Understanding longevity in Hong Kong: a comparative study with long-living, high-income countries

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Summary

Background Since 2013, Hong Kong has sustained the world's highest life expectancy at birth—a key indicator of population health. The reasons behind this achievement remain poorly understood but are of great relevance to both rapidly developing and high-income regions. Here, we aim to compare factors behind Hong Kong's survival advantage over long-living, high-income countries.

Methods Life expectancy data from 1960–2020 were obtained for 18 high-income countries in the Organisation for Economic Co-operation and Development from the Human Mortality Database and for Hong Kong from Hong Kong's Census and Statistics Department. Causes of death data from 1950–2016 were obtained from WHO's Mortality Database. We used truncated cross-sectional average length of life (TCAL) to identify the contributions to survival differences based on 263 million deaths overall. As smoking is the leading cause of premature death, we also compared smoking-attributable mortality between Hong Kong and the high-income countries.

Findings From 1979–2016, Hong Kong accumulated a substantial survival advantage over high-income countries, with a difference of 1·86 years (95% CI 1·83–1·89) for males and 2·50 years (2·47–2·53) for females. As mortality from infectious diseases declined, the main contributors to Hong Kong's survival advantage were lower mortality from cardiovascular diseases for both males (TCAL difference 1·22 years, 95% CI 1·21–1·23) and females (1·19 years, 1·18–1·21), cancer for females (0·47 years, 0·45–0·48), and transport accidents for males (0·27 years, 0·27–0·28). Among high-income populations, Hong Kong recorded the lowest cardiovascular mortality and one of the lowest cancer mortalities in women. These findings were underpinned by the lowest absolute smoking-attributable mortality in high-income regions (39·7 per 100 000 in 2016, 95% CI 34·4–45·0). Reduced smoking-attributable mortality contributed to 50·5% (0·94 years, 0·93–0·95) of Hong Kong's survival advantage over males in high-income countries and 34·8% (0·87 years, 0·87–0·88) of it in females.

Interpretation Hong Kong's leading longevity is the result of fewer diseases of poverty while suppressing the diseases of affluence. A unique combination of economic prosperity and low levels of smoking with development contributed to this achievement. As such, it offers a framework that could be replicated through deliberate policies in developing and developed populations globally.

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Introduction

Life expectancy is the fundamental measure of population health. Before COVID-19, life expectancy trends towards improvement were already stagnating or declining in the UK and USA, leading to important sentinel alerts.[1] The ongoing pandemic has exacerbated the situation, substantially reducing life expectancy around the world.[2,3]

Hong Kong's life expectancy, the highest in the world for the seventh year in a row, has motivated calls from developing and high-income countries (HICs) to understand the underlying determinants and to emulate Hong Kong's success.[4–7] The longevity of the Hong Kong population is remarkable given that socioeconomic development from preindustrial to postindustrial conditions occurred within five decades. Hong Kong has achieved this improvement while keeping health expenditure as a fraction of gross domestic product at 5·9%, in contrast with 17·1% in the USA, 9·6% in the UK, and 10·9% in Japan.[8] Understanding the drivers for Hong Kong's longevity would, therefore, be of relevance to both rapidly developing and high-income regions.[5,6] However, no study to date has examined how Hong Kong's life expectancy surpassed other populations.

Over the past few decades, Hong Kong has enjoyed rapid economic growth, established universal health coverage, and reduced infant and maternal mortality rates to among the lowest globally.[9] Yet these achievements are shared by other regions including Japan, Singapore, South Korea, and Taiwan (sometimes collectively known as the Asian Miracle[10]), which also

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For the **life expectancy visualisation tool** see https://longevity.sph.hku.hk

Research in context

Evidence before this study

We searched PubMed, EMBASE, Global Health, and CINAHL Plus for studies published on life expectancy in Hong Kong from the inception of each database to Feb 21, 2021. We used the following search terms with no language restrictions ((“Life expectancy”[MeSH Terms] OR “Longevity”[MeSH Terms] OR “Mortality”[MeSH Terms]) AND “Hong Kong”[All Fields]) for PubMed, and adapted them for other databases. Only one study compared causes of death in Hong Kong with another population (the USA), which showed that Chinese Americans had lower mortality than Hong Kong residents. Hong Kong’s life expectancy might therefore be even longer if emigrants were accounted for. None of the previous studies examined how Hong Kong’s life expectancy surpassed other populations.

Added value of this study

This study is the largest and most comprehensive assessment of Hong Kong’s longevity to date. We applied a novel method—truncated cross-average length of life—to compare all the available mortality history of Hong Kong with 18 high-income countries from the Organisation for Economic Co-operation and Development (OECD). We identified, for the first time, that Hong Kong’s survival advantage was due to its attainment of the lowest mortality for cardiovascular diseases and transport accidents for both sexes, and one of the lowest mortalities for cancer in females. Compared with high-income countries in the OECD, and Japan, Singapore, and South Korea, Hong Kong achieved the lowest smoking-attributable deaths per 100 000 population for men since 1979 and women since 2013.

Implications of all the available evidence

The reasons for Hong Kong’s longest life expectancy were until now poorly understood, yet of great relevance to rapidly developing and high-income countries. The reasons remain relevant for the UK and USA where life expectancy had stagnated or declined even before COVID-19. Here, we show that Hong Kong’s survival advantage was achieved with improved cardiovascular and smoking-attributable mortality compared with other high income settings. The advantage was underpinned by Hong Kong’s early success in tobacco control that achieved the lowest overall smoking prevalence among high-income regions in 1990 as current life expectancy is affected by smoking patterns two to three decades earlier. Hong Kong’s unique combination of economic prosperity and low smoking prevalence has led to the decline of diseases of poverty (such as infectious diseases), while suppressing the rise of cardiovascular diseases (ie, the leading cause of death in high-income countries). To protect population health during and after COVID-19, in addition to mass vaccination, major determinants of life expectancy will remain important and should not be overlooked. Smoking is the single largest cause of preventable death. However, tobacco use remains very high among men in China (42%) and South Korea (36%), and high among both sexes in France (28%), Spain (24%), UK (16%), and the USA (16%). Hong Kong has also attained the lowest mortality for transport accidents among high-income populations. Tobacco control and accident prevention should therefore be at the forefront of the forthcoming public health agenda. In particular, Hong Kong’s rapid economic growth and early urbanisation could serve as an epidemiologic sentinel for mainland China and could inform tobacco control policies in cities in China, Asia and elsewhere.

have similar levels of obesity,[11,12] and therefore may not fully explain Hong Kong’s survival advantage. Smoking is a natural candidate for explaining differences in life expectancy among high-income populations[13,14] because tobacco use is the single most important cause of premature death, and smoking patterns vary substantially between populations.[13,15] By contrast with other high-income regions, Hong Kong has achieved one of the lowest overall smoking prevalences in the world, yet notably smoking has not been examined as an explanation for Hong Kong’s leading longevity.[16]

Smoking and other drivers of mortality also vary greatly within a population (ie, from one cohort or generation to another). Examining the differences in mortality experience between cohorts could therefore reveal the true contributions to life expectancy. International comparative studies of cohort survival and mortality drivers could reveal how Hong Kong’s longevity has surpassed other populations. Hong Kong retains its own immigration controls as a Special Administrative Region of China. This controlled mobility with the rest of the mainland therefore renders comparisons with HICs valid. Accordingly, the aims of this study are to assess the contributions of age, sex, and diseases to Hong Kong’s longevity gains from a cohort and period perspective; to compare cohort survival and causes of death internationally; and to compare smoking-attributable mortality in Hong Kong with other high-income populations.

See **Online** for appendix

Methods

Data sources

For Hong Kong, we obtained life tables, population data, and death data from the Hong Kong Government Census and Statistics Department, which recorded 1 281 336 deaths from 1979 onwards (appendix p 11). Life tables calculations were comparable to those from the Human Mortality Database. Causes of death were coded using the International Classification of Diseases (ICD), Ninth Revision (ICD-9) for 1979–2000 and the Tenth Revision (ICD-10) for 2001–19. ICD-9 codes were converted to ICD-10 using General Equivalency Mapping by the US Centers for Medicare and Medicaid Services (CMS; appendix p 12). Analyses using cause of death data, therefore, commenced from 1979. As a statutory requirement, deaths in Hong Kong are certified and the cause of death is determined by medical doctors, which is consistent with the WHO requirements of using exclusively medical-certified deaths. Audits of death certificates are performed and clinicians are legally required to refer uncertain causes of death to the coroner.[17] Doctors are required to document the chain of events that led to death including the immediate, intervening and underlying causes. The underlying cause is recorded as the main cause of death in the mortality statistics.

For international data, we obtained life tables by sex, population and death data from the Human Mortality Database for South Korea (2003–16) and 18 HICs (1950–2016) from the Organisation for Economic Co-operation and Development (OECD), including Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, and USA (appendix p 13). This set of 18 OECD HICs has been used in recent international comparisons of life expectancy.[1,14,18] Life tables for Singapore were obtained from the Government of Singapore Statistics Department. Causes of death information for the 18 HICs, Singapore, and South Korea were obtained from the WHO Mortality Database from 1950–2016. Life expectancies at birth from 1960–2019 were obtained from the World Bank for rankings of period life expectancy (or the average number of years lived by a synthetic cohort exposed to the mortality rates of a specific calendar time).[4] Ethical approval was not required by the Institutional Review Board of the University of Hong Kong or Hospital Authority Hong Kong West Cluster.

Statistical analysis

We identified temporal inflections in life expectancy in Hong Kong using the Joinpoint Regression Program.[19] Life expectancies at birth and associated 95% CIs were calculated by bootstrapping.[20] We used Arriaga's decomposition, an established method to compare longevity across regions, to examine the age, sex, and cause-specific contributions to changes in the period life expectancy at birth in Hong Kong over time and to the differences in period life expectancy at birth between Hong Kong and HICs.[1,21,22] However, conventional period life expectancy only assesses mortality for a specific calendar time and thus provides a narrow view of historical mortality. We therefore also examined cohort survival, which summarises the mortality experience of an actual birth cohort of individuals and accounts for changes in mortality risks over the life course.[23] We used truncated cross-sectional average length of life (TCAL) to compare cohort survival for Hong Kong and the 18 HICs. TCAL condenses all of the available mortality history of cohorts present at a given time into one summary measure and allows comparisons of populations even when complete series of mortality data for all cohorts are not available.[24,25] The TCAL is the closest measure of the true average longevity of populations. We used Lexis surfaces to show comparisons in cohort survival between populations.[24,26] We used TCAL to identify the cohorts, age, sex, and causes of death contributing to differences in survival between Hong Kong and each of the 18 HICs populations. Singapore and South Korea were included in comparisons of smoking-attributable mortality but not for TCAL as comparable data were not available.

We used the smoking impact ratio (SIR) to measure smoking-attributable mortality.[27] The SIR uses lung cancer mortality to indicate the contributions of cumulative smoking exposure to overall mortality. However, contributions of non-smoking risk factors to lung cancer are larger in Chinese populations than in others, which would result in the SIR overestimating smoking-attributable mortality.[28,29] We therefore used the modified Peto-Lopez method to convert SIR to background-adjusted SIR using lung cancer mortality rates from the Hong Kong Lifestyle and Mortality study.[30] We then applied Arriaga's method to determine the proportion of life expectancy gains at age 50 years from 1979 to 2016 that were attributable to changes in smoking.[15] All statistical analyses were conducted in R version 4.1.0; R Core Team (2020).

Role of the funding source

The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or the decision to submit the manuscript for publication.

Results

Hong Kong experienced sustained improvements in life expectancy at birth for both sexes from 1960 to 2020. Women's life expectancy gains accelerated in 1993, contributing to Hong Kong's further rise in world rankings. Although life expectancy gains have slowed since 2001, there is no evidence of stagnation or decline (figure 1). As a result, Hong Kong has surpassed Japan (appendix p 14) to become the longest living population since 2013 (see online life expectancy visualisation tool). Hong Kong's life expectancy is also currently higher than high-income regions or countries with a population size comparable to Hong Kong (appendix p 15). In 2020, life expectancy at birth reached 82·7 years for men and 88·1 years for women.[31]

Most of the older adult population in Hong Kong are migrants from mainland China, where several immigration waves have occurred since the late 1940s.[32] We

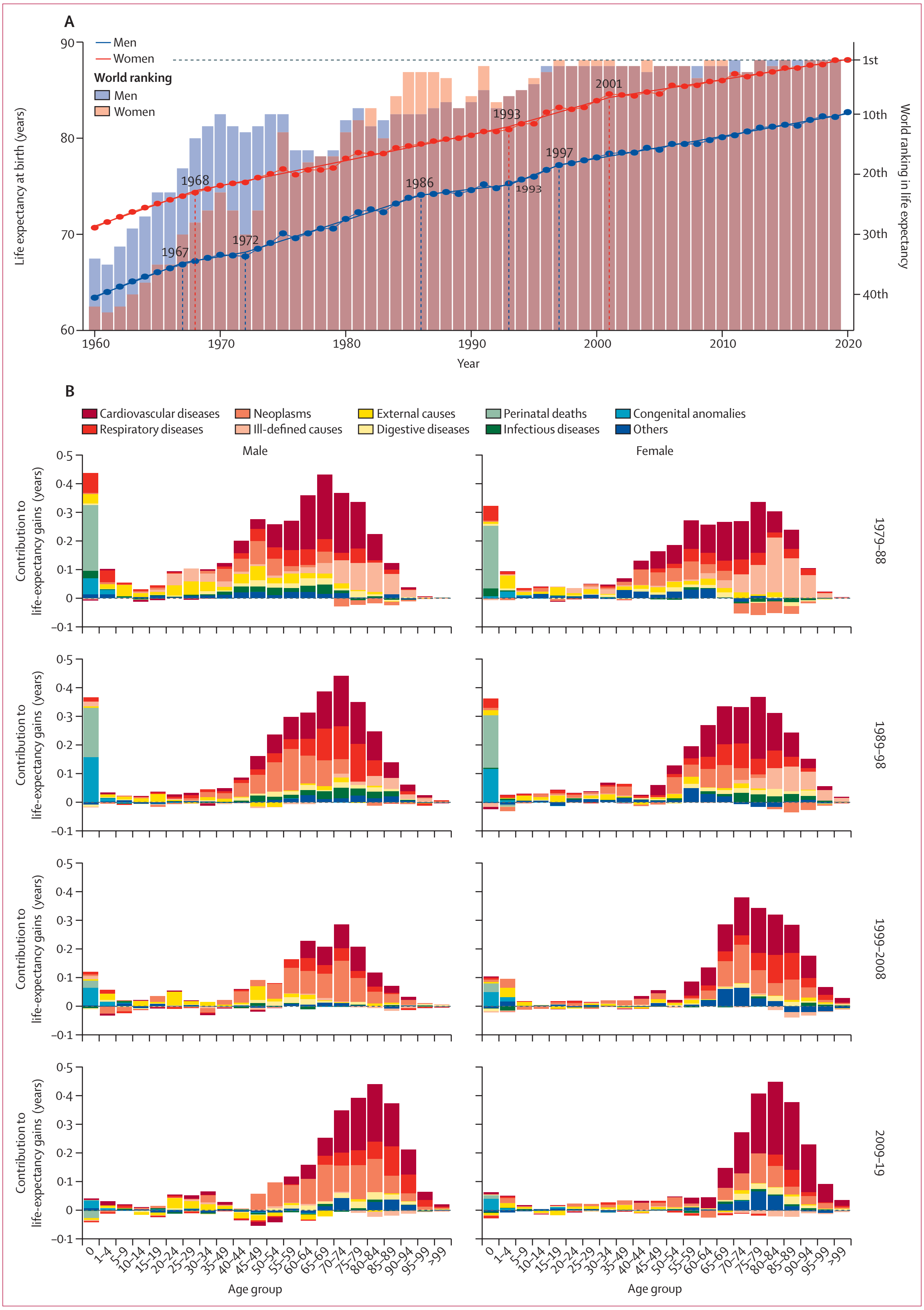

***Figure 1:* Trends in life expectancy at birth in Hong Kong (A) and contributions to life expectancy gains by age, sex, and underlying cause of death (B)**
(A) Life expectancy at birth in Hong Kong: 1960–2020. World rankings in life expectancy were obtained from the World Bank. Joinpoint analysis was used to identify when life expectancy gains in Hong Kong took place. Inflections in the life expectancy at birth identified by the jointpoint regression are indicated by the dotted lines and the year. The solid blue and red lines indicate the trends in life expectancy at birth for men and women and were predicted using Joinpoint analysis. (B) Contributions to life expectancy gains by age, sex, and underlying cause of death: 1979–2019.

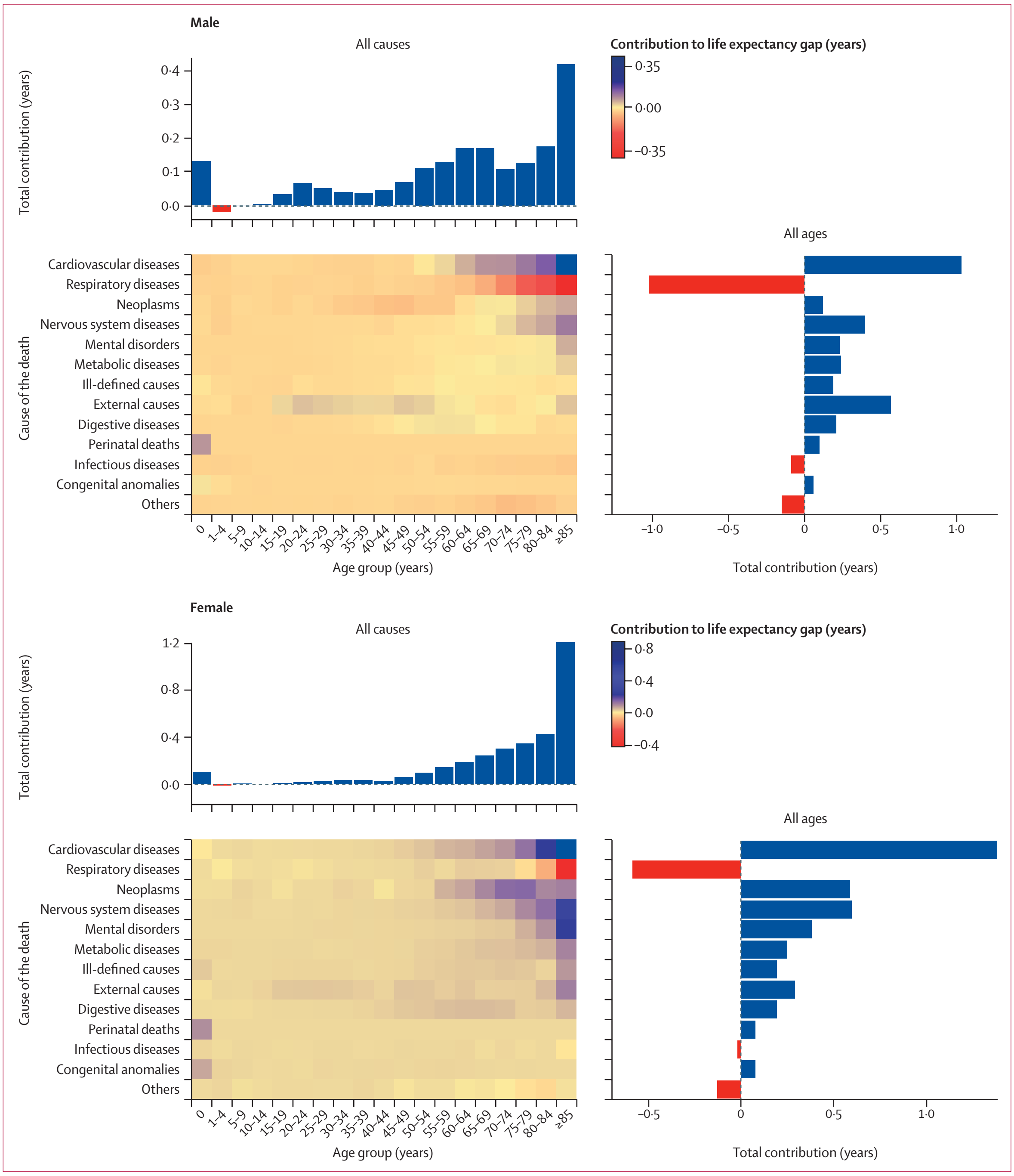

Figure 2: **Contributions to the difference in life expectancy between Hong Kong and 18 OECD high-income countries in 2016**
Blue shades in the heat map indicate the age group and cause of death where Hong Kong has an advantage over high-income countries, yellow indicates no difference, and red shades indicate that high-income countries have an advantage over Hong Kong.

therefore compared life expectancy and period mortality by migrant status (appendix) at birth and age 50 years. Life expectancy of Hong Kong's native-born individuals was higher than the overall life expectancy in Japan and HICs (appendix p 16). Although migrants had a lower life expectancy than natives in Hong Kong, the life expectancy and mortality of migrants from mainland China to Hong Kong were comparable to HICs, including the UK and USA (appendix pp 16–17).

Over the past four decades, life expectancy gains in Hong Kong have shifted from infants and middle-aged adults to older adults, with such gains increasingly concentrated among older women (figure 1). The main contributors to absolute life expectancy gains in Hong Kong include

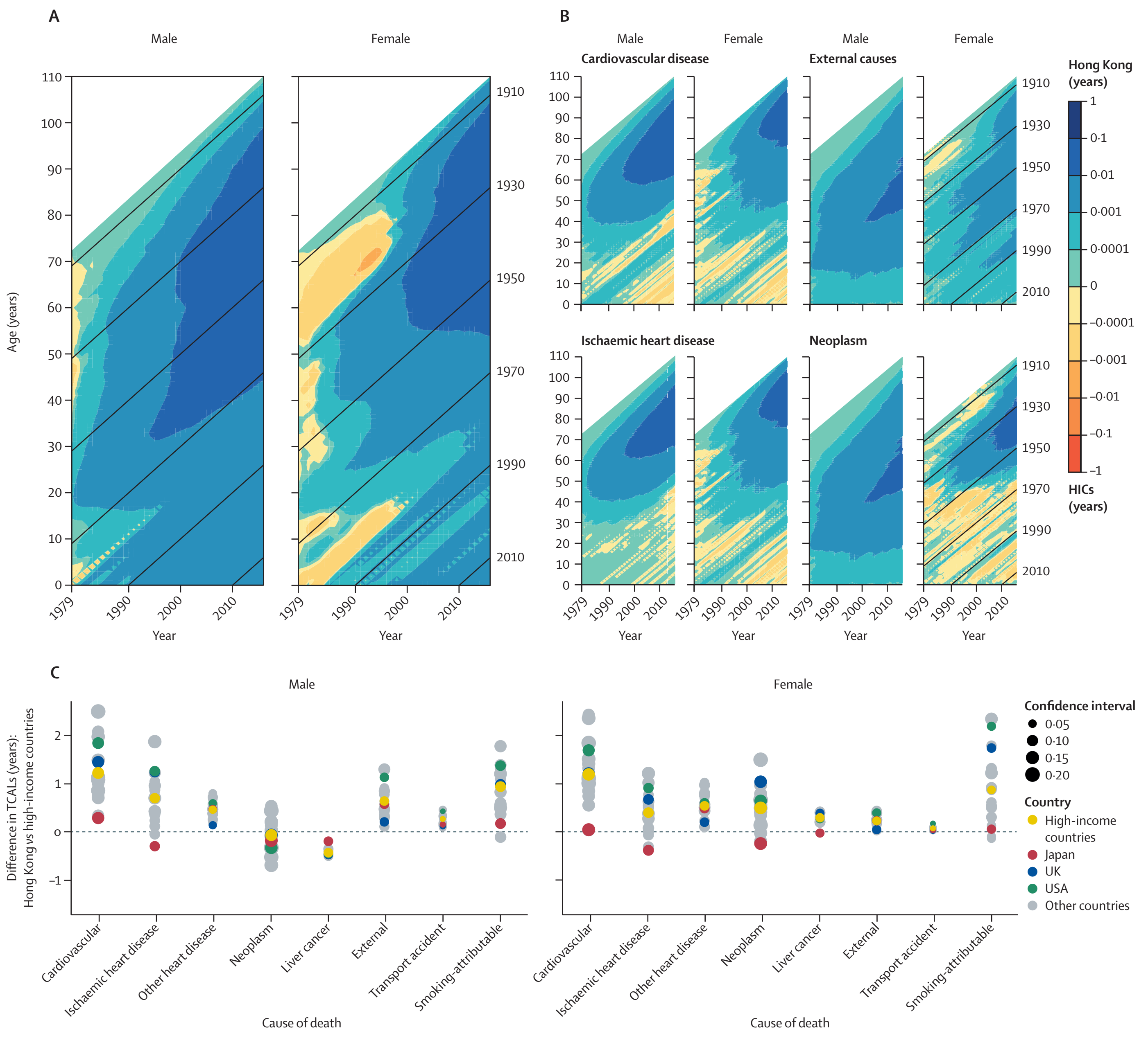

Figure 3: **Lexis surface of cohort survival comparisons between Hong Kong and 18 OECD high-income countries and cause of death contribution to their differences in cohort survival**
(A) Lexis surface of cohort survival comparisons between Hong Kong and high-income countries. Diagonally, the figures show the mortality pattern of each cohort from birth (or the age when data are first available) to older age from 1979 to 2016. The black diagonal lines indicate the mortality history of cohorts born in a specific year. Blue shades indicate Hong Kong's cohort survival advantage and red and yellow shades indicates disadvantage. (B) Lexis surface of the cause of death contribution to the difference in cohort survival between Hong Kong and high-income countries for selected diseases. Differences in the cohort survival by cause of death are calculated as TCAL (Hong Kong)–TCAL (high-income country). (C) Cause of death contribution to differences in cohort survival between Hong Kong and high-income countries. Positive values indicate that Hong Kong has a survival advantage. The size of the bubbles corresponds to the 95% CIs, which are calculated by bootstrapping. If the bubble does not overlap the dotted horizontal line then this indicates that the TCAL for the country is significantly different from Hong Kong. TCAL=truncated cross-sectional average of life.

cerebrovascular disease, ischaemic heart disease, other heart diseases, pneumonia, chronic obstructive pulmonary diseases, lung cancer, and accidents, accounting for the majority of absolute period life expectancy gains in men (59·5%) and women (59·2%; appendix pp 18–19).

From 1979 to 2016, the difference in female life expectancy at birth between Hong Kong and HICs changed from –0·5 years (95% CI –0·5 to –0·5; ie, women in HICs lived longer) to 3·3 years (3·2 to 3·3; women in Hong Kong lived longer). The corresponding male life expectancy gap between Hong Kong and HICs changed from 0·0 years (–0·1 to 0·0) to 1·9 years (1·9 to 2·0).

50·0% (1·6 years, 95% CI 1·6–1·7) of the female gap and 31·8% (0·6 years, 0·5–0·7) of the male gap between Hong Kong and HICs in 2016 were due to differences in individuals aged 80 years or older (figure 2). The leading disease contributor to the life expectancy gap between Hong Kong and HICs was cardiovascular disease among those aged 60 years or older, which contributed to 40·7% (1·3 years, 1·2–1·3) of the female gap and 53·6% (1·0 years, 0·8–1·0) of the male gap. Despite improvements in mortality from pneumonia over time in Hong Kong (appendix pp 18–19), respiratory diseases remained the main negative contributor to the life expectancy gap with HICs in 2016 (figure 2). This finding highlights that international comparisons, as opposed to examining domestic life expectancy gains, are required to explain Hong Kong's survival advantage over HICs.

The cohort survival comparison between Hong Kong and HICs, in the TCAL perspective, uses data from 263 462 588 deaths. Figure 3 shows the cohort mortality comparisons across ages from 1979 to 2016. Both sexes in Hong Kong initially had a slight survival disadvantage (yellow shades in figure 3A) for most cohorts in 1979. However, survival for all cohorts had since improved relative to HICs as they transitioned from yellow to dark blue over time. Since the 21st century, all cohorts in Hong Kong have had a survival advantage (blue shades) over HICs. In recent years, the survival advantage of Hong Kong older adults has further outpaced HICs (darker blue).

Both men and women in Hong Kong had better overall survival than their HIC counterparts, with 1·86 years (95% CI 1·83–1·89) for males and 2·50 years (95% CI 2·47–2·53) of extra years of life as captured by TCAL comparisons (table 1). Main contributors to Hong Kong's survival advantage were cardiovascular diseases for males (1·22 years, 95% CI 1·21–1·23) and females (1·19 years, 1·18–1·21), cancer in females (0·47 years, 0·45–0·48) and transport accidents for males (0·27 years, 0·27–0·28; table 1). From a cohort perspective, Hong Kong men ranked first while Hong Kong women were second only to Japan (appendix p 20). Japanese women's cohort survival advantages are the result of ranking at top positions in period life expectancy for more than 25 years.[33] While period life expectancy can rapidly fluctuate from year to year (eg, during the 1918 influenza or COVID-19 pandemics), the cohort perspective has a smooth and slower pace of change. As such, it would take time for Hong Kong women's period advantage in survival to translate into a cohort advantage over their Japanese counterparts. Comparisons with Japan (appendix pp 21–22) and with each HIC by sex and disease can be visualised using the online life expectancy visualisation tool.

Hong Kong men's improved cohort survival over HICs has been mainly due to lower mortality from cardiovascular diseases (mainly ischaemic and other heart diseases) and external causes (transport accidents; table 1). Hong Kong women's improved cohort survival

	Male		Female	
	TCAL difference, years (95% CI)	Overall TCAL difference (%)	TCAL difference, years (95% CI)	Overall TCAL difference (%)
Overall	1·86 (1·83 to 1·89)	100·0%	2·50 (2·47 to 2·53)	100·0%
Cardiovascular diseases	1·22 (1·21 to 1·23)	65·6%	1·19 (1·18 to 1·21)	47·6%
Ischemic heart disease, I20–I25	0·70 (0·70 to 0·71)	37·6%	0·40 (0·40 to 0·41)	16·0%
Other heart diseases, I00–I09 and I26–I52	0·46 (0·46 to 0·47)	24·7%	0·54 (0·54 to 0·55)	21·6%
Cerebrovascular disease, I60–I69	–0·03 (–0·04 to –0·03)	–1·6%	0·10 (0·09 to 0·11)	4·0%
Neoplasms	–0·06 (–0·07 to –0·05)	–3·2%	0·50 (0·49 to 0·51)	20·0%
Any cancer	–0·09 (–0·10 to –0·07)	–4·8%	0·47 (0·45 to 0·48)	18·8 %
Breast cancer, C50	··	··	0·30 (0·29 to 0·30)	12·0%
Ovarian cancer, C56–C57	··	··	0·10 (0·10 to 0·10)	4·0%
Cervical cancer, C53	··	··	–0·03 (–0·03 to –0·03)	–1·2%
Liver cancer, C22	–0·42 (–0·43 to –0·42)	–22·6%	–0·14 (–0·15 to –0·14)	–5·6%
Lung cancer, C33–C34	–0·17 (–0·18 to –0·16)	–9·1%	–0·12 (–0·13 to –0·11)	–4·8%
Colorectal cancer, C18–C21	–0·04 (–0·04 to –0·03)	–2·2%	–0·03 (–0·04 to –0·02)	–1·2%
Leukaemia, C91–C95	0·03 (0·03 to 0·04)	1·6%	0·03 (0·03 to 0·03)	1·2%
External causes	0·64 (0·64 to 0·65)	34·4%	0·23 (0·23 to 0·24)	9·2%
Transport accidents, V01–V99	0·27 (0·27 to 0·28)	14·5%	0·08 (0·08 to 0·08)	3·2%
Diseases of the nervous system	0·27 (0·27 to 0·28)	14·5%	0·41 (0·41 to 0·41)	16·4%
Endocrine, nutritional, metabolic diseases	0·23 (0·23 to 0·23)	12·4%	0·19 (0·19 to 0·20)	7·6%
Diabetes, E10–E14	0·14 (0·14 to 0·14)	7·5%	0·11 (0·11 to 0·12)	4·4%
Ill-defined causes	0·23 (0·22 to 0·23)	12·4%	0·22 (0·21 to 0·22)	8·8%
Mental and behavioural disorders	0·21 (0·21 to 0·21)	11·3%	0·30 (0·30 to 0·31)	12·0%
Digestive diseases	0·16 (0·15 to 0·16)	8·6%	0·14 (0·14 to 0·15)	5·6%
Congenital and perinatal diseases	0·05 (0·05 to 0·06)	2·7%	0·04 (0·03 to 0·04)	1·6%
Blood diseases	0·01 (0·01 to 0·01)	0·5%	0·02 (0·01 to 0·02)	0·8%
Pregnancy, childbirth, and the puerperium	··	··	0·00 (0·00 to 0·00)	0·0%
Eye and ear diseases	0·00 (0·00 to 0·00)	0·0%	0·00 (0·00 to 0·00)	0·0%
Skin, connective, and musculoskeletal diseases	0·00 (0·00 to 0·00)	0·0%	0·02 (0·02 to 0·03)	0·8%
Infectious diseases	–0·09 (–0·09 to –0·08)	–4·8%	–0·04 –0·04 to –0·03)	–1·6%
Tuberculosis, A15–A19	–0·07 (–0·07 to –0·07)	–3·8%	–0·02 (–0·02 to –0·02)	–0·8%
Genitourinary diseases	–0·18 (–0·19 to –0·18)	–9·7%	–0·28 (–0·29 to –0·28)	–11·2%
Respiratory diseases	–0·84 (–0·85 to –0·83)	–45·2%	–0·45 (–0·46 to –0·44)	–18·0%
Pneumonia, J12–J18	–0·77 (–0·78 to –0·76)	–41·4%	–0·66 (–0·66 to –0·65)	–26·4%
Smoking-attributable diseases	0·94 (0·93 to 0·95)	50·5%	0·87 (0·87 to 0·88)	34·8%

Positive data suggest Hong Kong has longer TCAL than high-income country comparators. Each cause of death is followed by the International Classification of Diseases, 10th Revision code. TCAL=truncated cross-sectional average of life.

***Table 1:* Cohort survival comparisons and cause of death decomposition between Hong Kong and 18 Organisation for Economic Co-operation and Development high-income countries using TCAL**

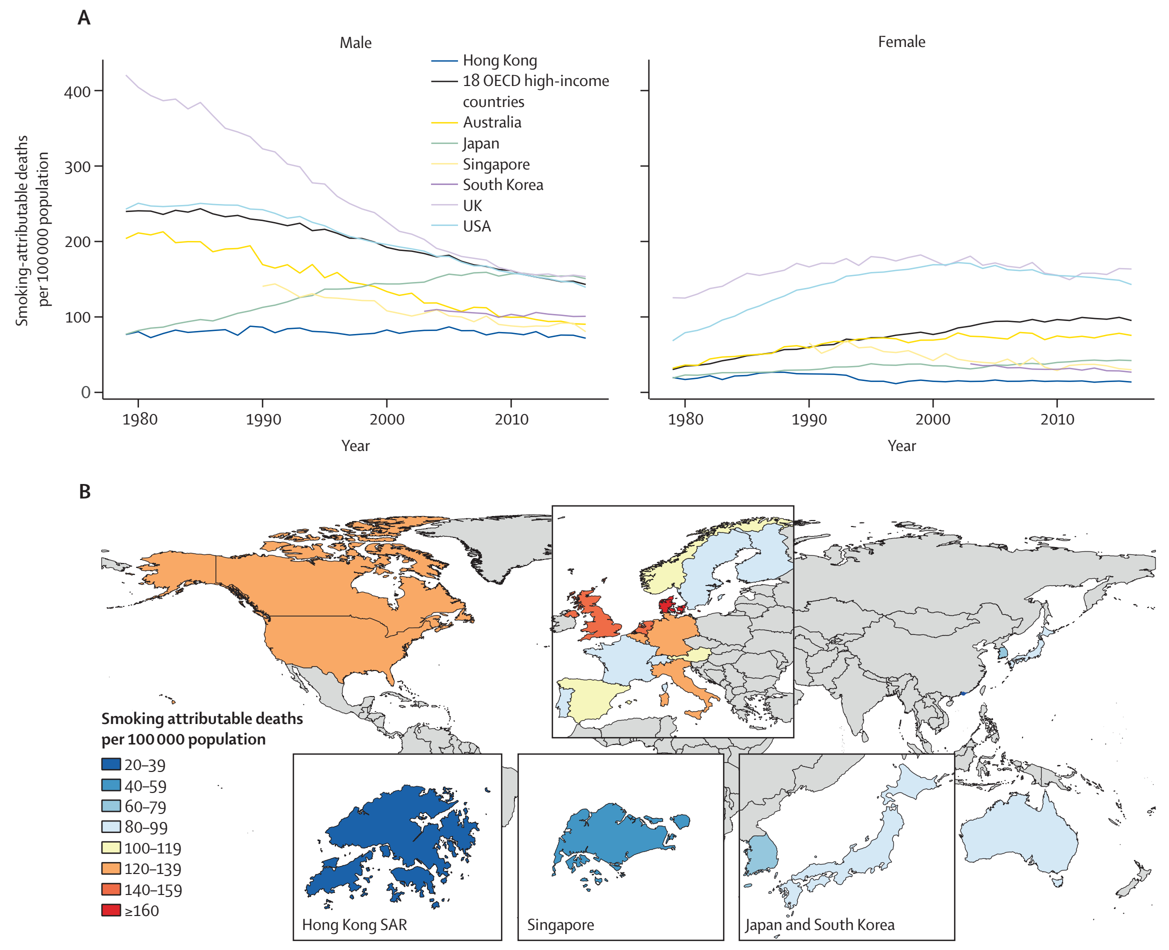

Figure 4: **Smoking-attributable mortality**
(A) Number of smoking-attributable deaths (per 100 000 population per year) by sex from 1979 to 2016. (B) Overall number of smoking-attributable deaths (per 100 000 population per year) in 2016. SAR=special administrative region.

over HICs has been due to lower mortality from cardiovascular diseases (ischaemic and other heart diseases) and neoplasms (breast cancer; table 1). Specifically, the cohorts in Hong Kong with the largest survival advantage for cardiovascular diseases over HICs were males aged at least 60 years since the 1990s, and females aged at least 75 years since the 2000s (figure 3B). For external causes, male cohorts aged 40–69 years have experienced a survival advantage since the 1990s. For neoplasms, female cohorts aged 65–90 years experienced an advantage since the 2000s. The survival advantage for these diseases has increased over time. Figure 3C summarises the major contributors to differences in TCAL cohort survival between Hong Kong and each of the 18 HICs. Among high-income regions, Hong Kong had the lowest mortality in cardiovascular diseases for both sexes, and one of the lowest neoplasm mortalities for females (all positive differences in figure 3C). Hong Kong also had the lowest mortality in transport accidents for both sexes compared to HICs, whereas Portugal and the USA sustained the highest mortality for transport accidents among males and females, respectively.

The smoking-attributable mortality rate has increased for women in HICs since 1979 (figure 4). By contrast, the corresponding rate in women in Hong Kong has remained stable over the past four decades leading to a widening gap in smoking-attributable mortality between Hong Kong and HICs. Smoking-attributable mortality in Hong Kong men has been substantially lower than HICs since 1979. Reduced smoking rates among men improved life expectancy in all high-income regions (table 2; appendix p 23), with the largest life expectancy gains (3·7 years) in the UK, where the smoking epidemic peaked and regressed before other countries.[34] By contrast, declines in smoking among women in HICs have been more gradual over the past four decades and have even plateaued in some countries.[16] Smoking patterns in women have therefore led to reduced life expectancy at age 50 years in nearly all HICs (mean of –0·4 years) with the largest reduction among Dutch women (–1·3 years; appendix p 23). Hong Kong women experienced the largest life expectancy gains (0·4 years) among high-income populations due to changes in smoking in the past four decades. From a cohort perspective, smoking contributed to 50·5% (0·94 years; 95% CI 0·93–0·95) and 34·8% (0·87 years; 0·87–0·88) to the TCAL difference between Hong Kong and HICs in 2016 for males and females, respectively (table 1).

In 2016, the smoking-attributable mortality rate in Hong Kong was 69·1 per 100 000 population (95% CI 60·2–79·9) for men and 12·9 per 100 000 population (95% CI 8·3–19·3) for women. By comparison, the smoking-attributable mortality rate was highest among men in Belgium (188·2, 179·4–196·8), Spain (179·5, 173·5–185·8), and Italy (175·7, 169·4–182·1), and among women in Denmark (193·8, 179·8–207·2), the UK (161·2, 152·2–167·5), and the Netherlands (141·7, 133·1–150·0; appendix p 24). Hong Kong had the lowest rate of death associated with smoking and proportional mortality (percentage of all deaths; appendix p 25) attributed to smoking among high-income regions.

	1990			2018		
	Overall	Male	Female	Overall	Male	Female
Hong Kong	15·7%	28·5%	2·6%	10·2%*	18·1%*	3·2%*
Japan	28·5%	53·1%	9·7%	18·3%	27·9%	8·7%
Singapore	18·3%†	33·2%†	3·1%†	13·3%	23·0%	3·7%
South Korea	34·6%‡	65·7%‡	6·4%‡	20·6%	36·1%	5·1%
Australia	28·6%‡	30·2%‡	27·0%‡	11·8%	13·2%	10·4%
Canada	28·2%	29·6%	26·7%	11·2%	13·8%	8·5%
Denmark	44·5%	47·0%	42·0%	14·5%	14·1%	15·0%
Finland	25·9%	32·4%	20·0%	15·0%	16·2%	13·9%
France	31·0%	39·0%	22·0%	28·0%	29·6%	26·5%
Germany	25·1%‡	32·8%‡	18·0%‡	22·4%	25·2%	19·6%
Italy	27·8%	37·8%	17·8%	19·2%	22·5%	15·9%
Netherlands	37·0%	43·0%	32·0%	18·0%	20·0%	16·0%
Norway	35·0%	36·0%	33·0%	9·3%	11·0%	7·5%
Portugal	19·0%§	33·6%§	5·1%§	21·8%	26·6%	16·9%
Spain	35·9%‡	51·5%‡	21·4%‡	23·9%	25·1%	22·6%
Sweden	25·8%	25·8%	25·9%	17·9%	22·7%	13·0%
Switzerland	28·1%†	34·0%†	22·9%†	20·3%	21·5%	19·2%
UK	30·0%	31·0%	30·0%	16·0%	17·1%	14·3%
USA	25·5%	28·4%	22·8%	16·3%	19·3%	13·3%
18 OECD high-income countries	29·7%¶	33·6%¶	22·3%¶	18·1%	20·6%	15·3%

*Daily cigarette smokers in 2018, which accounted for 98% of all daily tobacco users in 2018. †Data from 1992. ‡Data from 1989. §Data from 1987. ¶Average based on available data (eg, country OECD membership status) of the specified year (ie, 1990 or 2018); data closest to 1990 used (±3 years) and if not available, then the country was omitted. Data from WHO Global Health Observatory, OECD Data, Hong Kong SAR Thematic Household Survey Report, Hong Kong Council on Smoking and Health, and SingStat.

Table 2: **Daily tobacco use in selected high-income settings**

Discussion

Hong Kong's epidemiological transition took place in the 20th century when drivers of mortality had progressively shifted from infectious diseases and infant deaths to non-communicable diseases and deaths in older adults (figure 1B). In the 21st century, all cohorts in Hong Kong had longer lives than their HIC counterparts (figure 3), with older adults being the major contributor to the life expectancy gap with HICs (figure 2). This situation is remarkable because most older adults in Hong Kong grew up under limited living conditions. Our finding that Hong Kong natives currently live longer than its migrants and people in HICs is interesting (appendix p 16) and suggests that longevity gains could be indigenous rather than imported (the so-called healthy migrant effect). Hong Kong's population therefore benefited from policy interventions and this could be replicated elsewhere with appropriate policy stewardship.

As the largest and most comprehensive assessment of Hong Kong's longevity to date, we showed that the leading contributor to Hong Kong's survival advantage is that it has the lowest cardiovascular mortality among high-income regions (table 1, figure 3). Other contributors to Hong Kong men's survival advantage include the lowest mortality for transport accidents in high-income regions (figure 3), which might be due to Hong Kong's excellent public transport system, low car ownership, and low alcohol consumption and drunk driving compared with many HICs.[35,36] As Hong Kong's low car ownership is facilitated by its high population density and public transport system, these findings are more relevant to highly urbanised areas elsewhere. However, the finding could also inform public health strategies elsewhere including urban areas in China, where road traffic injuries are one of the top ten causes of death in all provinces.[6] Women in Hong Kong have one of the lowest cancer mortalities, in particular from breast cancer despite the absence of a mass screening programme, potentially contributed by favourable behavioural patterns such as low alcohol and tobacco consumption.[36,37] However, Hong Kong's survival advantage has been partially offset by higher mortality from pneumonia and liver cancer (table 1). High liver cancer mortality could be attributed to prevalent hepatitis B infections in Hong Kong, which should decline over the next few decades following universal neonatal vaccination introduced since 1988.[38] The reasons for relatively higher pneumonia mortality in Hong Kong are unclear, but might include air pollution and fewer deaths from other major causes (ie, cardiovascular diseases and cancer) in a competing risk paradigm.[39]

We posit that a key explanation for Hong Kong's population's longevity is the unique combination of two major drivers of life expectancy: economic prosperity and successful tobacco control (table 2).[13,40] The combination resulted in the decline in the diseases associated with poverty (figure 1B), while suppressing the rise of the leading cause of death in high-income regions:

cardiovascular diseases (figure 3C). Hong Kong's low cardiovascular mortality in both sexes and low cancer mortality in women is probably due to the attainment of one of the lowest smoking prevalences in the world,[16] resulting in the lowest smoking-attributable mortality in high-income regions (figure 4). We showed that among high-income regions, Hong Kong achieved the lowest smoking-attributable deaths per 100 000 population for men and women since 1979 and 2013, respectively (figure 4). By contrast, the absolute risk levels for the USA and UK are among the highest and more than three-fold of Hong Kong (figure 4), and therefore these countries would stand to gain the most from smoking reductions.[41] Notably, HICs such as Norway, Canada, and Australia have attained substantial declines in smoking reaching levels that are comparable to Hong Kong (table 2). Nevertheless, their smoking-attributable mortality remains substantially higher than that of Hong Kong because current patterns are shaped by smoking trends 20–30 years earlier.[13]

High levels of obesity in HICs (eg, the USA and Australia) have contributed to a recent reversal in their decline in cardiovascular mortality and life expectancy trends.[42,43] Yet obesity might only partly explain differences in mortality as a third of adults in Hong Kong are obese.[12] Moreover, France has below-average obesity levels yet developed one of the most worrying trends in cardiovascular mortality among HICs, which has been attributed to higher smoking prevalence in French men and women.[42] As smoking is the single largest preventable cause of death, it remains a major explanation for divergent trends in longevity.[13,15] Indeed, we have shown that smoking has contributed to 50·5% and 34·8% of Hong Kong's survival advantage over men and women in HICs, respectively (table 1). As the mortality burden of smoking is often underestimated,[44] our findings suggest that smoking could be the most important explanation for Hong Kong's survival advantage over HICs.

Contributions of tobacco control and traffic safety to population health have been documented before.[13,45] Yet these have not been comprehensively achieved in many parts of the world, partly due to competing priorities and ineffective implementation.[16,45,46] For example, tobacco use remains very high among men in China and South Korea, and high among both sexes in France, Germany, Portugal, Spain, UK, and USA (table 2).[16] Moreover, concerning trends in tobacco use around the world indicate that current policies are insufficiently implemented.[47,48] Our study shows that successful tobacco control was a key reason for life expectancy in Hong Kong to reach the highest in the world. These findings lend empirical support for a renewed focus on tobacco control—which has often been side-lined by newer but less consequential risk factors of mortality.[49] Hong Kong's approach could serve as a roadmap for rapidly developing and high-income economies.[5–7,47] Specifically for tobacco control, Hong Kong has been at the forefront since the 1970s and was one of the first governments in the Western Pacific Region to introduce tobacco control measures.[50] Hong Kong's progressive, comprehensive tobacco control measures (eg, legislation, taxation, health promotion, and education) have served as an example for other jurisdictions.[51] These measures include statutory no-smoking areas, taxing cigarettes, regulating promotion and packaging of tobacco products, and smoking cessation services. Hong Kong was also among the first jurisdictions in the world to impose a total ban on smoking in public places.[46] Institutional changes in Hong Kong that could be similarly applied elsewhere include the establishment of an anti-smoking council (which represented the first such government-funded council in Asia), and a government agency dedicated to coordinate, formulate, implement, and promote smoke-free policies.[51]

Our study is subject to a number of limitations including the comparability of mortality data across regions. For example, higher pneumonia mortality could be due to a tendency in Hong Kong to attribute causes of death to acute illnesses rather than underlying medical conditions (eg, dementia) or underreporting of pneumonia in HICs.[1,52] Nevertheless, the proportion of deaths coded as ill-defined, an indicator for the validity of mortality data, has declined to low levels in both Hong Kong and HICs over time.[14] Furthermore, we primarily used broad causes of death categories to reduce bias from misclassification and changes in ICD codes.[1,24] Second, other important factors such as diet, alcohol use, physical activity, obesity, and the social determinants of longevity were not assessed.[18,40,53] These factors might also confound the association between smoking and mortality.[44,54] However, previous studies have shown that adjustment for sociodemographic and behavioural factors and anthropometrics had little impact on risk estimates for smoking and mortality.[44,54] Future studies could compare the contributions of social determinants of life expectancy by leveraging population registries and international consortiums of long-term, prospective cohort studies with standardised protocols and linkage with routine data sources including death registries.[55–57] Third, mortality data for emigrants out of Hong Kong, as everywhere, are difficult to obtain.[58] The direction of bias would plausibly be such that HICs could have selected migrants from Hong Kong with better socioeconomic status and health, as evidenced by lower mortality of Chinese migrants in the USA than Hong Kong residents.[59] Excluding these emigrants would have underestimated Hong Kong's longevity. Fourth, most older population in Hong Kong were migrants from mainland China and some life expectancy gains from self-selection cannot be excluded.[32] Hong Kong's longevity could also be susceptible to the so-called salmon bias (ie, migrants returning to their homeland to die thus not counted in the mortality statistics of their host region).[58] However, this factor might be less applicable in the current context as few older migrants die outside of Hong Kong due to the city's universally accessible and well-established health and social services, compared with elsewhere in the country.[60] Fifth, the generalisability of our findings would depend on the context. Racial disparities would have a larger impact on population health elsewhere since the majority of migrants in Hong Kong originate from southern China and share a common sociocultural background and gene pool with natives.[32] Sixth, Hong Kong's high life expectancy compared with HICs might be attributed to it being a highly urbanised city, in contrast to HICs which have both urban and rural populations. However, Hong Kong's survival advantage remained, even when compared to highly urbanised high-income regions (appendix p 15). We compared Hong Kong to a frequently used group of HICs[1,14,18] as direct comparisons with other cities could be susceptible to the salmon bias given urban–urban or rural–urban migration patterns within a country.[58] Further, Hong Kong's population of 7·5 million residents is larger than several countries (eg, Denmark, Finland, and Norway) that have been assessed to have sufficient population size to produce reliable estimates of mortality.[1] Last, while life expectancy is an important measure of physical well-being, WHO has defined health as a state of complete physical, mental and social well-being. Hong Kong has the longest work hours and lowest housing affordability in the world, and reports one of the most unequal income distributions and highest population densities.[61,62] Hong Kong people might live the longest but a global survey showed that they also report the lowest meaning in life, and have recently sustained substantial psychiatric sequelae following major protests and social unrest.[63–65] Therefore, the best approaches for maximising longevity (eg, tobacco control and accident prevention) are important but clearly insufficient to enhance the broad definition of well-being. To comprehensively improve population health, public policy should prioritise healthy life expectancy, mental well-being, and life satisfaction.[66]

To protect population health during and after COVID-19, prevailing determinants of life expectancy will remain important and must not be overlooked. Our findings provide empirical support that tobacco control and accident prevention should be at the forefront of the forthcoming public health agenda.

Contributors

MYN, VC-R, and GML conceived the study. MYN wrote the analytic plan with input from VC-R, CMS, ADL, ME, and GML. MYN, VC-R, JS, FPF, MSCC, SYH, and THL carried out the study. MYN, VC-R, JS, FPF, and XIY analysed the data. MYN, VC-R, ADL, ME, and GML interpreted the data. MYN wrote the first draft, and all authors critically revised the manuscript and approved the final version. MYN obtained funding for the study. MYN, JS, and FPF had access and verified all the data and all authors were responsible for the decision to submit the manuscript.

Declaration of interests

We declare no competing interests.

Data sharing

Data from the Human Mortality Database, WHO Mortality Database, and World Bank are publicly available. A data request for Hong Kong data needs to be submitted to The Hong Kong Government Census and Statistics Department. Findings from the study are also available online at https://longevity.sph.hku.hk/. Source code for truncated cross-sectional average length of life (TCAL) is available in reference 24 and at https://github.com/selectPRIN/TCAL. Other code used in this study are available at https://github.com/Hong-Kong-Longevity/Longevity.

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