Secular trends of life expectancy and disability-free life expectancy at age 65 and associated gender and area-level socioeconomic inequalities in Hong Kong: a serial cross-sectional study between 2007 and 2020

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Summary

Background Despite Hong Kong's world leading longevity, little is known about its associated disability burden and social patterning. Hence, this study assessed the gender-specific secular trends and area-level inequalities in life expectancy (LE) and disability-free life expectancy (DFLE) at age 65 in Hong Kong.

Methods Population structure, death records, and disability data in 2007, 2013, and 2020 were retrieved from the Census and Statistics Department to estimate LE and DFLE using the Sullivan Method. District-based sociodemographic indicators were used to compare LE and DFLE across 18 districts of Hong Kong in 2013.

Findings Between 2007 and 2020, LE at age 65 increased by 3.7 years (from 18.3 to 22.0) in men and by 2.1 years (from 22.7 to 24.8) in women. By contrast, DFLE increased more slowly, by 1.8 years (from 14.6 to 16.3) in men and by only 0.1 year (from 16.4 to 16.5) in women, leading to a substantial increase in proportion of life spent with disability. Results from multiple linear regression using district-based data in 2013 showed a similar extent of associations of education with LE and DFLE (mean year difference: 0.81 [95% CI: 0.14, 1.48] and 0.68 [0.10, 1.27], respectively, per 10% increase in average education level), while female gender was more strongly associated with LE (4.44 [3.56, 5.31]) than with DFLE (2.00 [1.18, 2.82]).

Interpretation Expansion of disability burden and male-female health-survival paradox hold true in Hong Kong. Unlike Western countries with a stronger socioeconomic patterning of DFLE, the extent of area-level socioeconomic inequalities in LE and DFLE appears to be more comparable in Hong Kong.

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Introduction

Since the first decade of the 21st century, Hong Kong has overtaken Japan to lead the world in life expectancy (LE) at birth, with 88.1 years for women and 82.2 years for men in 2019.[1] As a result of the post-war industrialization and rapid socioeconomic development, improvement of nutrition, advances in technology and medicine, and enhanced maternal and child healthcare,

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Research in context

Evidence before this study

Secular trends and social patterning of life expectancy and different types of healthy life expectancies have been well-documented in Western settings; nonetheless, relevant research is relatively scarce in Asian regions. We searched articles in PubMed and Google Scholar published between 1 January 2000 and 31 March 2023 using the terms "life expectancy", "health expectancy", "healthy life expectancy", "active life expectancy", "quality-adjusted life expectancy", "disability-free life year", "longevity", "trend", "inequalities", "gender", "sex", "socioeconomic status", "education", "area", "neighbourhood", "geographical", with specific focus on studies in high-income Western and Asian settings. Both English and Chinese articles were screened and assessed. Existing evidence shows that despite a general rising trend of life expectancy in most countries, the increase in healthy life expectancy (e.g., disability-free life expectancy, active life expectancy) does not keep up with the rise in life expectancy. Gender and socioeconomic differences have been highlighted in the existing literature. In general, a longer life expectancy with greater disability burden is commonly observed among women compared with men. As for socioeconomic difference, inequalities in healthy life expectancy are found greater than that in life expectancy in most Western settings but less apparent in Asian regions.

Added value of this study

Using data on mortality and disability rates among older adults in Hong Kong, a jurisdiction with world leading life expectancy, this study reaffirms the clear presence of the expansion of disability burden despite increased longevity and male-female health-survival paradox that women in Hong Kong are living a longer life but with greater disability than men. This study is also the first in Hong Kong to assess the area-level socioeconomic patterning of disability-free life expectancy in addition to its secular trend. Unlike Western countries, the extent of area-level socioeconomic inequalities in life expectancy and of disability-free life expectancy was comparable in Hong Kong, which largely echoes with the limited Asian studies in Japan, Singapore, and Taiwan.

Implications of all the available evidence

This study corroborates existing evidence conveying a strong message that it is not adequate to focus only on one place's life expectancy, which may work as a façade that conceals the problems related to disability. Disability-free life expectancy is a critical indicator to assess and monitor the progress of improvement not only in population health and healthy ageing but also offer a more comprehensive picture on the health equity situation of a society.

the mortality rates and living conditions nowadays have greatly improved compared to that in the 1950s.[2] The ever-increasing policy attention on non-communicable diseases, especially via tobacco control, may have also facilitated the further increase in LE over the more recent decades.[3] Nonetheless, an improved LE does not necessarily reflect better health state of people before death. Given the significant influences of lifestyles, comorbidities, and physical and mental functioning throughout the life-course, it is equally, if not more, important and relevant to examine the overall quality of life of a population.

The paradigm shift to one's functioning and quality of life from simply emphasizing on the quantity of life alone has eventually led to the development of health expectancy. Despite variations in measurement, health expectancy is broadly defined as *"the average number of years that a person can expect to live in "full health" by taking into account years lived in less than full health due to disease and/or injury"*.[4] In other words, it is a single composite measure that takes into account both mortality and health beyond the conventional focus on LE. In addition to health expectancy at birth, the World Health Organization also advocated for the use of health expectancy at old age (e.g., 60, 65 or 70 years) and the associated proportion of life years lived in a healthy state to evaluate the progress of healthy ageing of a society in terms of expansion or compression of morbidity among older adults.[5]

Specifically, disability has emerged as a major public health challenge despite Hong Kong's world leading longevity—the overall disability prevalence rapidly rose from 5.2% to 8.1% between 2007 and 2013, which was also coupled with increasing age-specific disability rates.[6] Nonetheless, the estimates and secular trends of disability-free life expectancy (DFLE) have rarely been reported in previous local studies. Using the disability prevalence of Hong Kong estimated from the WHO's Global Burden of Disease (GBD) study, Law and Yip[7] reported DFLE, estimated by the Sullivan's method, of 70.3 years for men and 75.7 years for women based on the GBD estimates in 2000, whereas Zhou et al.[8] reported 72.1 years and 74.8 years, respectively for men and women, based on the GBD estimates in 2015. Alarmingly, these reported DFLE increased only by two years in men and even dropped in women despite an overall rising trend of LE for more than three years for both genders between 2000 and 2015 in Hong Kong.

Apart from the secular trends and potential gender difference between LE and DFLE, their associated socioeconomic inequalities deserve further research and policy attention, especially in Hong Kong given its persistently high GINI coefficient (between 0.525 in 2001 and 0.539 in 2016) over the past two decades[9] and

the well-documented health inequalities.[10] To this end, the framework of social determinants of health inequalities has been widely adopted to investigate the potential discrepancies in health outcomes and the resultant health expectancies through the lens of social epidemiology. Taking the *Marmot Review*[11] in 2010 as an example, Marmot demonstrated the presence of area-level socioeconomic gradients of LE and DFLE in the UK. More importantly, the Review also highlighted the steeper gradient of DFLE than that of LE, which revealed a more complicated picture of the poorer social determinants of health faced by the disadvantaged.[11] In particular, the more socially disadvantaged tend to have shorter lives, and with greater proportion of life with disability. Hence, the concept of DFLE is critical for assessing the progress of improvement not only in population health but also the health equity situation of a society.

Despite the recognition of the concept and social patterning of DFLE in the public health agenda of many world regions (e.g., the Public Health Outcomes Framework for England), it has not yet received adequate attention from policymakers in Hong Kong. To the best of our knowledge, while the Hong Kong Government has been continuously monitoring the trend of LE, no official statistics on DFLE of the overall Hong Kong population has ever been published over the past decades, let alone its disparities across the social ladder. Also, no existing local studies have attempted to examine the area-level socioeconomic gradient of DFLE as reported in the *Marmot Review*. In the light of the identified knowledge gaps, this proposed study assessed the secular trends of LE, DFLE, and the proportion of life spent without disability at age 65 over the recent two decades in Hong Kong, and examined their social patterning across gender and area-level socioeconomic status.

Methods

As a secondary data analysis, we retrieved data on the age-gender specific rates of mortality and disability in Hong Kong, as well as the population structure and Hong Kong life tables in corresponding years from existing data sources. The analysis was divided into two parts. We first assessed the gender-specific secular trends of LE, DFLE, and the proportion of life spent without disability at age 65 between 2007 and 2020. Data sources required for assessing the secular trends included (i) mortality rates and LE retrieved from the official Hong Kong life tables and (ii) estimated disability rates in 2007, 2013, and 2020. Then, we performed a district-based analysis to examine the socioeconomic inequalities across 18 districts among community-dwelling older adults in 2013. Data sources available for the district-based analysis included (i) estimated disability rates of community-dwelling older adults by 18 District Council districts, (ii) mortality records by districts, and (iii) district-based indicators including population size and sociodemographic characteristics. We have summarized the data sources in a flowchart (Appendix 1) and described in detail below.

Assessment of secular trends between 2007, 2013, and 2020

Hong Kong life tables

The official Hong Kong life tables published by the Census and Statistics Department (C&SD) annually report the age-gender mortality rates, total person-years lived after a given age, and the official estimated LE for the overall Hong Kong population.[12] As the current study focused on older adults aged 65 years or above, we retrieved the respective data from age 65 for both genders in 2007, 2013, and 2020.

Disability data

The age-gender specific rates of disability among adults aged 65 or above estimated in the General Household Surveys (GHS): Special Topics Reports No. 48, 62, and 63 were obtained from the C&SD, with both community-dwelling and institutionalized samples collected in 2007, 2013, and 2020, respectively.[6] The community-dwelling households were sampled from randomly selected quarters in all permanent quarters of built-up areas and from quarters in segments of non-built-up areas using a sampling frame maintained by the C&SD covering about 99% of the Hong Kong resident population. In total, the numbers of sampled households were 41,000 (1.8% of all households with a response rate of 87% in 2007), 33,000 (1.4% of all households with a response rate of 80% in 2013), and 40,600 (1.5% of all households with a response rate of 72% in 2020). Regarding the institutionalized samples, a two-stage stratified sampling design was adopted. A random sample of institutions was first drawn from an up-to-date list of all institutions in Hong Kong stratified by type of service (related to the main disability type of residents). Then, a pre-determined proportion of residents was systematically selected from each of the sampled institutions. In total, the numbers of sampled institutionalized residents were around 1800 (from 100 institutions with a response rate of 91% in 2007), 1800 (from 120 institutions with a response rate of 90% in 2013), and 1700 (from 130 institutions with a response rate of 87% in 2020).

In the GHS surveys, persons with disabilities were defined as *"those with restriction of or those who lack ability to perform an activity in the manner or within the range considered normal for a human being."* Respondents were first asked to report whether they have one or more of the following four impairment conditions (i.e., restriction in body movement, seeing difficulty, hearing difficulty, and speech difficulty) which had lasted, or were likely to last, for a period of 6 months or more, as well as

whether they have one or more of the following diagnosed conditions (i.e., mental illness/mood disorder, autism, specific learning difficulties, and attention deficit/hyperactivity disorder, and intellectual disability).[13] Nonetheless, intellectual disability was excluded in this study to avoid distortions and misleading results due to the considerable underestimation of persons with intellectual disability via surveys. Subsequently, those reporting any of the above conditions were asked to what extent they had difficulties in day-to-day living due to these conditions (i.e., no difficulty, some difficulty, a lot of difficulty, and cannot do at all).[13] In the present study, respondents who reported at least some difficulty in day-to-day living due to any of the above conditions, including those who need specialised aids or tools to restore functioning in daily life, were considered having disability. The resultant disability rates were estimated by the weighted average of the estimates from the community-dwelling and institutionalized samples (Appendix 2). Further information on the data collection, methodologies, and limitations for measuring disability were detailed in the corresponding GHS Special Topics Reports.[6]

District-based analysis using data of community-dwelling samples in 2013

Disability data

Specifically for GHS Special Topics Report No. 62, disability rates across 18 District Council districts in the community-dwelling sample were available for purchase from the C&SD (Appendix 3), which enabled the estimation of DFLE across districts in 2013. Sampling method of the community sample, definition of disability, and measurement methods of impairment and extent of difficulty were reported above.

Mortality record

As mortality rates and LE in the Hong Kong life tables are not stratified by districts, mortality record was purchased from the C&SD to retrieve data on known registered deaths in Hong Kong by age, gender, and area of residence in 2013 (Appendix 4). With the Tertiary Planning Units (TPUs) demarcated by the Planning Department of the Hong Kong Government for town planning purposes, the mortality records can be regrouped by the 18 District Council districts of Hong Kong. To calculate the mortality rates, the observed numbers of death by age, gender, and districts were divided by the corresponding population sizes. Cases with missing values on TPU in the mortality record were discarded listwise due to a small proportion of missing values (0.66%).

Sociodemographic indicators

Data on population size and relevant demographic and socioeconomic indicators across 18 District Council districts were retrieved from the report *"Population and Household Statistics Analysed by District Council District 2013"* published by the C&SD, which covered all land-based non-institutionalized population in Hong Kong.[14] Educational attainment is of primary interest because it is the most fundamental socioeconomic indicator that captures the transition from childhood to adulthood and acts as a strong determinant of other socioeconomic factors such as occupation, income, and housing.[15] Given that the 9-year universal education was not guaranteed for children in Hong Kong before the late 1970s, older adults who had access to secondary education back then had a socioeconomic advantage over those who had only primary education or below. Therefore, the proportion of older adults attaining secondary education or above was adopted as the primary area-level socioeconomic indicator of this study. Nonetheless, as socioeconomic position is a multidimensional concept,[15] we have also retrieved other relevant socioeconomic factors from the report including income (i.e., proportion of low-income families with a monthly household income below HK$10,000, approximately equivalent to US$1280) and housing (i.e., proportion of owner-occupier households) to assess whether the association of area-level education level is independent of other socioeconomic indicators. It is also worth noting that occupation and employment status was not included as this study focused on older adults, most of whom have already retired. Moreover, the association of area-level socioeconomic indicators is prone to confounding by the demographic characteristics across districts. Therefore, we also adopted additional district-based indicators including the proportion of people aged 75 years or above among all older adults and the proportion of married population for confounding control, in addition to gender.

Statistical analysis

LE and DFLE were estimated based on the Sullivan method, which is one of the most widely used approaches for combining mortality and morbidity into a single summary health measure using cross-sectional data.[16] The above-mentioned information on the age-gender specific mortality and disability rates in 2007, 2013, and 2020 were inputted into the abridged period life tables with five-year age bands (i.e., 65–69, 70–74, 75–79, 80–84, and 85 or above) stratified by gender and districts. The method of LE estimation across 18 districts was consistent with the template published by Public Health England,[17] in which age-gender specific disability rates were used in the abridged period life tables to estimate DFLE. As survival in the final age group was assumed to be exponential, the number of years lived in the "85 or above" age group was derived by the number of survivors at the start of the age interval divided by the observed age-specific mortality rate. Hence, the gender-specific secular trends of LE and DFLE, as well as the proportion of life spent without

disability (i.e., DFLE divided by LE), were assessed and graphically illustrated. As for the district-based analysis in 2013, multivariable linear regression, weighted by population size across districts, was employed to examine the associations of gender and the above-mentioned district-based demographic and socioeconomic indicators with LE, DFLE, and the proportion of life spent without disability, respectively. Assumptions of the absence of multicollinearity, normality of residuals, homoscedasticity, and linearity of associations were tested (Appendix 5–7). While the test results supported linearity of associations ($p > 0.05$ in the Ramsey Regression Equation Specification Error Tests for all models) and the absence of multicollinearity (all variables with a variance inflation factor <5), we observed violations of normality of residuals for the regression against LE ($p = 0.011$) and the presence of heteroscedasticity for the regression against the proportion of life spent without disability ($p = 0.031$). To account for these assumption violations, unbiased standard errors were obtained by using the Huber-White sandwich estimator to estimate the variance–covariance matrix corresponding to the estimates. Effect modification between socioeconomic indicators and gender was also tested by including the interaction term into the regression model. The statistical software Stata version 17, R version 4.3.1, and Microsoft Excel were used for data analyses, which were two-tailed with the significance level of $p < 0.05$.

Role of the funding source

The funder of this study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Descriptive analysis on the secular trends of LE and DFLE at age 65 between 2007 and 2020 in Hong Kong showed an increasing LE from 18.3 to 22.0 years and from 22.7 to 24.8 years in men and women, respectively (Fig. 1). Nonetheless, the corresponding trend of DFLE over the same period did not entirely parallel that of LE but showed a smaller increase from 14.6 to 16.3 years in men and a negligible change from 16.4 to 16.5 years in women. As a result, the proportion of life spent without disability dropped substantially from 79.7% to 74.2% in men and from 71.9% to 66.3% in women between 2007 and 2020. In addition, the gender difference in LE reduced from 4.4 to 2.8 years, while that in DFLE substantially narrowed from 1.8 to only 0.1 years over the study period. Further breakdown of LE, DFLE, and the proportion of life spent without disability by age groups are presented in Table 1.

Table 2 shows the sociodemographic characteristics, LE, DFLE, and proportion of life spent without disability across 18 District Council districts in Hong Kong in 2013. Results from multivariable linear regression analysis showed positive associations of female gender (mean year difference = 4.44 [95% CI = 3.56, 5.31]) and area-level average education level (0.81 [0.14, 1.48], per 10% increase in percentage of older adults attaining secondary education or above) with LE, after adjusting for regional differences in the proportions of low-income families, owner-occupier households, adults aged 75 or above, and married population across districts (Table 3). As for DFLE, positive associations were also observed for education level (0.68 [0.10, 1.27], per 10% increase in percentage of older adults attaining secondary education or above) and female gender despite substantial attenuation (2.00 [1.18, 2.82]). Moreover, the proportion of life spent without disability was substantially lower in older women than in older men (mean difference in proportion = –6.26% [–9.06, –3.47] after adjustment for district-based characteristics). Nonetheless, no apparent difference by area-level education level was observed (0.18% [–1.94, 2.30], per 10% increase in percentage of older adults attaining secondary education or above). The proportion of variance accounted for by the regression models in terms of R^2 were 82.6% for LE, 60.2% for DFLE, and 60.8% for the proportion of life spent with disability. No effect modification between education level and gender was detected in all the above analyses.

Discussion

The present descriptive study showed that most of the LE gained between 2007 and 2020 were spent with disability and the proportion of disability-free life has been dropping considerably over years in Hong Kong. Also, while the gender difference in LE remained apparent, the advantage of DFLE in older women almost disappeared in 2020. The substantially lower proportion of disability-free life in older women than that in men suggested a particularly heavy disability burden under prolonged life in older women. Apart from the gender difference, there was also apparent socioeconomic gradient of LE and DFLE, but not the proportion of life spent without disability, across regions of different average education level in older adults.

Our finding that the change in DFLE could not keep up with the rise in LE is consistent with the international literature. A recent systematic review found greater gain in LE than DFLE in most high-income countries, leading to an expansion of disability at old age over the past decades.[18] Such a phenomenon is also supported by three earlier local studies on Hong Kong older adults. Cheung et al.[19] reported an increase in LE at age 65 for 1.58 and 2.06 years in men and women, respectively, between 1996 and 2008, but only for a 0.64 and 0.34 years in terms of DFLE. Decrease in DFLE was even observed for men aged 80 or above and women aged 75 or above. Also, Yu et al.[20] showed that life years

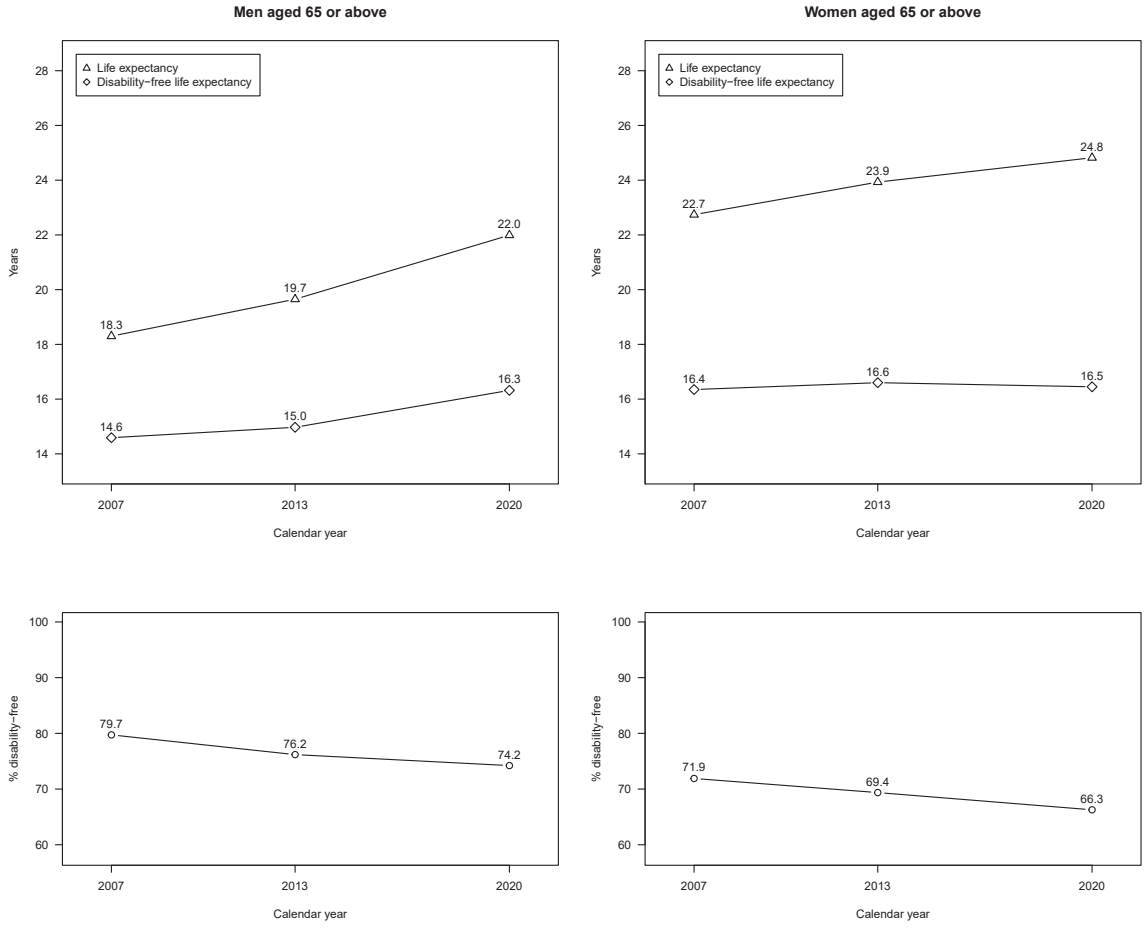

Fig. 1: Secular trends of life expectancy, disability-free life expectancy, and proportion of life spent without disability at age 65 in men and women between 2007 and 2020.

spent without physical or cognitive impairment increased to a lesser extent than LE between 2001/02 and 2011/12 in older women aged 65 or above, not to mention a decrease in life years without impairment in older men. Moreover, Zheng et al.[21] explicitly concluded an expansion of impairments and other ill-health conditions among people aged 50 years or above in Hong Kong between 2007 and 2016. Consistently, our finding showed a small increase in DFLE, especially in older women, despite the rising LE in Hong Kong due to a rapid surge in age-specific disability rates over the study period. Hence, the present study further enriched the international and local evidence supporting the expansion rather than compression of disability under increased longevity, where the discrepancy between LE and DFLE in Hong Kong has continued to widen in both genders.

Apart from the overall secular trends, it is also worth noting the greater gender difference in LE than DFLE over the study period. As almost universally observed across the globe, Pongiglione et al.[22] concluded in a systematic review on inequalities in health expectancy in older adults that all the identified studies converge to support a longer LE accompanied by a greater proportion of life with disability in older women. Our finding thus lends additional support to the male-female health-survival paradox[23] under the Asian context that Chinese women in Hong Kong are living with greater and ever-increasing disability burden than men in later life despite longer longevity. Moreover, as DFLE stalled in older women but slightly increased in older men over the study period, the gender difference in DFLE is no longer apparent in Hong Kong. This may be related to the exceptionally high LE in Hong Kong, given that a previous study showed that the advantage in health expectancies in women tended to be minimal or even reversed in populations with higher LE due to a reduced survival advantage with an increased disability disadvantage as compared to men in healthier populations.[24] In addition, an earlier study on a cohort of Singaporean older adults also reported comparable active life expectancies at age 60 between older men and women

	2007		2013		2020	
	Male	Female	Male	Female	Male	Female
At age 65						
Life expectancy (year)	18.3	22.7	19.7	23.9	22.0	24.8
Disability-free life expectancy (year)	14.6	16.4	15.0	16.6	16.3	16.5
% disability-free	79.7	71.9	76.2	69.4	74.2	66.3
At age 70						
Life expectancy (year)	14.6	18.4	15.8	19.6	18.2	20.5
Disability-free life expectancy (year)	11.0	12.3	11.3	12.6	12.6	12.4
% disability-free	75.2	66.8	71.6	64.2	69.3	60.4
At age 75						
Life expectancy (year)	11.3	14.4	12.3	15.5	14.8	16.3
Disability-free life expectancy (year)	7.8	8.7	8.1	8.8	9.3	8.7
% disability-free	69.4	60.3	65.3	57.1	63.0	53.4
At age 80						
Life expectancy (year)	8.5	10.9	9.3	11.7	12.1	12.5
Disability-free life expectancy (year)	5.2	5.7	5.4	6.0	6.7	5.6
% disability-free	61.5	52.4	58.3	50.9	55.3	44.6
At age 85						
Life expectancy (year)	6.3	8.1	6.8	8.6	10.0	9.3
Disability-free life expectancy (year)	3.3	3.5	3.4	3.6	4.7	3.4
% disability-free	52.5	42.9	50.4	41.8	47.3	36.3

Table 1: **Age-gender specific life expectancy, disability-free life expectancy, and proportion of life spent without disability in 2007, 2013, and 2020.**

(i.e., 18.9 and 18.1 years, respectively), which did not mimic the pattern previously observed in Western countries.[25] While it is true that earlier studies in Western countries generally revealed marked gender difference in DFLE by the early 2000s,[26,27] growing evidence from more recent trend studies, however,

	Socio-demographic characteristics						Life expectancy		Disability-free life expectancy		% disability-free	
	% secondary education or above	% low-income families	% owner-occupier households	% aged 75 years or above	% married	Population size	Male	Female	Male	Female	Male	Female
Central & Western	51.8	15.9	57.0	50.6	57.5	34,800	21.2	24.2	14.3	15.0	67.5	61.8
Wan Chai	60.7	17.4	59.8	50.8	58.8	24,600	21.5	23.9	13.6	15.7	63.2	65.8
Eastern	45.7	20.0	60.8	48.9	59.1	96,000	20.6	24.9	14.1	14.4	68.7	57.9
Southern	34.3	18.0	52.0	47.8	58.2	38,100	18.9	22.3	12.3	12.9	65.2	57.8
Yau Tsim Mong	45.6	22.4	55.6	48.4	59.2	45,700	18.3	22.7	11.5	14.0	63.0	61.6
Sham Shui Po	33.6	26.5	41.2	51.0	55.6	62,600	20.3	26.2	13.0	14.8	64.2	56.4
Kowloon City	46.4	20.2	53.6	50.1	59.0	60,700	19.2	23.9	13.9	15.5	72.2	64.8
Wong Tai Sin	22.8	24.7	41.3	53.1	53.6	72,700	19.3	24.8	12.9	13.3	67.2	53.5
Kwun Tong	30.9	27.0	32.1	50.8	56.1	105,600	19.7	25.7	13.2	15.6	67.3	60.7
Kwai Tsing	26.5	24.3	33.4	44.3	56.7	74,100	18.8	24.0	12.2	13.1	65.2	54.6
Tsuen Wan	38.9	19.7	57.8	47.2	62.7	39,000	18.1	21.9	11.3	12.9	62.4	58.8
Tuen Mun	32.6	23.4	55.2	39.8	58.9	50,200	18.0	20.6	13.7	12.9	76.5	62.7
Yuen Long	30.1	21.0	49.8	45.6	57.4	55,000	18.6	22.6	13.8	15.3	74.0	67.8
North	26.4	20.1	59.4	46.7	58.2	31,500	17.8	20.8	13.6	14.6	76.5	70.1
Tai Po	33.5	17.4	64.5	45.0	59.0	32,000	17.9	21.3	13.2	15.0	73.9	70.4
Sha Tin	36.6	18.6	58.3	45.0	59.8	79,100	20.7	24.8	14.7	14.9	71.1	60.3
Sai Kung	39.1	14.1	65.5	43.1	59.7	41,500	18.6	22.9	13.7	15.2	73.6	66.4
Islands	40.6	21.1	43.4	47.3	58.6	14,600	23.8	27.5	12.9	11.8	54.3	42.9

Table 2: **Socio-demographic characteristics, life expectancy, disability-free life expectancy, and proportion of life spent without disability at age 65 among community-dwelling residents across 18 districts in Hong Kong in 2013.**

	Life expectancy		Disability-free life expectancy		% disability-free	
	Mean difference [95% CI]	*p*-value	Mean difference [95% CI]	*p*-value	Mean difference [95% CI]	*p*-value
Female (versus male)	4.435 [3.560, 5.310]	<0.001	2.000 [1.178, 2.822]	<0.001	−6.263 [−9.056, −3.470]	<0.001
% secondary education or above	0.081 [0.014, 0.148]	0.019	0.068 [0.010, 0.127]	0.023	0.018 [−0.194, 0.230]	0.861
% low-income families	−0.060 [−0.280, 0.159]	0.578	−0.076 [−0.259, 0.106]	0.399	−0.086 [−0.699, 0.527]	0.776
% owner-occupier households	−0.068 [−0.145, 0.009]	0.082	0.002 [−0.070, 0.074]	0.955	0.268 [−0.024, 0.560]	0.071
% aged 75 years or above	0.107 [−0.042, 0.256]	0.154	0.034 [−0.132, 0.200]	0.680	−0.233 [−0.752, 0.286]	0.366
% married	−0.127 [−0.455, 0.201]	0.435	−0.189 [−0.599, 0.221]	0.354	−0.504 [−1.684, 0.676]	0.389

Table 3: **Associations of gender and district-based socio-demographic indicators with life expectancy, disability-free life expectancy, and proportion of life spent without disability at age 65.**

supports a diminishing gender difference in DFLE or other health expectancies in these countries. For example, a research in the United States by Freedman et al.[28] explicitly concluded that the advantage in DFLE at age 65 in women over men observed in 1982 was no longer present in 2011, whereas another study in England by Jagger et al.[29] even reported a higher DFLE at age 65 in men (12.9 years) than women (11.5 years) in 2011 due to a much smaller gain in DFLE in women (0.5 versus 2.6 years in men) since 1991. Therefore, our finding on diminishing gender difference in DFLE is largely consistent with the recent international trend.

In addition to gender difference, the extent of socioeconomic patterning between LE and DFLE also appear to differ across settings. While most existing studies in the Americas and European countries supported greater socioeconomic inequalities in health expectancies than LE,[30,31] the two gradients seemed more comparable at both neighbourhood and individual levels in Asian settings. For example, both the *Health Inequalities in Taiwan* report and another recent research in Japan showed comparable gradients in LE and DFLE by area-level relative deprivation.[32,33] In terms of individual-level educational difference, a previous study by Chan et al.[25] also reported comparable educational patterning between LE and active life expectancy in Singaporean older adults. Also, Yong and Saito[34] reported a slightly greater individual-level educational difference in DFLE (about 2.5 years) than in LE (about 2 years) in Japan despite a weaker education–health relationship as compared to the Western countries, plausibly due to Japan being a relatively egalitarian society with lower social inequalities. Such findings are in line with our observations in Hong Kong on the comparable extent of area-level educational inequalities between LE and DFLE. Although welfare regimes may determine the prevalence and socioeconomic patterning of disability, such explanation may be insufficient to explain the case in Hong Kong given its extraordinarily high income inequality with post-tax post-social transfer Gini coefficients of 0.473–0.475 between 2006 and 2016.[9] Other contextual and historical factors specific to Hong Kong should be considered when interpreting our findings. For example, the compact and highly interconnected urban planning in Hong Kong as a small city may offset the area-level disadvantage of low education in terms of access to amenities, services, and other health-promoting social resources within the neighbourhood community, unlike the Western countries where the slum areas are segregated from the residential areas for the middle and upper classes.[35,36] From a historical perspective, the mass influx of Mainland immigrants who survived the Chinese Civil War in the 1950s, who tended to have lower educational attainment than the natives,[37] may have led to the healthy migrant effect especially among the less educated older adults nowadays; thereby resulting in a relatively less apparent educational patterning of disability and DFLE at old age in Hong Kong. Further studies are warranted to delineate other possible drivers for the comparable area-level socioeconomic inequalities between LE and DFLE in Hong Kong.

Public health implications

Given its currently leading LE across the globe, Hong Kong seems to also fare better in terms of DFLE when compared with other developed settings. Despite the variations in disability measurements, our estimated DFLE at age 65 in Hong Kong (i.e., 16.3 years in men and 16.5 years in women in 2020) was substantially greater than DFLE at 65, defined as number of years spent free of activity limitation, reported by 26 member countries of the Organisation for Economic Co-operation and Development, which averaged at 9.4 years in men and 9.6 years in women in 2017 or the latest year.[38] However, with the continuous decline in the proportion of life without disability (i.e., the expansion of the disability burden) among older adults in Hong Kong, it is questionable how long the DFLE advantage will last in Hong Kong. This trend is particularly concerning given the rapidly aging population and rising dependency ratio in Hong Kong, which places overwhelming caregiving demand and significant cost on health and social care. Moreover, the presence of socioeconomic inequalities in health expectancies across districts highlights the inadequacies of current efforts to address the underlying social determinants of health with an equity focus. Our findings underscore the

urgent need for comprehensive policy approaches to promoting healthy aging for all. Specifically, the report *"The United Nations Decade of Healthy Ageing: Plan of Action 2021–2030"* highlighted four key areas for actions on (i) tackling ageism and negative stereotypes towards older adults, (ii) ensuring an age-friendly living environment in the community, (iii) delivering person-centred primary care services in response to their health needs, and (iv) offering equitable access to long-term care to older adults in need.[5] Furthermore, policymakers in Hong Kong should go beyond focusing on its achievement in LE but enhance the health surveillance system by including DFLE at birth and at old age, as well as the proportion of life spent without disability as routinely reported vital statistics to better monitor the progress of population health, healthy ageing, and equity.[39] The adoption of the above priority policy actions could enable older adults of the next generation in Hong Kong to live longer with greater independence and quality of life while also reducing the otherwise anticipated burden on health and social care systems in the coming decades.

Strengths and limitations

The present study is the first attempt in Hong Kong to assess the area-level socioeconomic patterning of DFLE in addition to its secular trend. Nonetheless, several limitations should be noted. First, the Sullivan method for DFLE calculation relied on the cross-sectional prevalence of disability in each survey year rather than incidence and transition among health states, assuming the observed prevalence is equal to the equilibrium of multi-state transition rates. Nonetheless, as the multi-state life-table method requires large-scale longitudinal data which are not available at regular basis, the Sullivan method is suitable for population health monitoring on the secular trends of LE and DFLE. Second, as the disability data were self-reported, the accuracy of estimated disability rates depends on respondents' health awareness and ability to recognise and recall functional difficulties resulting from disability. Overall, as the definition of disability varies across relevant studies in the literature, the estimated DFLE should be interpreted and compared with caution. Third, while we were able to retrieve the disability rates from the General Household Surveys conducted by the Census and Statistics Department, detailed information on the sample size across age and gender groups were not provided to calculate the confidence interval of the estimated DFLE. Fourth, the survey response rate among community-dwelling households in 2020 was relatively lower at 72% compared with 87% in 2007 and 80% in 2013, likely due to the COVID-19 pandemic. Nonetheless, no information on age-specific response rate, number of missing data, and demographic characteristics in the non-response households was available to assess its potential bias on the representativeness of the sample. Fifth, specifically regarding the district-based analysis, the mortality and disability data by 18 districts in 2013 covered only the community-dwelling older adults but excluded the institutionalized persons; therefore, the district-based LE and DFLE were slightly underestimated compared with those for the overall population. Sixth, disability rates in 2013 were only available at District Council district level but not at smaller area level. Despite the fact that districts in Hong Kong are relatively small when compared to other jurisdictions as Hong Kong is a small administrative region, the geographic definition of districts may not be small enough to show differences due to the mixed population characteristics and to account for the potentially high variability within each district with the use of mean summary measures of district-based indicators at arbitrary thresholds based on available data. Relatedly, as district-based disability data were only available in 2013 but not in 2007 and 2020, the potential space–time interactions cannot be assessed by spatio-temporal analyses. Lastly, as the available district-based indicators in 2013 are not exhaustive, residual confounding may be present due to other potential factors such as deprivation of basic necessities, asset, ethnicity, migrant status, and the burden of other chronic diseases.

Conclusion

Despite the rising trend of LE at age 65, most of the extra LE was spent with disability due to the small increase in DFLE, especially in women, between 2007 and 2020 in Hong Kong. The male-female health-survival paradox holds true in Hong Kong as the female advantage is much stronger for LE than DFLE, implying that women are living a longer life but with greater disability than men. In addition, apparent socioeconomic patterning was found for both LE and DFLE across districts; nonetheless, in contrast with the stronger socioeconomic patterning of DFLE than LE in most Western countries, the socioeconomic gradients of LE and DFLE appears to be more comparable in Hong Kong, possibly due to the less segregated neighbourhoods and the post-war influx of healthy migrants with relatively low socioeconomic position from the Mainland China in the 1950s. Historical and contextual factors should be taken in account when interpreting the extent of socioeconomic patterning of LE and DFLE across different settings. To further improve longevity in good health especially in the relatively disadvantaged groups, policymakers are encouraged to work towards mitigating the existing gender and socioeconomic inequalities in disability.

Contributors

GKC contributed to literature search, study design, data analysis, result interpretation, and manuscript write-up. RYC was responsible for study design, result interpretation, and oversaw the project as the Principal Investigator. IYH assisted in literature search, data management, and analysis. MM, SC, ETL, HW, SYW, EY, and JW contributed to study design and result interpretation. JW also provided guidance on manuscript write-up. All authors critically appraised and approved the manuscript.

Data sharing statement

The data that support the findings of this study are available from Census and Statistics Department of the Hong Kong Government, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of Census and Statistics Department of the Hong Kong Government.

Ethics approval and consent to participate

No ethical approval is required as we conducted secondary data analysis using existing surveys conducted by the Census and Statistics Department of the Hong Kong Government. All procedures involving human participants were in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Editor note

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Declaration of interests

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2023.100909.

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