.33(45.3,45.35)	49.19(49.15,49.22)	-3.86	41.24(41.22,41.25)	43.55(43.53,43.57)	-2.31	87.34	85	2.34
45	36.08(36.05,36.1)	39.5(39.47,39.53)	-3.42	32.2(32.19,32.22)	33.96(33.94,33.98)	-1.76	85.69	82.53	3.16
55	27.15(27.12,27.17)	30.14(30.11,30.17)	-2.99	23.54(23.53,23.56)	24.79(24.77,24.82)	-1.25	83.25	78.96	4.29
65	18.83(18.81,18.85)	21.32(21.29,21.36)	-2.49	15.56(15.55,15.58)	16.34(16.32,16.37)	-0.78	79.34	73.58	5.76
75	11.39(11.37,11.42)	13.48(13.44,13.51)	-2.09	8.57(8.55,8.58)	8.97(8.94,8.99)	-0.4	72.19	63.88	8.31
85	5.76(5.73,5.78)	7.26(7.23,7.29)	-1.5	3.32(3.3,3.34)	3.52(3.5,3.55)	-0.2	55.41	46.56	8.85
95	3.28(3.25,3.32)	2.62(2.59,2.65)	0.66	1.16(1.12,1.2)	0.79(.75,.82)	0.37	33.93	28.87	5.06
				Female					
1	82.71(82.68,82.73)	86.72(86.69,86.75)	-4.01	76.42(76.4,76.43)	77.7(77.68,77.73)	-1.28	88.7	86.02	2.68
5	78.75(78.73,78.78)	82.73(82.7,82.76)	-3.98	72.5(72.49,72.52)	73.74(73.72,73.77)	-1.24	88.38	85.57	2.81
15	68.81(68.78,68.83)	72.79(72.76,72.82)	-3.98	62.79(62.78,62.81)	63.91(63.88,63.93)	-1.12	87.61	84.29	3.32
25	58.96(58.94,58.99)	62.88(62.85,62.91)	-3.92	53.15(53.14,53.17)	54.07(54.04,54.09)	-0.92	86.54	82.54	4
35	49.25(49.22,49.27)	52.99(52.96,53.02)	-3.74	43.61(43.6,43.63)	44.22(44.2,44.25)	-0.61	85.02	80.11	4.91
45	39.69(39.67,39.71)	43.21(43.18,43.24)	-3.52	34.28(34.27,34.3)	34.55(34.52,34.57)	-0.27	82.92	76.76	6.16
55	30.42(30.39,30.44)	33.64(33.61,33.67)	-3.22	25.31(25.29,25.32)	25.24(25.21,25.26)	0.07	79.88	72.03	7.85
65	21.54(21.52,21.56)	24.4(24.37,24.43)	-2.86	16.8(16.79,16.82)	16.49(16.47,16.51)	0.31	74.87	64.86	10.01
75	13.35(13.32,13.37)	15.82(15.79,15.85)	-2.47	8.96(8.94,8.98)	8.53(8.51,8.56)	0.43	64.46	51.78	12.68
85	6.71(6.69,6.74)	8.68(8.65,8.71)	-1.97	3(2.99,3.02)	2.95(2.93,2.98)	0.05	42.95	32.66	10.29
95	4.09(4.07,4.11)	3.48(3.46,3.5)	0.61	.84(.82,.87)	0.6(.58,.63)	0.24	19.83	16.65	3.18

was slightly positive among male migrants (increasing their HLE at age one by 0.30 years) and among UK-born, Germany-born, and South Africa-born migrants (adding 0.53, 0.21 and 1.18 years, respectively, to their HLE at age 45).

The contribution due to mortality differences and the contribution due to morbidity differences varied in different age patterns. As shown in Fig. 1, the overall positive contribution due to migrants' lower mortality (2.65 years) was largely from above age 25 (ranging from 0.12 to 0.56 years for each age) and less from ages under 25 (less than 0.11 years and even negative). In contrast, the contribution due to morbidity differences (-0.30 years) was largely from age under 55 (varying from 0.01 to 0.24 years for each age), while after age 55, the contribution due to morbidity differences turned negative (from − 0.01 years at age 55 to a notable − 0.02 years at age 70 and a − 0.61 years at age 83), which offset the positive contribution due to morbidity differences before age 55. This resulted in an overall negative contribution due to morbidity differences in relation to HLE differences at age one between the Australia-born and overseas-born populations.

The results also show notable gender differences in relation to the magnitude of the contribution due to mortality differences and that of the contribution due to morbidity differences. Specifically, although migrants' lower mortality positively contributed to an overall higher HLE of migrants at age one, the magnitude of this positive effect was more prominent for male migrants. Conversely, while migrants' overall higher morbidity negatively contributed to HLE of migrants at age one, the degree of this negative effect was greater for female migrants. For example, as shown in Fig. 2, the lower mortality of male migrants than of the male Australia-born population at age 35 added 0.04 years to male migrants' longer HLE at age one, while the corresponding figure for female migrants in relation to the female Australia-born population at the same age was only 0.02 years. Similarly, the higher morbidity of female migrants' than of the female Australia-born population at age 80 caused a loss of 0.09 years to female migrants' HLE at age one, while the corresponding figure for male migrants in relation to the male Australia-born population at the same age was only at 0.03 years. Additionally, there was also a gender difference in relation to the age in which the contribution due to morbidity differences turned negative, with this turning point coming at age 60 among male migrants but earlier at age 54 among female migrants, suggesting a quicker deterioration in morbidity among female migrants than that of male migrants.

The age-decomposition results further indicate that the contribution due to mortality differences and the contribution due to morbidity differences vary among people by country of birth. Among migrants from UK-born, Germany-born and South Africa-born migrants, both mortality differences and morbidity differences positively contributed to HLE at age 45. The positive contribution was most significant for South Africa-born migrants (positive throughout all ages and above 0.02 years before age 90 for mortality and positive throughout all ages before age 80 for morbidity) (see Fig. 3h) and were less significant for UK-born and German-born migrants (almost all less than 0.05 years at all the ages above 45) (see Fig. 3a and b). In contrast, among migrants from the other five countries, the contribution due to mortality differences and the contribution due to morbidity differences were opposite. For China-born and India-born migrants, the contribution due to mortality difference was positive and

Table 3 LE, HLE, and HLE/LE Ratio of the Australia-born and Overseas-born Populations by Selected Ages and Country of Birth, 2016

	LE (95%CI)	HLE (95%CI)	HLE/LE (%)	Gap		
				LE	HLE	HLE/LE (%)
Australia-born						
45	37.91(37.89,37.93)	33.26(33.25,33.27)	84.21	-	-	-
55	28.80(28.78,28.82)	24.43(24.42,24.44)	81.43	-	-	-
65	20.21(20.19,20.23)	16.18(16.17,16.19)	76.87	-	-	-
75	12.41(12.39,12.43)	8.75(8.74,8.76)	67.72	-	-	-
85	6.31(6.29,6.33)	3.13(3.12,3.14)	47.60	-	-	-
95	3.19(3.17,3.21)	0.79(0.77,0.80)	23.66			
Overseas-born						
45	41.35(41.32,41.37)	34.25(34.24,34.27)	79.53	-3.44	-0.99	4.68
55	31.88(31.85,31.90)	25.01(24.99,25.02)	75.31	-3.08	-0.58	6.12
65	22.85(22.83,22.87)	16.40(16.38,16.42)	68.89	-2.64	-0.22	7.98
75	14.66(14.64,14.69)	8.72(8.71,8.74)	57.10	-2.25	0.03	10.62
85	8.05(8.02,8.07)	3.19(3.17,3.21)	38.05	-1.74	-0.06	9.55
95	3.27(3.26,3.29)	0.69(0.67,0.71)	20.15	-0.08	0.10	3.51
UK-born						
45	38.39(38.35,38.43)	34.20(34.17,34.23)	85.52	-0.48	-0.94	-1.31
55	29.07(29.03,29.12)	25.04(25.02,25.07)	82.69	-0.27	-0.61	-1.26
65	20.34(20.30,20.38)	16.59(16.56,16.61)	78.28	-0.13	-0.41	-1.41
75	12.45(12.41,12.49)	8.98(8.96,9.01)	69.26	-0.04	-0.23	-1.54
85	6.24(6.20,6.28)	3.23(3.20,3.26)	49.65	0.07	-0.10	-2.05
95	2.45(2.42,2.48)	0.56(0.53,0.59)	22.04	0.74	0.23	1.62
Germany-born						
45	38.40(38.27,38.52)	33.87(33.79,33.95)	84.68	-0.49	-0.61	-0.47
55	28.89(28.77,29.02)	24.54(24.46,24.61)	81.53	-0.09	-0.11	-0.10
65	20.34(20.23,20.46)	16.25(16.18,16.33)	76.70	-0.13	-0.07	0.17
75	12.87(12.76,12.98)	8.93(8.85,9.00)	66.57	-0.46	-0.18	1.15
85	7.01(6.90,7.12)	3.35(3.27,3.43)	45.90	-0.70	-0.22	1.70
95	1.38(1.30,1.46)	0.27(0.21,0.33)	18.75	1.81	0.52	4.91
Italy-born						
45	39.85(39.76,39.93)	32.82(32.75,32.88)	79.06	-1.94	0.44	5.15
55	30.46(30.39,30.54)	23.65(23.59,23.70)	74.52	-1.66	0.78	6.91
65	21.45(21.39,21.52)	14.97(14.92,15.02)	66.98	-1.24	1.21	9.89
75	13.31(13.25,13.38)	7.28(7.24,7.33)	52.51	-0.90	1.47	15.21
85	6.79(6.73,6.85)	2.21(2.16,2.25)	31.20	-0.48	0.92	16.40
95	1.89(1.84,1.95)	0.29(0.25,0.34)	14.79	1.30	0.50	8.87
Greece-born						
45	39.85(39.73,39.97)	31.40(31.30,31.49)	75.64	-1.94	1.86	8.57
55	30.42(30.31,30.53)	22.29(22.20,22.37)	70.34	-1.62	2.14	11.09
65	21.57(21.47,21.66)	13.91(13.83,13.98)	61.91	-1.36	2.27	14.96
75	13.35(13.26,13.45)	6.65(6.59,6.72)	47.84	-0.94	2.10	19.88
85	6.79(6.69,6.90)	1.89(1.82,1.96)	26.66	-0.48	1.24	20.94
95	1.72(1.62,1.82)	0.16(0.09,0.22)	8.66	1.47	0.63	15.00
Lebanon-born						

Table 3 (continued)

	LE (95%CI)	HLE (95%CI)	HLE/LE (%)	Gap		
				LE	HLE	HLE/LE (%)
45	37.87(37.67,38.08)	26.42(26.26,26.58)	66.96	0.04	6.84	17.25
55	28.49(28.28,28.69)	17.86(17.71,18.02)	60.18	0.31	6.57	21.25
65	19.80(19.59,20.01)	10.65(10.50,10.80)	51.63	0.41	5.53	25.24
75	12.20(11.98,12.42)	4.83(4.69,4.98)	38.04	0.21	3.92	29.68
85	6.83(6.58,7.07)	1.48(1.34,1.62)	20.84	-0.52	1.65	26.76
95	1.54(1.31,1.76)	0.13(0.05,0.21)	7.94	1.65	0.66	15.72
China-born						
45	42.90(42.77,43.03)	34.08(33.99,34.18)	76.27	-4.99	-0.82	7.94
55	33.27(33.14,33.40)	24.49(24.39,24.59)	70.67	-4.47	-0.06	10.76
65	23.83(23.70,23.96)	15.37(15.27,15.47)	61.91	-3.62	0.81	14.96
75	15.17(15.04,15.30)	7.38(7.28,7.48)	46.72	-2.76	1.37	21.00
85	8.12(7.98,8.25)	2.28(2.19,2.38)	27.00	-1.81	0.85	20.60
95	3.21(3.11,3.30)	0.47(0.37,0.57)	14.06	-0.02	0.32	9.60
India-born						
45	40.93(40.77,41.09)	34.57(34.45,34.69)	81.10	-3.02	-1.31	3.11
55	31.29(31.13,31.45)	25.04(24.91,25.16)	76.82	-2.49	-0.61	4.61
65	22.22(22.06,22.38)	16.22(16.10,16.35)	70.09	-2.01	-0.04	6.78
75	14.07(13.90,14.24)	8.54(8.41,8.67)	58.28	-1.66	0.21	9.44
85	7.55(7.37,7.72)	3.22(3.08,3.35)	40.91	-1.24	-0.09	6.69
95	2.00(1.89,2.11)	0.52(0.40,0.64)	24.90	1.19	0.27	-1.24
South Africa-born						
45	41.42(41.21,41.63)	36.82(36.67,36.97)	85.34	-3.51	-3.56	-1.13
55	31.83(31.62,32.05)	27.30(27.15,27.45)	82.32	-3.03	-2.87	-0.89
65	22.71(22.50,22.93)	18.28(18.12,18.43)	77.26	-2.50	-2.10	-0.39
75	14.43(14.21,14.66)	10.15(9.98,10.31)	67.49	-2.02	-1.40	0.23
85	7.57(7.33,7.81)	3.77(3.58,3.95)	47.77	-1.26	-0.64	-0.17
95	1.96(1.82,2.10)	0.50(0.35,0.64)	24.37	1.23	0.29	-0.71

exceeded the negative contribution due to morbidity difference, resulting in their higher HLE at age 45 (compared with the Australian-born individuals) (see Fig. 3f and g). Conversely, for Italy-born, Greece-born and Lebanon-born migrants, the positive contribution due to mortality difference was diminished by the negative contribution due to morbidity difference, resulting in a lower HLE at age 45 for these three migrant groups (see Fig. 3c, d and e).

Robustness check

To test the robustness of the above findings, this study conducted robustness checks using the census data of 2006 and 2011 (i.e. the two preceding census years before 2016). The corresponding results of estimated LE, HLE and the ratios of HLE/LE, as well as the decomposition results of HLE differences, are presented in Supplementary Material 3. The comparison results of LE, HLE and the ratios of HLE/LE by

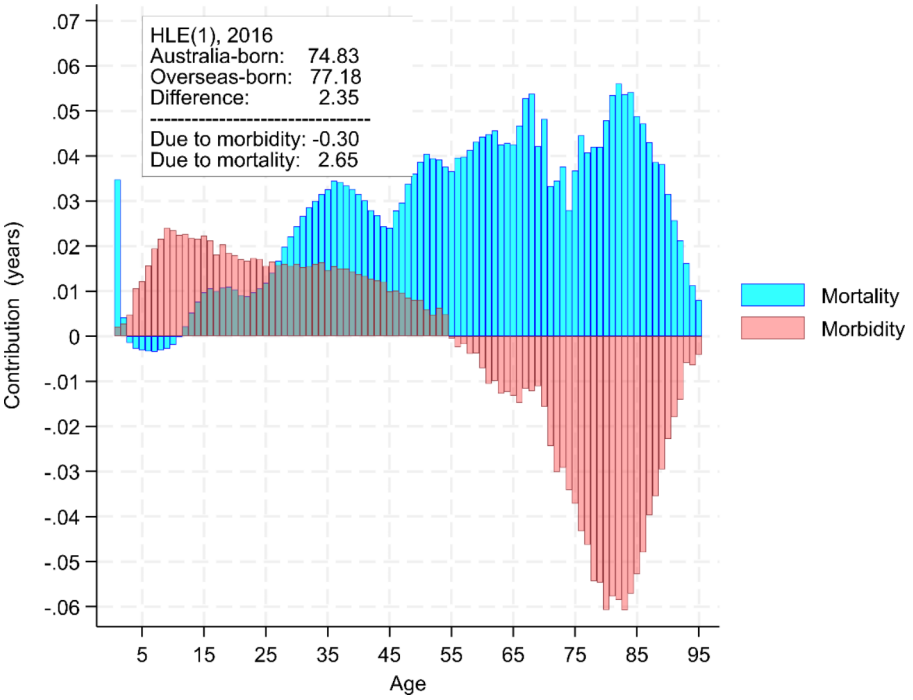

Fig. 1 Decomposition of the Differences in HLE at Age One between the Australia-born and Overseas-born Populations, 2016

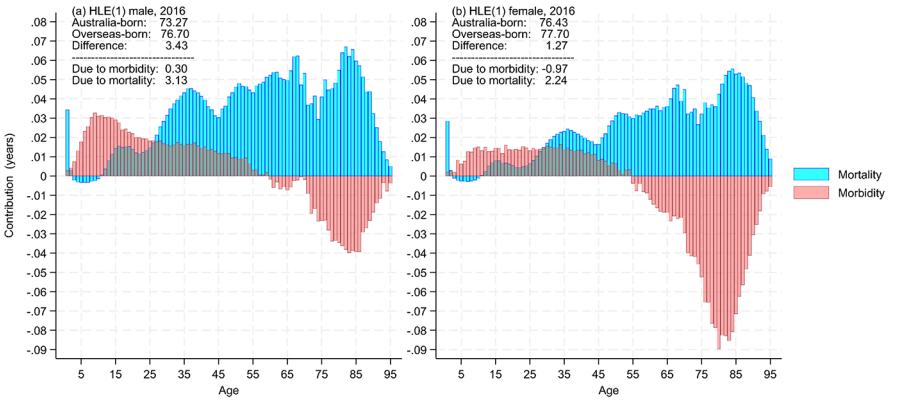

Fig. 2 Decomposition of the Differences in HLE at Age One between the Australia-born and Overseas-born Populations by Gender, 2016

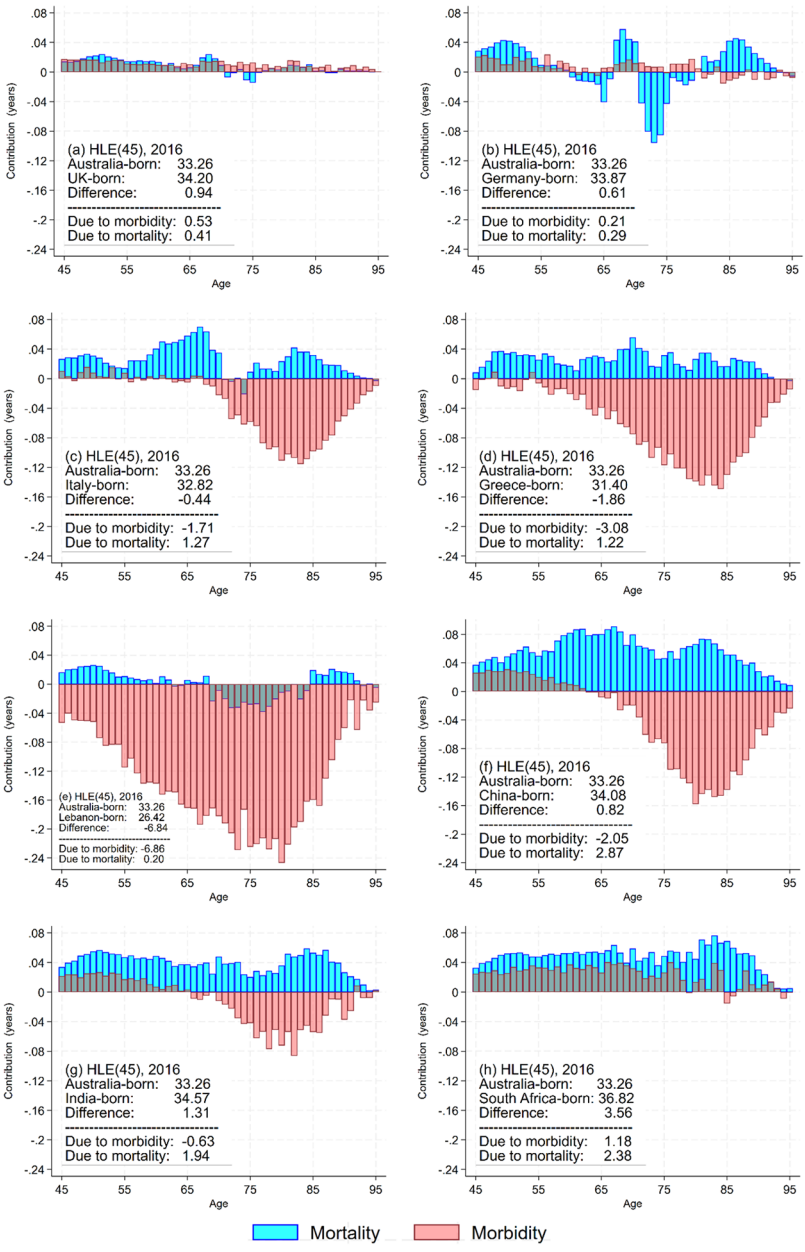

Fig. 3 Decomposition of the Differences in HLE at Age 45 between the Australia-born Population and Eight Major Migrant Groups, 2016

place of birth and the decomposition results of HLE differences at age one by place of birth in 2006 and 2011 were highly consistent with the above findings derived from the data in 2016, demonstrating a high robustness of the above findings.

Conclusion and discussion

Migrant health has been increasingly recognised as an important issue of public health in many migrant-receiving countries, and is attracting growing attention from governments, health practitioners and the public. This study provides a new understanding of how the healthy migrant effect manifests differently in relation to mortality and morbidity, as well as how the different manifestations of the migrant-native health disparities in mortality and morbidity change over the life course. The results demonstrate that the overseas-born population overall lived longer than the Australia-born population, but they had a lower HLE after age 65 and a lower HLE/LE ratio throughout all ages. The results also demonstrate that the overseas-born population's higher HLE was largely attributable to migrants' lower mortality, however, it was partly offset by the negative contribution by migrants' overall higher morbidity. Further, the positive contribution due to migrants' lower mortality was particularly prominent among young migrants, male migrants and those born in China, India and South Africa, while the negative contribution due to the overseas-born population's higher morbidity was particularly pronounced for migrants aged above 55, female migrants and migrants born in Lebanon, Italy, Greece, China and India.

The results of this study are in line with the previous studies finding that migrants enjoy a health advantage in mortality but do not have a similar health advantage in morbidity (Forna et al., 2003; Dobson et al., 2004; Hodge et al., 2004; Araneta & Barrett-Connor, 2005; DesMeules et al., 2005; Trajkovski & Loosemore, 2006; Vang et al., 2017). However, by recognising this pattern, this study further demonstrates that the pattern of health differences between migrants and natives varies by age. That is, young migrants enjoy a pronounced health advantage over their young native-born counterparts, in relation to both mortality and morbidity. However, early-life migrants and older migrants manifest only a minor health advantage over similarly aged native-born individuals and their health advantage is largely attributable to mortality. Notably, older migrants even suffer dramatically worse morbidity outcomes, which diminishes their advantage in mortality and results in overall worse health outcomes than that experienced by native-born older adults. These results suggest that the healthy migrant effect, both in mortality and in morbidity, is not evenly distributed by age group and manifests differently when migrants age in the host society.

While the age variations of the healthy migrant effect are puzzling, they can be plausibly explained by two factors: the different levels of stringency applied in the migration selection process for migrant groups of different ages and the negative effect of acculturation on migrants' health. First, compared with early-life migrants and older migrants, young migrants are more likely to migrate for work-related opportunities, and thus, they need to meet established health

requirements for employment and are therefore more likely to arrive in the host country in better health (Gubernskaya et al., 2013). However, early-life migrants tend to migrate following their parents while late-life migrants for the purpose of family reunification. Neither of these two migrant groups necessarily require health examinations as stringent as that experienced by young migrants. Therefore, these two groups of migrants may have weaker health advantages given the differences in health screening during the selection process for migration (Angel et al., 2010; Treas, 2015). Second, adaption to a new cultural environment is not a smooth process and might be stressful and accompanied by cultural, social and financial problems (Berry, 1997, 2000). Therefore, the health advantage of migrants at young ages might be reduced by acculturation-related challenges, such as homesickness, discrimination, stigmatisation, poor living conditions and limited knowledge of and access to health and care resources (Jasso et al., 2005; Dey & Lucas, 2006; Jasinskaja-Lahti et al., 2006; Fennelly, 2007; Safi, 2009; Huijts & Kraaykamp, 2012). The adverse effects of acculturation on migrants' health might be strengthened by migrants' ageing process, which also causes a decline in socioeconomic resources and health status in all populations (Jasinskaja-Lahti et al., 2006). Moreover, migrants migrating in old age are more likely to be socially isolated and less acculturated to the receiving society than are early-life migrants and young migrants, because of their lack of social networks and supports, language barriers and cultural maladjustment (Mui & Kang, 2006). Therefore, migrants are more likely to manifest a reduced health advantage in old age compared with migrants at other age groups.

This study also finds that when the health advantage of migrants diminishes with age, this diminishment proceeds more drastically in morbidity than in mortality. This suggests that migrants are more prone to suffering a reduced quality of life rather than a shortened lifespan during their acculturation process in the host society. The different rates of decline of migrants' health in mortality and morbidity are intriguing and might be explained by the different ways in which the post-migration environment affects mortality and morbidity, and by the accumulated negative effect of acculturation on migrant's health, which might intensify over time. That is, the negative experiences that migrants suffer in receiving societies (e.g. discrimination, stigmatisation and worse living conditions) generally affect migrants' health but not drastically. For example, perceived discrimination, which is a common risk to migrant health, is consistently found to be closely associated with unfavourable health outcomes, from both physical and mental health as well as self-assessed health status (Pascoe & Smart Richman, 2009; Williams & Mohammed, 2009; Agudelo-Suárez et al., 2011). However, findings about the effects of discrimination on mortality are largely inconsistent and suggest that the effect is indirect (Albert et al., 2010; Sutin et al., 2015; Farmer et al., 2019). Therefore, the effects of acculturation-related challenges on migrants' health are not generally life threatening, and hence, are less significant for mortality rates than for morbidity rates. Additionally, migrants' stressful experiences related to acculturation and integration can accumulate through the life course and this negative effect on migrants' health might intensify over time. Previous studies have demonstrated that health disorders accumulated during young age and mid-

life predict an accelerated deterioration in health and wellbeing (e.g. cognitive dysfunction and fragility) in later life (Kulminski et al., 2006, 2007; Elliott et al., 2019). Thus, stressful life events of migrants accumulated through the long-term acculturation process might accelerate migrants' health deterioration with longer duration of residency. This acceleration in health deterioration is expected to be more prominent in migrants' morbidity outcomes given that migrants' morbidity rates are more directly and more prominently affected by the negative effect of acculturation than are their mortality rates.

The results of this study also demonstrate that female migrants suffer a faster decline in health status than do male migrants. This suggests that female migrants are more vulnerable than male migrants to the adverse effects of acculturation in the post-migration environment. The greater vulnerability of female migrants' health during the acculturation process might be caused by female migrants' having less-stringent migration selection requirements (Trovato & Odynak, 2011; Garcia et al., 2017) and the greater likelihood of them being socioeconomically disadvantaged in the receiving society (Garcia et al., 2015). For example, among the recent migrants in Australia (i.e. those arriving after 2009), the proportion of family stream migrants was 45.7% among female migrants, which is significantly higher than that of male migrants (25.4%), whereas the proportion of skilled migrants was 44.6% for female migrants, which is substantially lower than for male migrants (61.4%) (Australian Bureau of Statistics, 2020). Given that family reunion migration is less likely to require health examinations than employment migration, female migrants are less likely to be selected in relation to their health status during the migration process. In addition, due to traditional cultural expectations of males as wage earners and women as caretakers, female migrants from some cultures are less likely to participate in the labour market in the host society. In Australia, 25% of recent female migrants and only 11.7% of recent male migrants have not had a job since arrival (Australian Bureau of Statistics, 2020). The lower probability of being employed might result in female migrants' having a higher level of financial dependency and fewer opportunities for outdoor social interaction and participation. This might increase the difficulties associated with acculturation for female migrants and thus have an adverse effect on their health over the life course.

This study also observed remarkable variations in the healthy migrant effect by country of birth. This heterogeneity in the health outcomes of migrants from different origin countries might arise because of the differences in levels of sociocultural similarity between sending and receiving societies. Specifically, migrants to Australia born in the UK, Germany and South Africa (the majority of South African migrants originate from Western Europe and are English speaking) (Lucas et al., 2006; Wasserman, 2018) share very similar cultural elements with the Australia-born population, such as native language, food, customs, ethnic heritage and religious beliefs. This helps them adapt more smoothly and quickly to Australian society after arrival, and thus are less likely to have negative experiences during the acculturation and integration process. In contrast, the origin societies of migrants from the other five countries, particularly those of China, India and Lebanon, are greatly different from the Australian society. Thus, migrants from

these culturally different societies might face greater acculturation-related and health-threatening challenges in the process of acculturation and integration into the Australian society and hence do not have health advantage in both mortality and morbidity.

The results of this study have profound implications for Australia and other migrant-receiving societies to optimise their policy formulations to improve migrant health outcomes. First, the healthy migrant effect should not be taken for granted and it can be enhanced if more appropriate and targeted programmes and services are in place to help migrants become better and more easily acculturated and integrated into the society, culture and economy of the receiving country. Second, it is suggested that multiculturalism and cultural diversity be promoted to help reduce the negative experience of acculturation. These measures would help lead to eliminating discrimination and building culturally inclusive social environments, and would therefore be helpful for migrants, particularly those from culturally different countries, in developing a sense of belonging and of having social value in the receiving society. Third, given the rapid decline of migrants' health status in old age, targeted measures to mitigate the deterioration of migrants' health over time are needed. These measures might include promotion of healthy ageing over the entire life course and the provision of pertinent health and aged care services for older migrants from culturally and linguistically diverse background. Such measures need to consider that acculturation/integration are ongoing, dynamic processes - people may revert to culture and language in later life and that cultural and linguistic differences are also dynamic due to new and emerging migrant groups. Fourth, it is suggested to create policies to improve the autonomy and financial independence of female migrants, which would benefit female migrants by allowing greater opportunity and resources to fully acculturate to the host society and thus would improve the health and well-being outcomes of this group.

This study also has several limitations. First, migrant health is affected by a wide range of societal factors as well as individual factors, including age of migration, the type of visa category, the generation of migrants and the socioeconomic profiles of the areas in which the migrants reside in the host society (Cho et al., 2004; Huijts & Kraaykamp, 2012; Garcia et al., 2017). However, given the limitation of data, this study was unable to incorporate these dimensions when examining the differences in migrants' LE and HLE. Second, this study has not examined the age variations of LE and HLE of migrants younger than age 45 by country of birth because of small population size of certain migrant groups. With further data available (e.g. combined mortality data over five or ten years), future studies should investigate changes in LE and HLE at young ages by country of birth. Third, LE and HLE in this study are estimated using the period life table method and the Sullivan method, which rest on the assumption that the mortality and morbidity data of a certain period represent the actual experiences of a cohort of the population. This means that LE and HLE estimated in this study are not based on the data of a real cohort of the population over the entire life course. However, the period life table method and the Sullivan method are standard methods in computing LE and HLE and are widely used in the existing

literature. Fourth, the Sullivan method might produce underestimated (or overestimated) results of HLE if transition rates of different health status are not smooth and regular over time. Given that incidence rates between states of health might change during the period 2006–2016 (e.g. ratio of HLE/LE declined slightly but continuously in 2006, 2011 and 2016 for both the Australia-born and overseas-born populations according to the robustness check), the results of HLE estimated by the Sullivan method in this study might include some bias. Fifth, given the small population size of the eight migrant subpopulations at the very old age and the overseas-born population at very young age, there might be yearly variations regarding the age-specific death rate at these ages, which might cause small biases in the estimates of the exact level of LE. Sixth, the data from the CPH is self-reported, which may be associated with self-reporting biases, such as social desirability bias and recall bias. For example, males may underreport undesirable health conditions due to social expectation of masculinity (e.g. being physically strong) (Verbrugge, 1985), which may lead to an overestimated proportion of being healthy, and hence, an overestimated HLE among males. Similarly, due to declined cognitive function with age, older adults might experience difficulties in reporting their previous health status (e.g. whether inability of conducting the three core activities is due to health conditions longer than six months); this may lead to inaccurate estimates of prevalence of being healthy, and hence, biased estimates of HLE at very old age. There are also studies demonstrating self-reporting biases in health data between different cultural backgrounds (e.g. Chinese are more likely to report self-health status as 'fair') (Kandula et al., 2007), which may also affect the estimates of HLE among the eight migrant groups. Despite these limitations, this study provides a comprehensive investigation of the healthy migrant effect concurrently considering mortality and morbidity and variations in migrants' health trajectory over the life course and among different migrant groups. The results of this study will assist government policymakers and aged care service providers to optimise the allocation of health and aged care resources and to improve quality of life outcomes for migrant communities that are increasingly more diverse and ageing in Australia and in many other migrant-receiving countries.

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Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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