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Original Article

Assessment of age, period, and cohort effects of lung cancer incidence in Hong Kong and projection up to 2030 based on changing demographics

Jianqiang Du[1*], Haifeng Sun[2*], Yuying Sun[3], Jianfei Du[4], Wangnan Cao[5], Shengzhi Sun[6]

[1]The Key Laboratory of Biomedical Information Engineering of Ministry of Education, School of Life Science and Technology, Xi'an Jiaotong University, Xi'an 710049, Shaanxi, China; [2]Third Department of Medical Oncology, Shaanxi Provincial Cancer Hospital Affiliated to Medical College of Xi'an Jiaotong University, Xi'an 710061, Shaanxi, China; [3]School of Public Health, The University of Hong Kong, Hong Kong, China; [4]Department of Oncology, Xi'an Gaoxin Hospital, Xi'an 710100, Shaanxi, China; [5]Center for Evidence Synthesis in Health, Brown University School of Public Health, Providence, RI 02912, USA; [6]Department of Environmental Health, Boston University School of Public Health, Boston, Massachusetts, MA 02118, USA. [*]Equal contributors.

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Abstract: The burden of lung cancer in Hong Kong continues to rise. We analyzed trends in lung cancer incidence and associations with age, period, and cohort from 1985 to 2019, made projections up to 2030 and examined the drivers of lung cancer incidence. We used age-period-cohort modeling to estimate age, period, and cohort effects on lung cancer incidence rates in Hong Kong between 1985 and 2019. We projected lung cancer incidence in Hong Kong from 2020 to 2030 using Bayesian age-period-cohort analysis with an integrated nested Laplace approximation. We decomposed changes in the number of lung cancer cases into population growth, population aging, and epidemiologic changes. From 1985 to 2019, the number of lung cancer incident cases in Hong Kong continued to rise, yet the age-standardized incidence rates have declined for both sexes while have fluctuated for females over the past two decades. The overall annual percentage change from 1985 to 2019 was -2.29 (95% CI, -2.53 to -2.05) for males and -0.86 (95% CI, -1.06 to -0.65) for females. Age-specific annual percentages for both sexes showed a decreasing trend in all age groups and were more pronounced for females older than 65 years and males younger than 65 years. Period effects for both sexes showed a similar monotonic downward pattern, with the downward trend slowing for females after 2000. The cohort effect declined monotonically for males and started to plateau for females after the 1945 birth cohort. It was projected that the incident cases of lung cancer in Hong Kong would continue to increase, with 4,435 male cases and 3,561 female cases in 2030. Demographic decomposition suggested that population growth and population aging play an important role in the change of lung cancer cases. Much progress has been made in reducing the incidence of lung cancer in Hong Kong, but this has been offset by demographic changes that will continue to increase the incident cases of lung cancer in Hong Kong, especially among females. There is an urgent need for continued public health policies and clinical programs for risk factor control and necessary screening.

Keywords: Lung cancer, Hong Kong, age-period-cohort analysis, projection, decomposition

Introduction

Lung cancer has been one of the most common causes of cancer deaths in Hong Kong [1, 2], where 98% are Chinese ethnicity. Considering the strong causal relationship between smoking and multiple adverse health outcomes [3-6], the Hong Kong government has successfully implemented a series of tobacco control interventions since the 1980s [7, 8]. The age-standardized incidence rate of lung cancer in Hong Kong has declined notably, particularly in males, but the incidence in females has not changed much over the past two decades [7]. Despite this, the burden of lung cancer in Hong Kong remains high. According to the latest survey data released by the Hong Kong Cancer Registry (HKCaR) (https://www3.ha.org.hk/cancereg/allages.asp), 3,424 men and 2,151 women were registered with lung cancer in

Hong Kong in 2019. The survey data shows that lung cancer remains the most common cancer among men and the third most common cancer among women in Hong Kong and that the number of lung cancer cases in Hong Kong have continued to increase in recent years, especially among women.

Consistent with studies in other populations [2, 3, 5, 7, 9], tobacco smoking is the well-documented significant risk factor of lung cancer in Hong Kong men, and smoking and exposure to cooking emissions from Chinese-style frying are the main risk factors for lung cancer in Hong Kong women. Smoking prevalence and lifestyle habits vary across birth cohorts [8, 10], leading to the varying risk of lung cancer incidence in different birth cohorts. The effect of temporal variation and birth cohort on lung cancer incidence can be separated and analyzed by age-period-cohort models, which are more suitable for elucidating possible determinants of temporal trends [11-13]. The age effect refers to the association of physiological changes in aging with cancer incidence independent of birth cohort and calendar period. Birth cohort effects represent intergenerational changes in the prevalence of causal factors, such as specific lifestyles or behaviors, which may have a delayed effect on lung cancer incidence. Period effects reflect changes in factors that affect all individuals simultaneously over a given period, such as changes in diagnostic methods and the introduction of screening programs. Understanding each factor of the age, period, and cohort effects may provide a more accurate understanding and projection of disease incidence, which may help guide public health policy, resource allocation, and the design of screening programs.

This study aimed to evaluate the relationship between age, period, and cohort with the incidence of lung cancer in Hong Kong. We used age-period-cohort (APC) modeling to assess the associations between age, period, and birth cohort and the incidence of lung cancer in Hong Kong. In addition, we projected the future incidence of lung cancer in Hong Kong from 2020 to 2030 by conducting a predictive model that included age, period, and cohort effects. Further, we analyzed the key drivers of the net change in lung cancer incident cases in Hong Kong, including population growth, population aging, and epidemiological shifts.

Material and methods

Data source

We obtained rates and incident cases of lung cancer in Hong Kong by sex, age group, and calendar year from 1985 to 2019 from the Hong Kong Cancer Registry (HKCaR). HKCaR was established in 1963 as a population-based cancer registry and is a member of the International Association of Cancer Registries. The primary mission of HKCaR is to report the cancer incidence and mortality rates in Hong Kong by collecting, consolidating, and validating preliminary demographic data, information on the topography and histology of all cancers diagnosed in Hong Kong. HKCaR has established quality control measures to check the completeness, accuracy, and validity of the data. The percentage of morphologically verified cases has increased significantly from 55% in 1983 to nearly 90% in 2019, and the percentage of cases confirmed by death certificates has decreased from 13.3% in 1983 to 0.2% in 2019, having achieved the highest standards for developed countries as depicted by the World Health Organization (WHO) International Agency for Research on Cancer (IARC). In addition, HKCaR has applied a series of validation rules to the data registered to ensure the accuracy and validity of the data before publication. All International Classification of Diseases (9th and 10th revision) codes pertaining to lung cancer (162 and C33-34) are included. As very few lung cancer cases were diagnosed at ages below 30, we only consider data of 12 five-year age groups ranging from 30-34 years to 85 years or older. Population data of Hong Kong from 1985 to 2030 were obtained from the United Nations (UN) World Population Prospects 2019 revision (https://population.un.org/wpp). Age-standardized incidence estimates were weighted to the age distribution of the WHO's world standard population based on world average population between 2000-2025 (http://www.who.int/healthinfo/paper31.pdf) by the direct method.

Age-period-cohort analysis

For age-period-cohort (APC) analyses, we arranged the incident lung cancer cases and population data of Hong Kong into 12 age intervals (from 30-34 years to 85 plus) and 7-period intervals (from 1985-1989 to 2015-2019). The cohort was defined using the difference between the midpoint of the age interval and period interval. Net drift and local drift were essential parameters in the APC models. Net drift indicates the overall annual percentage change in the expected age-adjusted rate. Local drift indicates estimated annual percentage change over time specific to age group. The longitudinal age curve indicates the expected age-specific rate in a reference cohort adjusted for period effects. The period (or cohort) rate ratio (RR), represents the ratio of age-specific rates in period (or cohort) relative to the reference period (or cohort). For relative rate measurements, the reference cohort was the 1945 birth cohort, and the reference period interval was from 2000 to 2004. The Wald chi-square test was adopted to test the significance of the estimable parameters and functions. The estimable parameters were obtained by the APC Web Tool (https://analysistools.cancer.gov/apc). All statistical tests were two-sided.

Projection analysis

Age-specific incident cases of lung cancer in Hong Kong from 2020 to 2030 were projected using the Bayesian age-period-cohort (BAPC) analysis with integrated nested Laplace approximations [14]. The model showed better coverage and accuracy than other prediction methods [15]. We prepared age-specific incident cases of lung cancer (from 1985 to 2019) and Hong Kong population data (from 1985 to 2030), followed by an 11-year (from 2020 to 2030) retrospective projection using the BAPC function in the R package BAPC, version 0.0.34.

Decomposition

Further, using 1985 as the reference year, we decomposed the drivers of the increase in the number of lung cancer cases in Hong Kong from 1986 to 2030 into three components: population growth, population aging, and changes in age-specific incidence rate. Changes in age-specific incidence rates represent epidemiological changes, including all differences in incidence that cannot be explained by population growth and population aging, such as changes in the prevalence of smoking and other risk exposures [16]. The net changes in these three components were equal to the difference in the total incident cases. We performed the decomposition using a validated algorithm [17-19] that is robust to the order of decomposition and the choice of the reference year. All statistical analyses were performed with R software (version 3.6.3; R Foundation for Statistical Computing).

Results

Trends in incidence rates of lung cancer

A total of 147,668 patients (97,435 male patients [66.0% of total patients] and 50,233 female patients [34.0%]) were included in our analysis. From 1985 to 2019, the incident cases of lung cancer have continued to rise in Hong Kong, from 2,133 and 1,052 to 3,421 and 2,148 for males and females, respectively (**Figure 1A**). There was a slight increase in the crude incidence rate of lung cancer for both sexes. However, in the same time period, marked declines were observed in the age-standardized incidence rate for both sexes, with a greater decline for males. The age-standardized incidence rate decreased from 93.1 per 100,000 persons in 1985 to 48.8 per 100,000 persons in 2019 for males and decreased from 39.3 per 100,000 persons in 1985 to 27.1 per 100,000 persons in 2019 for females (**Figure 1B**). However, the age-standardized incidence rate for females has fluctuated over the last two decades, with relatively little change.

Age-period-cohort analysis

Net drift indicates the overall annual percentage change (**Figure 2**), which is the APC analog of the estimated average percentage change of the age-standardized rate. There were marked sex differences in net drift. The net drift was -2.29% (95% confidence interval, CI: -2.53 to -2.05) for males and -0.86% (95% CI: -1.06 to -0.65) for females, reflecting decreases in incidence for both sexes from 1985 to 2019. Local drift reflects additional age-specific changes in lung cancer incidence trends. Values were less than zero in almost all age groups, indicating a decline in the incidence of lung cancer for both sexes in all age groups. The decline was more pronounced among women in the older age groups (>65 years) and men in the younger age groups (<65 years) (**Figure 2**).

The age-adjusted incidence rate of lung cancer increases with the patient age until around 80 years of age, after which it decreased slightly

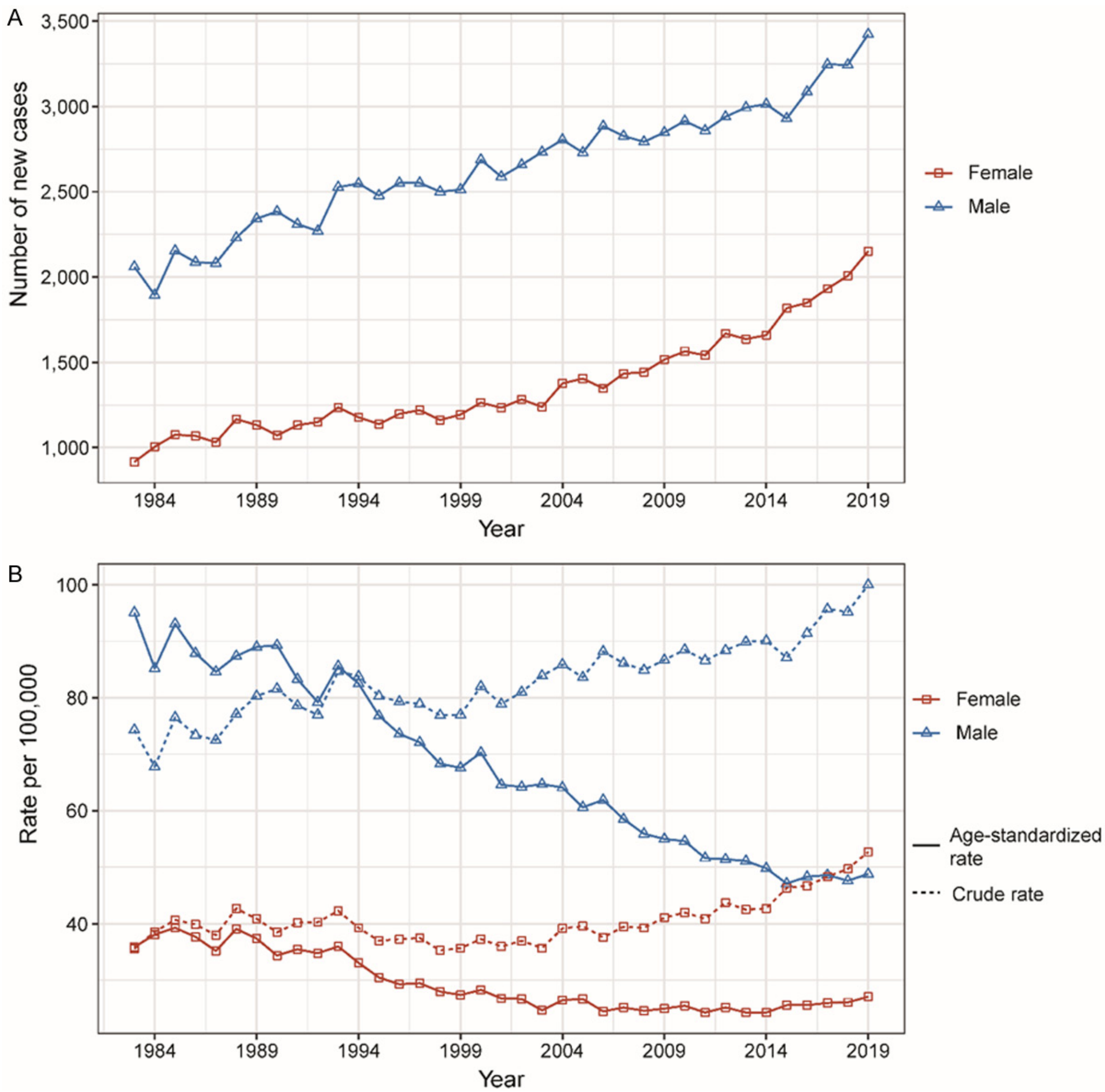

Figure 1. Changes in incidence rate and incident cases of lung cancer for males and females in Hong Kong, 1985-2019. A. Incident cases for males and females. B. Age-standardized incidence rate and crude incidence rate of lung cancer for males and females.

(**Figure 3**). Incidence rates were highest in those around 80 years of age and were much higher in men than in women, with the gap increasing with age. We performed curve estimates on the longitudinal age curves and found that they were all fitted with a second-order polynomial regression (Regression coefficients were significant at the $P<0.0001$ level, and adjusted R-squared were 0.999 for both sexes).

Period effects for both sexes followed similar monotonic declined patterns throughout the study period, with more quickly decreasing for males than for females and the trend slowing down after 2000 for females (**Figure 4**). Cohort effects followed different patterns across the sexes, with a consistent monotonic decline for males. On the other hand, females showed a monotonic decrease before the 1940-1944 birth cohort and appeared to be plateauing in the subsequent birth cohorts (**Figure 5**). The Wald tests showed that all net drifts, local drifts, cohort effects, and period effects were statistically significant for both sexes (P<0.0001 for all) (**Table 1**).

Projection

We next performed a projection analysis to estimate the future incidence of lung cancer in

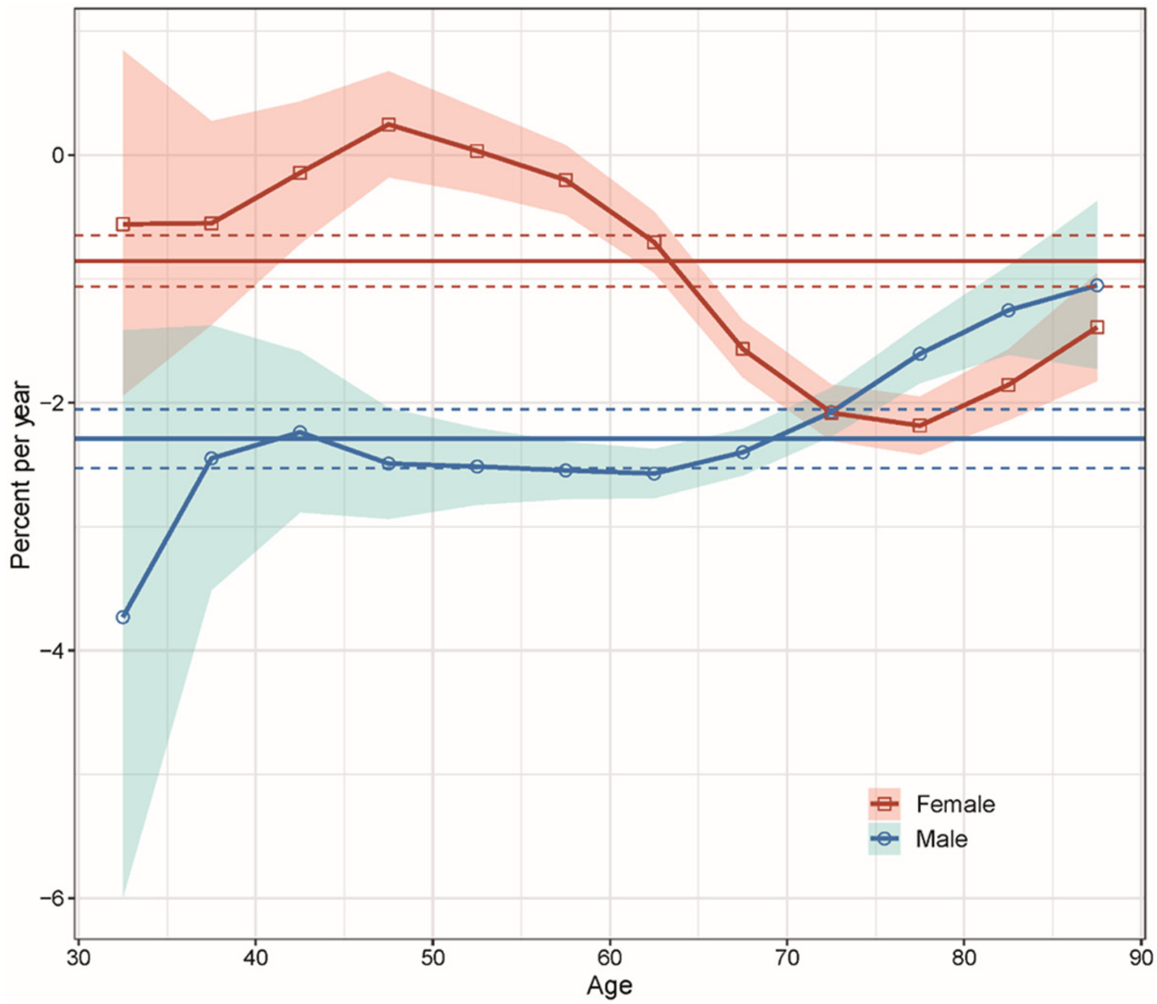

Figure 2. Local drifts with net drift values for males and females for lung cancer incidence in Hong Kong from 1985 to 2019. Shaded areas indicate 95% confidence interval.

Hong Kong. We found the number of lung cancer cases in Hong Kong would continue to increase, with 4,435 male cases and 3,561 female cases in 2030 (**Table 2**). The age-standardized incidence rate will continue to decline for males and may increase slightly for females (**Figures 6**, **7**). The largest increases in incidence were expected to be in the female population over 60 years of age and in the male population over 70 years of age (**Tables 2**, **3**).

Decomposition analysis

Finally, we conducted a demographic decomposition to analyze the potential driver of the incident cases of lung cancer from 1986 to 2030 in Hong Kong. Our results indicated that demographic factors (i.e., population growth and population aging) play an essential role in changing of the incident cases of lung cancer in Hong Kong. Although Hong Kong has made significant progress in preventing the incidence of lung cancer, population aging and population growth have led to a marked increase in the incident cases of lung cancer (**Figures 8**, **9**; **Tables 4**, **5**).

Compared to 1985, the incident cases of lung cancer in Hong Kong increased by 1,288 and 1,096 cases in males and females respectively in 2019, representing an increase of 60.4% and 104.2%, respectively. The change in epidemiology resulted in a decrease of 93.6% and 63.5% in the incident cases for males and females. The drivers of incident cases of lung cancer were population aging (67.8% and

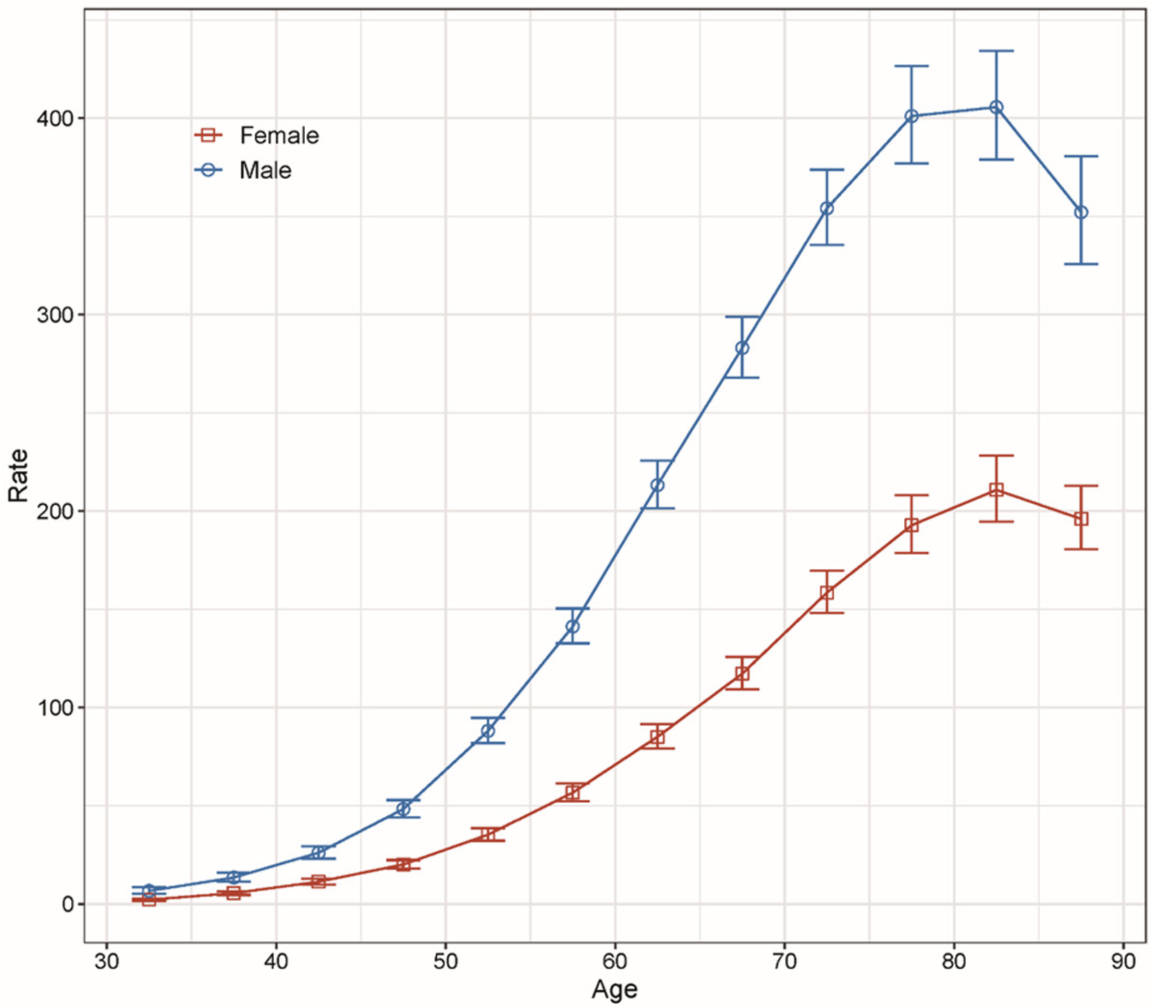

Figure 3. Fitted longitudinal age curves of lung cancer incidence (per 100,000 person-years) and the corresponding 95% confidence interval for males and females in Hong Kong.

29.7% increase for males and females respectively compared to 1985) and population growth (86.2% and 137.9% increase for males and females respectively compared to 1985) (**Tables 4**, **5**).

The projection and decomposition analysis suggested that the trend will continue. In 2030, Hong Kong will have 107.9% and 238.5% more incident lung cancer cases for males and females respectively than in 1985, with the contribution of population aging at 110.3% and 90.8%, population growth at 111.4% and 201.6%, and epidemiological changes at -113.7% and -53.8% respectively (**Tables 4**, **5**).

Discussion

This study used APC analysis to address why incident cases of lung cancer continue to increase in Hong Kong. We showed that, while age-standardized incidence rates declined for both sexes, the decline was relatively small for males >65 years and for females <65 years. In addition, the period effects showed monotonic decreases in both sexes. In contrast, the cohort effect showed a monotonic decline for males and appeared to be plateauing for females after the 1945 birth cohort. Moreover, demographic factors were the main drivers of incident cases of lung cancer in Hong Kong. Although Hong Kong has made significant progress in reducing the incidence of lung cancer, these gains have been offset by demographic changes. Therefore, there is a need for continued epidemiological and clinical research on the disease and its treatment.

One of the main values of this study is the APC analysis, which quantitatively describes the

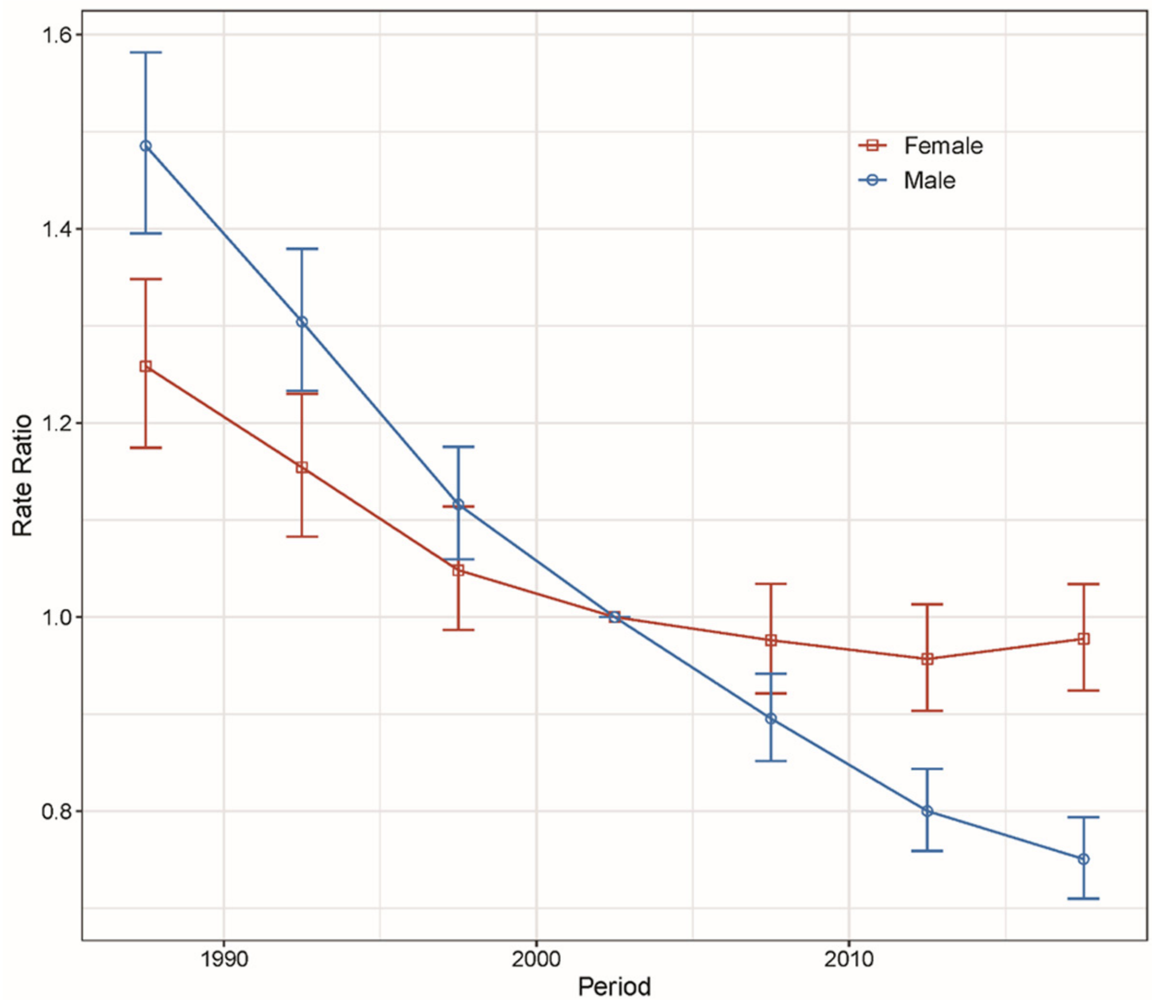

Figure 4. Relative risk of each period compared with the reference adjusted for age and nonlinear cohort effects and the corresponding 95% confidence interval for males and females.

relative age, period, and cohort effects. We showed an encouraging downward trend in period effects and cohort effects for both sexes. These trends were attributed to the efforts to reduce tobacco use in Hong Kong over the past decades. Smoking was the most critical risk factor associated with lung cancer [3], but the attributable risk was much higher in men than in women (45.8% vs. 6.2% in Hong Kong [9]). Hong Kong has been working on reducing the health burden of tobacco use with notable success [20]. Beginning with a tobacco-focused health ordinance in 1982, Hong Kong started a progressive approach to tobacco control that included a multipronged strategy to reduce the supply and demand for tobacco use. Further, in 2007, Hong Kong implemented legislation to protect against secondhand smoke exposure in indoor workplaces and in public places [20]. Smoking prevalence among those aged 15 or older in Hong Kong fell progressively from 23.3% in 1982 to 11.1% (18.1% in men and 3.2% in women) in 2019 [8, 21]. The period effect of lung cancer is consistent with the declining trend in smoking prevalence. However, heated tobacco products have become increasingly popular in recent years, especially among adolescents, and can be a pathway to smoking and a health risk for youth [22, 23]. Adolescents are less aware of the risks associated with heated tobacco products [22, 24], so stricter regulation of heated tobacco products is needed to limit adolescent exposure to heated tobacco products and enhance health education.

However, we found that the period effect for lung cancer in Hong Kong women has leveled

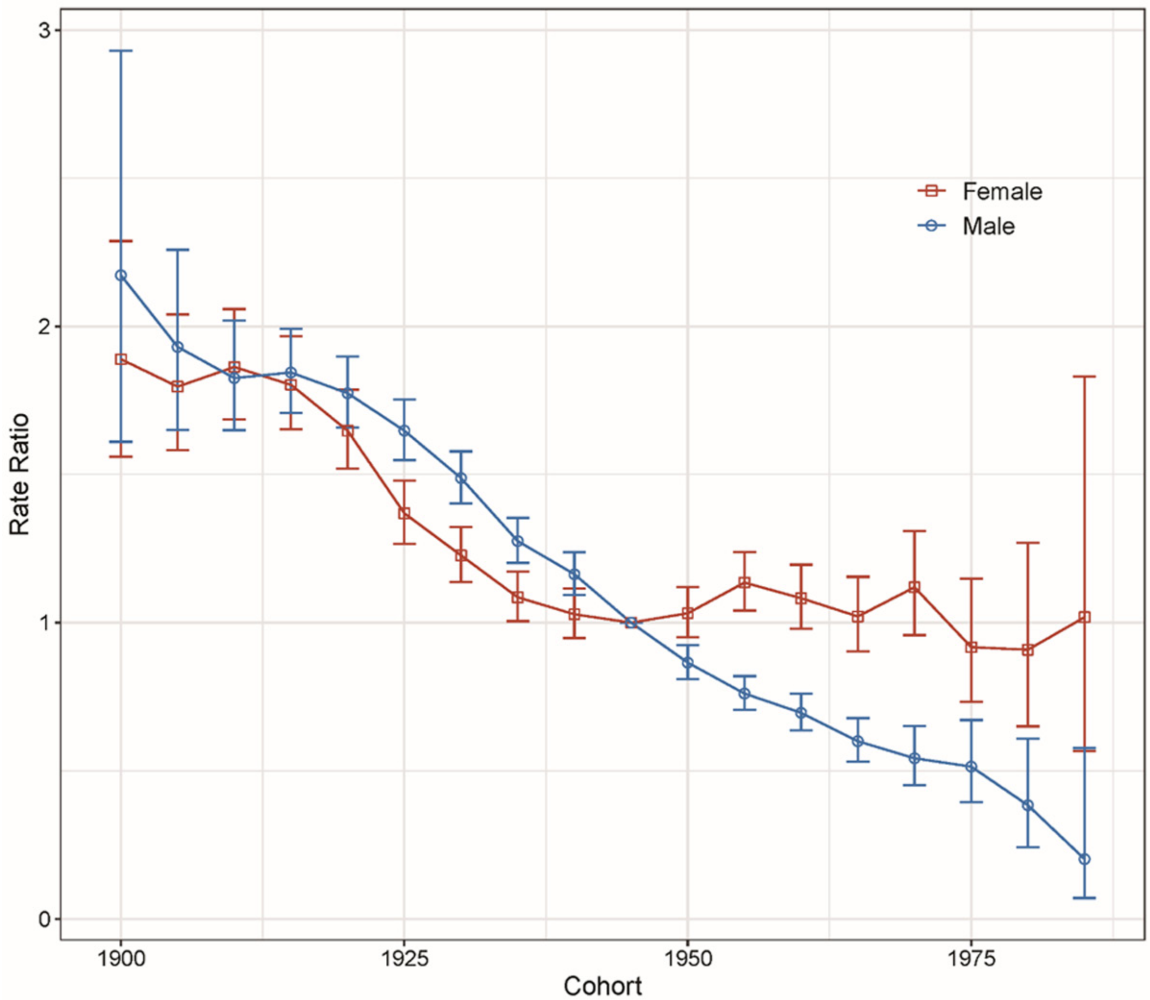

Figure 5. Relative risk of each cohort compared with the reference adjusted for age and nonlinear period effects and the corresponding 95% confidence interval.

Table 1. Wald Chi-square tests for estimable parameters in the APC model

Null Hypothesis	Males		Females	
	Chi-squre	*P*-value	Chi-squre	*P*-value
NetDrift =0	349.79	<0.001	65.49	<0.001
All Age Deviations =0	1460.28	<0.001	1000.59	<0.001
All Period RR =1	351.66	<0.001	74.53	<0.001
All Cohort RR =1	1034.75	<0.001	474.93	<0.001
All Local Drifts = Net Drift	56.48	<0.001	159.49	<0.001

off in the last two decades, probably due to the smaller proportion of lung cancer attributable to cigarette smoking and small change in smoking prevalence among Hong Kong women. For example, in another study, only 16% of lung cancers in Hong Kong women can be attributed to smoking, while 22% to environmental radon exposure and 26% to exposure to cooking fume [1]. In addition, the prevalence of smoking among women in Hong Kong has changed a little over the past few decades and has even increased notably among women as the population has grown [25, 26]. Our study highlights the need for Hong Kong women to lower their exposure to cooking emissions from Chinese-style frying and maintain a low smoking prevalence, leading to good health gains.

The cohort effect reflects early lifestyle factors or carcinogenic exposure. The development of lung cancer usually requires long-term expo-

Table 2. Estimated incident cases of age-specific lung cancer in Hong Kong males from 1985 to 2030

Year	Incident cases of age-specific and total lung cancer												
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+	Total
1985	15	36	42	108	219	295	400	371	344	182	90	31	2133
1990	16	20	51	83	185	297	400	426	402	293	145	50	2368
1995	25	31	57	93	107	206	409	455	456	334	229	70	2472
2000	9	19	64	100	149	193	314	479	519	412	260	168	2686
2005	10	22	50	101	177	207	278	417	497	497	304	168	2728
2010	6	18	37	84	210	261	336	365	483	491	381	242	2914
2015	2	10	40	59	155	308	382	461	430	451	382	244	2924
2019	5	19	29	67	157	313	507	584	572	453	376	339	3421
2020	4	12	28	64	135	292	495	566	590	432	434	396	3448
2021	4	12	27	63	132	282	502	592	621	459	421	419	3534
2022	4	11	27	62	130	271	502	624	647	504	400	441	3623
2023	4	11	27	61	130	259	498	657	672	560	381	459	3719
2024	4	11	26	59	130	249	489	686	701	614	377	470	3816
2025	4	10	26	58	129	242	478	708	737	659	395	474	3920
2026	4	10	26	57	127	237	464	719	774	695	425	485	4023
2027	4	10	25	57	125	235	447	722	818	726	470	490	4129
2028	4	10	24	56	123	235	429	717	863	757	523	492	4233
2029	4	10	24	56	121	234	413	707	904	793	573	496	4335
2030	3	10	24	55	119	233	402	693	935	838	616	507	4435

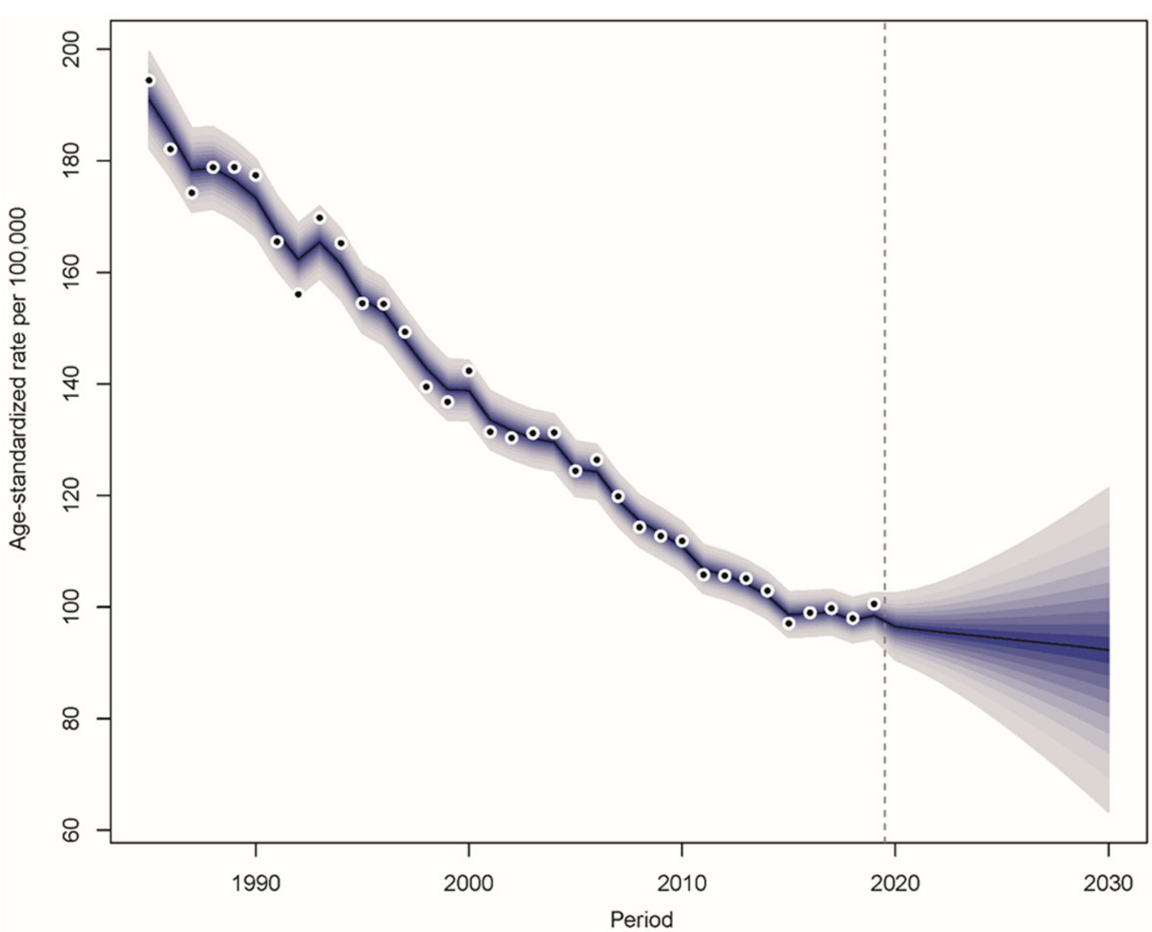

Figure 6. Trends and projected incidence rates of lung cancer for males in Hong Kong. Dots represent fitted points. Each lighter shade of blue represents an additional 10% CI.

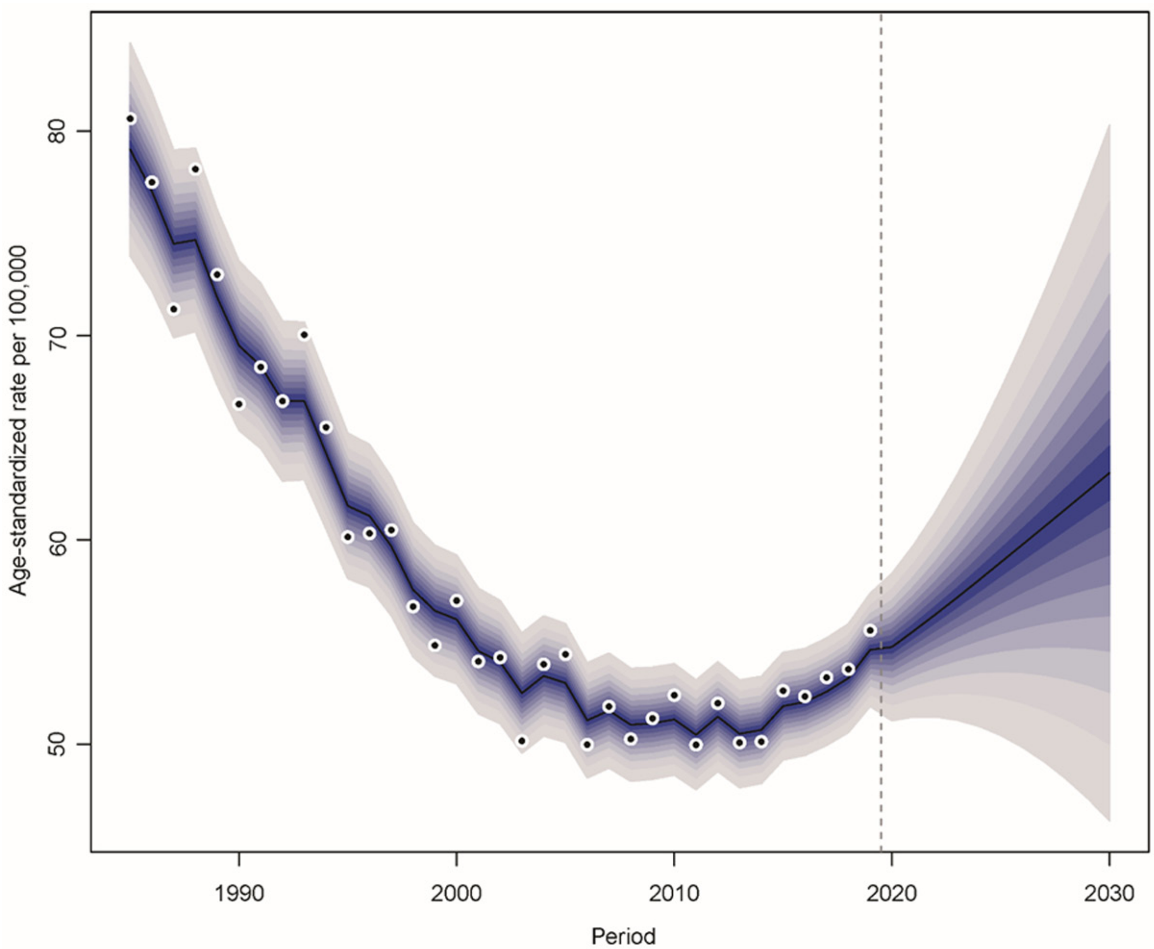

Figure 7. Trends and projected incidence rates of lung cancer for females in Hong Kong. Dots represent fitted points. Each lighter shade of blue represents an additional 10% CI.

Table 3. Estimated incident cases of age-specific lung cancer in Hong Kong females from 1985 to 2030

Year	Incident cases of age-specific and total lung cancer												
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+	Total
1985	7	11	15	33	62	99	163	181	184	141	89	67	1052
1990	3	13	19	18	44	79	118	167	204	186	112	105	1068
1995	9	31	25	37	40	65	109	156	180	199	162	116	1129
2000	6	21	41	47	53	59	113	147	209	218	182	163	1259
2005	6	13	28	55	106	97	96	150	227	251	187	185	1401
2010	10	11	35	78	136	146	154	140	181	242	218	213	1564
2015	7	16	30	85	145	193	231	232	165	230	220	262	1816
2019	3	21	33	84	140	250	324	299	290	202	211	291	2148
2020	7	19	41	76	131	230	309	333	314	199	234	324	2217
2021	7	19	41	77	132	232	324	358	347	221	225	337	2320
2022	7	19	42	77	133	231	339	383	377	257	211	350	2426
2023	7	19	44	79	136	228	353	409	407	303	199	362	2546
2024	7	19	44	80	138	227	364	434	439	350	197	371	2670

2025	7	19	45	81	140	227	370	457	474	394	210	377	2801
2026	7	18	45	83	143	229	373	479	511	435	235	381	2939
2027	7	18	45	86	145	233	372	502	549	474	274	380	3085
2028	6	19	44	88	147	238	369	523	586	512	323	380	3235
2029	6	18	43	90	150	242	368	539	622	554	374	387	3393
2030	6	18	43	91	153	247	369	550	657	601	422	404	3561

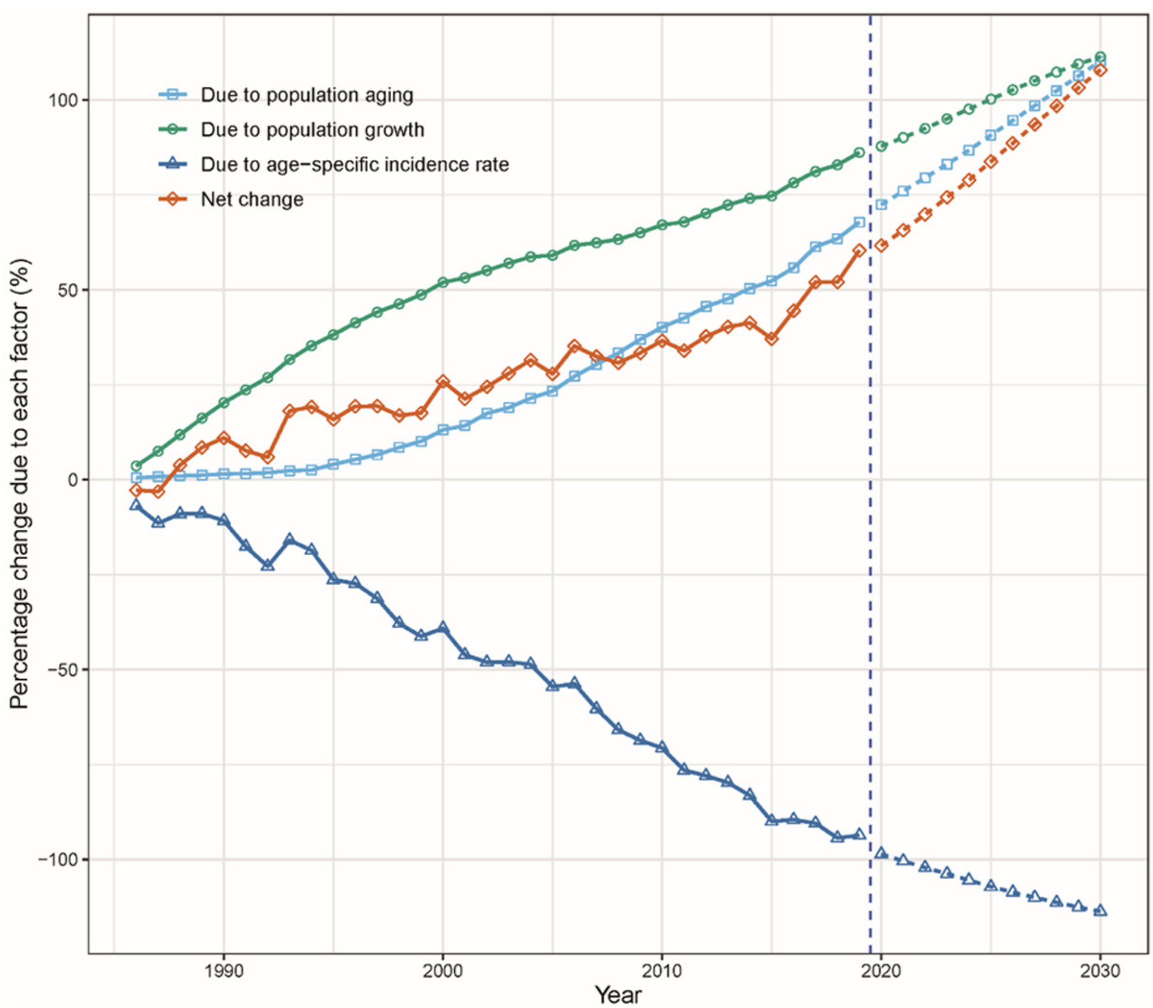

Figure 8. Contribution of changes in population aging, population growth, and age-specific incidence rate to changes in incident cases from 1986 to 2030 for Hong Kong males, using 1985 as the reference year. Data in the right of the blue dashed line were the decomposition based on the projected data.

sure and a long incubation period, such as smoking habits and secondhand smoke exposure [4, 27, 28]. Declines in smoking prevalence and exposure to secondhand smoke and sex differences in lung cancer attributable to smoking could explain the sex differences in lung cancer cohort effects in Hong Kong. We found an encouraging declining cohort effect among Hong Kong males. In contrast, the cohort effect was weaker in Hong Kong females born after the 1945 birth cohort, which may persist in the future. This weak cohort effect among women may be related to the multiple attributions of lung cancer in Hong Kong women. Other studies have indicated that smoking and secondhand smoke exposure are not the most important causes of lung cancer in women [1].

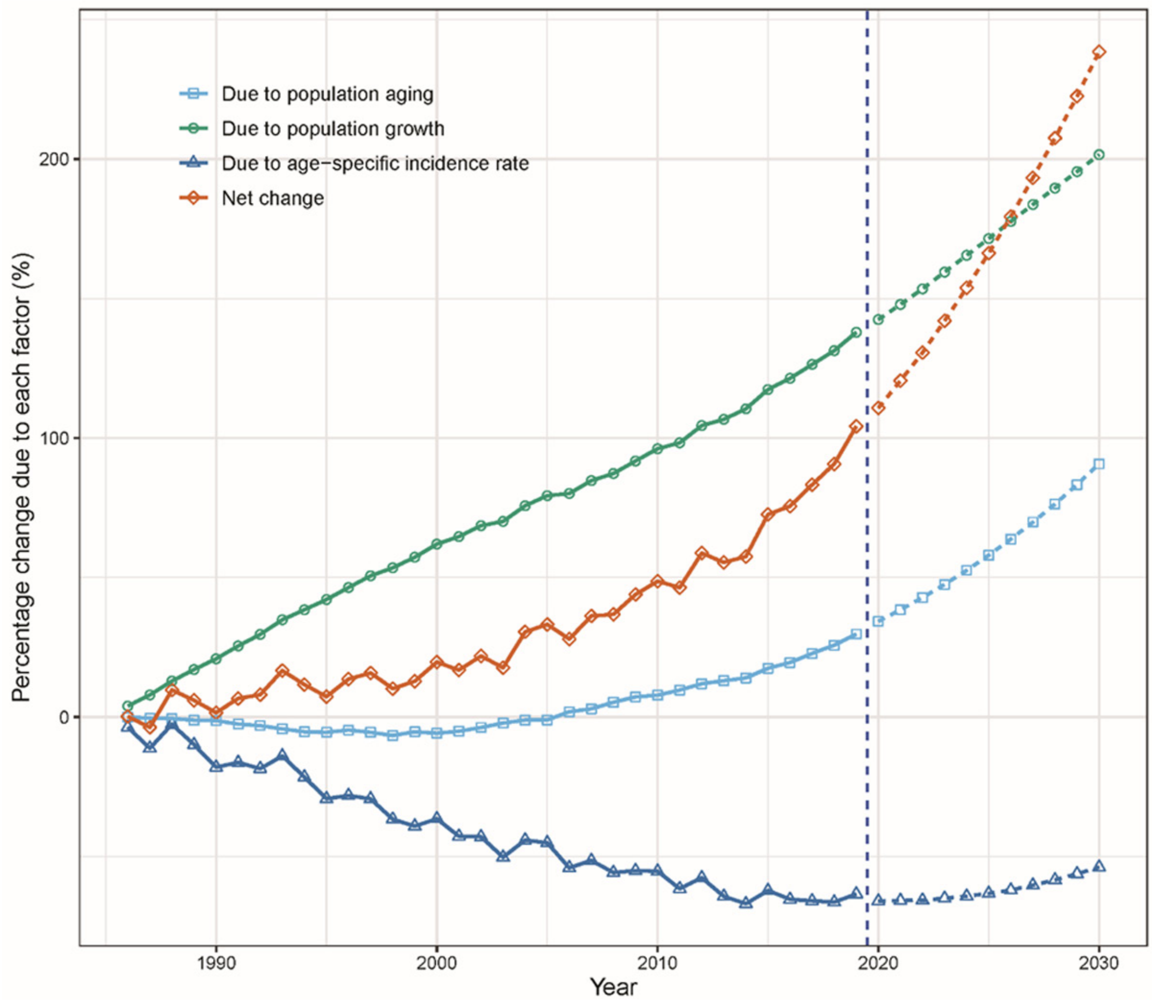

Figure 9. Contribution of changes in population aging, population growth, and age-specific incidence rate to changes in incident cases from 1986 to 2030 for Hong Kong females, using 1985 as the reference year. Data in the right of the blue dashed line were the decomposition based on the projected data.

Although we could estimate period effect and cohort effect as period RRs and cohort RRs, respectively, it is not appropriate to interpret them entirely separately [12, 29, 30]. The reason is that the period effect leads to cohort effect when they affect all age groups simultaneously; different cohorts are born in different periods and, therefore, inevitably have a confounding impact on period effects.

Another main value of this study is the prediction of trends in lung cancer incidence in Hong Kong. We showed that although there was a clear downward trend in age-standardized lung cancer incidence rates in Hong Kong, suggesting that Hong Kong has made great progress in preventing the occurrence of lung cancer. However, incident lung cancer cases in Hong Kong have continued to increase gradually over the past three decades. This inconsistency reflects the critical role of demographic change in the burden of lung cancer. Although tobacco reduction measures and other cancer-related lifestyle changes have reduced the incidence of lung cancer [7, 20, 31], demographic shifts have offset the effect of such epidemiological changes. Population growth and population aging have emerged as the main drivers of lung cancer cases in Hong Kong. Our projections suggest that this trend will continue as Hong Kong's population continues to age and grow.

Our results are generally consistent with previous epidemiological studies of lung cancer incidence in Hong Kong [2, 32]. In particular, we found a significant attenuation of the period

Table 4. Contribution of changes in population aging, population growth, and age-specific incidence rate to the net change of incident cases of lung cancer for males in Hong Kong from 1986 to 2030, using 1985 as the reference year

Year	Due to population aging	Percentage change due to population aging	Due to population growth	Percentage change due to population growth	Due to age-specific incidence rate	Percentage change due to age-specific incidence rate	Net change	Percentage change from 1985
1986	11	0.5	77	3.6	-147	-6.9	-59	-2.8
1990	33	1.5	433	20.3	-230	-10.8	235	11.0
1995	86	4.0	814	38.2	-562	-26.3	339	15.9
2000	280	13.1	1108	51.9	-835	-39.1	553	25.9
2005	498	23.4	1260	59.1	-1163	-54.5	595	27.9
2010	857	40.2	1431	67.1	-1507	-70.7	781	36.6
2015	1117	52.3	1594	74.7	-1919	-90.0	791	37.1
2019	1447	67.8	1838	86.2	-1997	-93.6	1288	60.4
2020	1545	72.4	1873	87.8	-2103	-98.6	1315	61.7
2021	1621	76.0	1922	90.1	-2142	-100.4	1401	65.7
2022	1696	79.5	1973	92.5	-2179	-102.2	1490	69.9
2023	1772	83.1	2027	95.0	-2213	-103.8	1586	74.4
2024	1851	86.8	2082	97.6	-2250	-105.5	1683	78.9
2025	1935	90.7	2138	100.2	-2286	-107.2	1787	83.8
2026	2018	94.6	2190	102.7	-2317	-108.6	1890	88.6
2027	2101	98.5	2241	105.1	-2346	-110.0	1996	93.6
2028	2185	102.4	2290	107.4	-2375	-111.3	2100	98.5
2029	2268	106.3	2335	109.5	-2401	-112.6	2202	103.2
2030	2352	110.3	2376	111.4	-2425	-113.7	2302	107.9

Table 5. Contribution of changes in population aging, population growth, and age-specific incidence rate to the net change of incident cases of lung cancer for females in Hong Kong from 1986 to 2030, using 1985 as the reference year

Year	Due to population aging	Percentage change due to population aging	Due to population growth	Percentage change due to population growth	Due to age-specific incidence rate	Percentage change due to age-specific incidence rate	Net change	Percentage change from 1985
1986	-1	0.0	41	3.9	-39	-3.7	2	0.2
1990	-14	-1.3	219	20.8	-189	-18.0	16	1.5
1995	-58	-5.5	443	42.1	-308	-29.3	77	7.3
2000	-61	-5.8	652	62.0	-384	-36.5	207	19.7
2005	-11	-1.1	835	79.3	-474	-45.1	349	33.2
2010	82	7.8	1012	96.2	-582	-55.3	512	48.7
2015	184	17.5	1235	117.4	-654	-62.2	764	72.6
2019	313	29.7	1451	137.9	-668	-63.5	1096	104.2
2020	361	34.3	1499	142.5	-694	-66.0	1165	110.7
2021	404	38.4	1556	147.9	-692	-65.8	1268	120.5
2022	450	42.8	1614	153.5	-691	-65.7	1374	130.6
2023	500	47.5	1678	159.5	-684	-65.0	1494	142.0
2024	553	52.6	1741	165.5	-676	-64.2	1618	153.8
2025	610	58.0	1804	171.5	-665	-63.2	1749	166.3
2026	671	63.8	1869	177.6	-653	-62.0	1887	179.4
2027	735	69.8	1933	183.7	-634	-60.3	2033	193.3
2028	803	76.3	1994	189.6	-614	-58.4	2183	207.5
2029	876	83.3	2056	195.5	-592	-56.2	2341	222.5
2030	955	90.8	2120	201.6	-566	-53.8	2509	238.5

and cohort effects in Hong Kong women. Although other studies have shown an association between lung cancer incidence and age [2, 3, 6, 32], after controlling for cohort and period effects, we found a second-order polynomial relationship between lung cancer incidence and age, and this age effect may be an increase in cancer risk with increasing age. It has been suggested that there is a roughly 20 to 30-year gap between smoking and the development of lung cancer [33], highlighting the health benefits of quitting smoking early. We estimate a similar relationship between exposure to cooking emissions and lung cancer development in women. Therefore there are significant health benefits for women from the early reduction of exposure to cooking emissions.

This retrospective analysis has some limitations. First, the quality of the early data of HKCaR was not good enough; for example, it was not until 1993 that the percentage of morphologically verified cases exceeded 60%. Second, HKCaR is limited because it does not contain specific data on whether patients smoke, comorbidities, and medications. It would be helpful to understand how these comorbidities coincide with the incidence of lung cancer to adjust our analysis. Third, data on the future structure and size of the population in Hong Kong obtained from United Nations World Population Prospects may be subject to biases, adding uncertainty to the projection. Finally, several modeling approaches were used, including projections and population decomposition, which inevitably introduced some degrees of uncertainty.

Conclusions

Age-standardized lung cancer incidence rates in Hong Kong showed a consistent decline in males but little change in females. Differences in smoking prevalence, exposure to second-hand smoke, and cooking emissions from Chinese-style frying may be associated with the period and cohort effects of lung cancer incidence in Hong Kong. With population growth and aging, lung cancer cases in Hong Kong are expected to continue to increase, especially among females. Further research on this trend and epidemiological assessment should be conducted.

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Disclosure of conflict of interest

None.

Address correspondence to: Dr. Shengzhi Sun, Department of Environmental Health, Boston University School of Public Health, 715 Albany Street, Boston 02118, Massachusetts, USA. Tel: 401-837-7248; E-mail: szsun@bu.edu; Dr. Jianfei Du, Department of Oncology, Xi'an Gaoxin Hospital, No. 16 Tuanjie Road, Xi'an 710100, Shaanxi, China. Tel: +86-298-6186624; E-mail: 38603287@qq.com

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