Original research

BMJ Public Health

Has the impact of cigarette smoking on mortality been underestimated by overlooking second-hand smoke? Tohoku medical megabank community-based cohort study

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To cite: Takase M, Nakaya N, Tanno K, *et al.* Has the impact of cigarette smoking on mortality been underestimated by overlooking second-hand smoke? Tohoku medical megabank community-based cohort study. *BMJ Public Health* 2025;**3**:e001746. doi:10.1136/bmjph-2024-001746

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjph-2024-001746).

Received 20 July 2024
Accepted 31 January 2025

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ABSTRACT

Objectives Previous studies have assessed the impact of active smoking on mortality using the population-attributable fraction (PAF). However, these studies have not included second-hand smoking (SHS), potentially underestimating smoking's impact. We compared the PAF from active smoking alone with the PAF, including SHS exposure.

Design Prospective cohort study.

Setting A community-based cohort study in Japan.

Participants 40 796 participants aged ≥20 years.

Main outcome measures SHS was defined as inhaling someone else's cigarette smoke at the workplace or home in the past year. We classified smoking status and SHS into ten categories: never-smoker without SHS, never-smoker with SHS, past smoker without SHS, past smoker with SHS, current smoker 1–9 cigarettes/day without SHS, current smoker 1–9 cigarettes/day with SHS, 10–19 cigarettes/day without SHS, 10–19 cigarettes/day with SHS, ≥20 cigarettes/day without SHS and ≥20 cigarettes/day with SHS. The main outcome was all-cause mortality.

Results During the median follow-up period of 6.5 (5.7–7.5) years, 788 men and 328 women died. For men, compared with never-smokers without SHS, past smokers without SHS (HR, 1.39 [95% CI, 1.11 to 1.73]) and past smokers with SHS (HR, 1.48 (95% CI, 1.10 to 2.00)) were associated with all-cause mortality. For women, never-smokers with SHS had a significantly higher risk of all-cause mortality (HR, 1.36 (95% CI, 1.00 to 1.84)). Without considering SHS, 28.0% and 2.3% of all-cause mortality in men and women, respectively, were attributable to past and current smoking. Including SHS, PAF increased to 31.3% in men and 8.4% in women.

Conclusions We clarified that smoking's impact was underestimated by not accounting for SHS, especially in women. Information on SHS is crucial for understanding smoking's health impact. This study supports the importance of avoiding smoking and preventing SHS.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Active smoking and second-hand smoking (SHS) are associated with several adverse outcomes such as cardiovascular disease, cancer and premature death. However, little is known about the impact of active smoking and passive smoking on premature death.

WHAT THIS STUDY ADDS

⇒ The population attributable fraction was increased by adding SHS to active smoking alone, which underestimates the impact on all-cause mortality.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study shows that the information on SHS is essential to reveal the impact of smoking on health outcomes and strongly supports the public health notion of the importance of avoiding smoking and preventing SHS.

INTRODUCTION

Active smoking has been associated with an increased risk of all-cause mortality, cardiovascular disease (CVD) and cancers such as lung, liver, stomach, pancreas, kidney, bladder and colorectal.[1–3] Furthermore, second-hand smoking (SHS) is related to lung cancer, ischaemic heart disease and stroke.[4] To reduce both active smoking and SHS, the WHO's Framework Convention on Tobacco Control, aimed at implementing evidence-based measures, was adopted in 2018.[5] However, the Global Burden of Disease Study

2019 estimated that over 1 billion individuals worldwide smoke and that 1.3 million non-smokers die annually from SHS.[6 7] Therefore, active smoking and SHS remain prevalent and cause a significant health burden worldwide.

To understand the burden of disease associated with causal risk factors such as active smoking in a particular population, epidemiological methods have been employed to estimate premature mortality, disability-adjusted life years lost and years of potential life lost. The estimation of population-attributable fraction (PAF), which is the percentage of disease mortality attributable to exposure, is central to calculating the burden of smoking and provides meaningful information for public health and policies.[17] The Global Burden of Disease Study 2019 showed that smoking tobacco is responsible for over 20% of all-cause deaths in men and about 5.8% in women.[7] The Prospective Urban Rural Epidemiology study showed that PAFs of past and active smoking in all-cause mortality were 17.9% in high-income countries, 12.6% in middle-income countries and 7.6% in low-income countries.[8] Thus, quantifying the strength of the evidence supporting the relationship between smoking, SHS and health outcomes is essential to inform tobacco control programmes aimed at protecting the public from tobacco-related harm.

However, the vast majority of previous studies worldwide have estimated the PAF of premature deaths attributable to past and active smoking without including SHS, which may underestimate the impact of smoking on health outcomes.[3 7–17] Comparing the PAF on mortality calculated by past and active smoking with the PAF calculated by integrating past and active smoking with SHS may reveal whether the impact of smoking is underestimated and subsequently provide important insight for smoking control policy. Additionally, although all individuals are at risk of exposure to SHS regardless of smoking status, most previous studies have estimated the impact of SHS on health outcomes only in never-smokers.[4 18–21] Therefore, information on the impact of SHS among past, current and never-smokers remains limited.

To assess the impact of past smoking, active smoking and SHS on mortality, we evaluated the association between these factors and all-cause mortality in a community-based prospective cohort study of the general Japanese population.

METHODS

TMM CommCohort study participants

The Tohoku Medical Megabank (TMM) project was conducted by Tohoku University, Tohoku Medical Megabank Organisation (ToMMo), and Iwate Medical University, Iwate Tohoku Medical Megabank Organisation (IMM).[22] The TMM Project included two prospective cohort studies: the Tohoku Medical Megabank Community-based Cohort Study (TMM CommCohort Study),[23] a large-scale adult population-based cohort study, and the TMM Birth and Three-Generation Cohort Study (TMM BirThree Cohort Study),[24] a birth and three-generation cohort study. We conducted a prospective cohort study using data from the TMM CommCohort study. The source population for this study comprised men and women aged ≥20 years who were living in the Miyagi and Iwate prefectures in northeastern Japan. All participants were recruited between May 2013 and March 2016. Written informed consent was obtained from all participants.

Overall, 67 355 participants were initially enrolled in a baseline survey of municipal health check-ups. The following participants were excluded: (1) those who lacked a self-reported questionnaire (n=4559), (2) those who participated in the TMM BirThree Cohort Study (n=1105), (3) those who did not follow up and withdrew consent on the recruitment day (n=66), (4) those with missing data on SHS (n=20 329), (5) those with missing data on active smoking status (n=429) and (6) those for whom the calculation of the sodium to potassium ratio (Na/K ratio) resulted in an infinite value (n=71). Finally, we analysed data for 40 796 participants.

Ethics approval statement

The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was reviewed and approved by the Ethics Committee of ToMMo, Tohoku University (first edition: 2012-4-617, latest edition: 2021-4-113, the Chief and institution: Nobuo Fuse, Tohoku Medical Megabank Organisation). At IMM, the first approval by the Ethics Committee of Iwate Medical University was on 4 April 2013 (HGH25-2, the Chief and institution: Yasushi Ishigaki, Iwate Medical University). Our ethics statement confirming was approved for all local ethics committees. The latest approval (revised 17th edition) was approved on 14 December 2023.

Active smoking

Active smoking status was classified into the following five categories: never-smokers (had smoked <100 cigarettes in their lifetime), ex-smokers (had smoked ≥100 cigarettes in their lifetime and were not current smokers), current smokers (1–9 cigarettes/day), current smokers (10–19 cigarettes/day) and current smokers (≥20 cigarettes a day).[25]

SHS

Information on SHS was collected via a self-reported questionnaire. Participants were asked, ‘Have you breathed in someone else’s cigarette smoke in the past years?’ The response categories included ‘more than 6 hours almost every day’, ‘4–5 hours almost every day’, ‘2–3 hours almost every day’, ‘less than 1 hour almost every day’ and ‘sometimes or rarely’. Participants provided answers on smoking exposures both at home and in the workplace. SHS was defined as exposure to smoking for ‘more than 6 hours almost every day’, ‘4–5 hours almost every day’, '2–3 hours almost every day', or 'less than 1 hour almost every day' at home and/or at the workplace.

Ascertainment of all-cause mortality

ToMMo and IMM employ different methods of following up on participants. ToMMo reviews and confirms the municipal basic resident register almost every year as follows: (1) those who received death information from their family members, (2) those whose address was unknown and did not receive mail and (3) those whose reason for withdrawing from the National Health Insurance was confirmed as 'death'. The follow-up period for survival analysis was until 31 December 2021. In addition, withdrawal of consent was confirmed using information up to 11 December 2023.

At IMM, deaths and move-outs were identified by collating electronic data annually from the municipal basic resident register or by requesting a resident certificate for all the participants at an approximately similar time. 'Death' referred to the date of death, whereas 'move-out' indicated the date of move-out. For those who withdrew consent for follow-up, it was terminated on the date of withdrawal of consent. For those who had no events, the follow-up period was until the last day of follow-up. The follow-up period for the survival analysis was until 31 December 2021. In addition, withdrawal of consent was confirmed using information up to 11 December 2023.

Covariate

Information on demographic characteristics, educational levels, psychological distress, social isolation, drinking status, physical activity, treatment for hypertension and diabetes was collected via a self-reported questionnaire. A history of disease (eg, CVD, lung cancer, other cancers, lung disease, liver disease, kidney disease, digestive disease and tuberculosis) was collected by a self-reported questionnaire. Age was determined during the visit to the municipal health check-up sites. Educational level was categorised into three categories: below high school; vocational school, junior college or technical college; and university or graduate school. Marital status was categorised into four groups: presence, absence (unmarried), absence (divorce) and absence (bereavement).

Psychological distress was assessed by the Japanese version of the Kessler six scale (K6), a brief scale consisting of six questions that were developed, validated and used.[26 27] We categorised K6 into three categories: K6 < 5 points, 5–12 points indicating the presence of psychological distress and ≥13 points indicating the presence of severe psychological distress.[27–29] Social isolation was assessed using the Japanese version of the Lubben Social Network Scale-6 (LSNS-6), which consists of six items with confirmed reliability and validity.[30–32] A score of <12 defined social isolation.

Alcohol type was classified into six categories: sake, distilled spirits, shochu-based beverages, beer, whiskey and wine. The frequency of alcohol consumption was classified into six categories: almost never, 1–3 days/month, 1–2 days/week, 3–4 days/week, 5–6 days/week and daily. The quantity of ethanol consumed was calculated by multiplying the type of alcohol consumed by the frequency and volume of consumption. Drinking status was classified into four categories: never drinkers (had consumed little or no alcohol or were constitutionally incapable of alcohol consumption), ex-drinkers (had stopped drinking alcohol), current drinkers (<23 g/day), and current drinkers (≥23 g/day).[33]

Participants answered questions on the hours spent for each activity (sitting, standing, walking and strenuous work) per average day in the last year.[34] We assigned 0, 30, 120, 240, 360, 480, 600 and 660 min to none, <1 hour, 1–3 hour, 3–5 hour, 5–7 hour, 7–9 hour, 9–11 hour and ≥11 hour, respectively. The average frequency (times/week) and duration (min/time) of normal walking, brisk walking, moderate-intensity exercise and high-intensity exercise during leisure were obtained.[35] The frequency was classified into the following categories: less than once per month, 1–3 times per month, 1–2 times per week, 3–4 times per week and almost every day. Moreover, the duration was classified into the following categories: <30 min, 30–59 min, 1–2 hour, 2–3 hour, 3–4 hour and ≥4 hour.

This study defined 'walking', 'normal walking', 'brisk walking' and 'moderate-intensity exercise' as moderate physical activities, and 'strenuous work' and 'high-intensity exercise' as vigorous physical activities. The average time of moderate and vigorous physical activities in leisure time was determined by multiplying frequency and duration. Subsequently, we calculated the minutes of moderate-intensity activity per week by adding the duration of walking and the average time of moderate physical activity during leisure time. Similarly, we calculated the minutes of vigorous physical activity per week by adding the duration of strenuous work and the average time of vigorous physical activity during leisure time. Regular physical activity was defined as moderate activity of at least 150 min per week or vigorous activity of at least 75 min per week.[36 37]

Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m). BMI followed the Western Pacific Region of the WHO criteria: <18.5 kg/m^2, 18.5–24.9 kg/m^2 and ≥25.0 kg/m^2.[38]

Blood pressure (BP) information was obtained during municipal health checkups. BP was measured on the right upper arm after participants had urinated and rested in a sitting position for at least 5 min, avoiding activities that could affect BP measurement, such as exercise, eating and smoking. Hypertension was defined as systolic BP of ≥140 mm Hg and/or diastolic BP of ≥90 mm Hg and/or self-reported treatment for hypertension. Blood samples were collected at the venues of the municipal health check-up. Blood glucose levels and haemoglobin A1c (HbA1c) were measured using an enzymatic method. Participants were instructed to fast, though some did not. Diabetes was defined using the following criteria: non-fasting glucose of ≥200 mg/

dL, HbA1c of ≥6.5% and/or self-reported treatment for diabetes.

Statistical analysis

The characteristics of the participants according to their SHS status have been described. Data were presented as means (SD) or median (IQR) and number (percentage) for continuous and categorical variables, respectively.

First, we examined the association between active smoking status (never-smoker, ex-smoker, current smoker 1–9 cigarettes/day, current smoker 10–19 cigarettes/day, current smoker ≥20 cigarettes/day) and all-cause mortality using the Cox proportional hazard model. Adjusted HRs and 95% CIs were calculated. The multivariate model adjusted for age, sex, education, marital status, BMI (<18.5 kg/m^2, 18.5–24.9 kg/m^2, ≥25.0 kg/m^2), drinking, hypertension, diabetes, history of CVD, lung cancer, other cancer, lung disease, liver disease, kidney disease, digestive disease, tuberculosis, psychological distress, social isolation, physical activity and study area (Miyagi or Iwate prefecture). Second, we examined whether there is an interaction between active smoking and SHS by adding an interaction term into the model. Third, to estimate the impact of smoking, including SHS, on all-cause mortality, we classified participants into 10 categories by active smoking status and SHS: never-smoker without SHS, never-smoker with SHS, past-smoker without SHS, past-smoker with SHS, current smoker (1–9 cigarettes/day) without SHS, current smoker (10–19 cigarettes/day) without SHS, current smoker (≥20 cigarettes/day) without SHS, current smoker (1–9 cigarettes/day) with SHS, current smoker (10–19 cigarettes/day) with SHS and current smoker (≥20 cigarettes/day) with SHS. The PAF was calculated as pd_i*{HR_i-1}/HR_i, where HR_i is the adjusted HR for the ith exposure category (relative to the unexposed stratum) and pd_i represents the proportion of total cases in the population arising from the ith exposure category.[39] The attributable fraction was calculated as (HR_i −1)/ HR_i, where HR_i is the adjusted HR for the $_i$th exposure category. The attributable fraction was calculated as (HR_i −1)/ HR_i, where HR_i is the adjusted HR for the $_i$th exposure category.

Among the analytic sample of 16 948 men and 23 848 women, some participants were missing data on covariates. Complete case analysis that ignored missing data results in a loss of 33.8% for men and 25% for women of the analytic sample. Thus, to address missing information on covariates, multiple imputations with 10 imputed datasets were performed using the mice package in R.[40] Several sensitive analyses were performed to confirm the robustness of our study. First, we repeated all analyses separately for SHS at home and at work, as the frequency and extent of SHS at these locations may differ and have distinct effects on mortality. Second, we conducted analyses after excluding participants who died during the first 3 years of follow-up. Third, we stratified by fasting blood sample or non-fasting blood sample. Finally, we conducted a complete case analysis.

Statistical significance was set at two-sided p<0.05. Statistical analyses were performed using R software version 4.1.2 (R Foundation for Statistical Computing, Vienna, Austria).

Patient and public involvement

The public was concerned about the health effects of SHS as well as active smoking, and their concerns informed our research question. Although participants were not involved in the study design, they played a central role in the conduct of the study by receiving repeat assessment centre-based surveys in our cohorts, and we appreciate their contributions. The results are relevant to the public and policymakers. We will disseminate results to the public through a press release, social media and the websites of our research institutions. We will also present results at public conferences and stakeholder meetings.

RESULTS

Participants' characteristics

Among the 40 796 (16,948 men and 23 848 women) participants, the median follow-up time was 6.5 years. The baseline characteristics of the participants according to active smoking status and SHS are shown in online supplemental table 1 for men and online supplemental table 2 for women. Among men, 4310 (25.4%), 8100 (47.8%) and 4538 (26.8%) were never-smokers, past-smokers and current smokers, respectively. Overall, 4789 (28.3%) were exposed to SHS. Among women, 19 486 (81.7%), 2544 (10.7%) and 1818 (7.6%) were never-smokers, past-smokers and current smokers, respectively. Of whom, 5330 (22.3%) were exposed to SHS.

Both men and women exposed to SHS were younger and had lower educational levels, regardless of their active smoking status. For men, participants with SHS engaged in regular physical activity and had severe psychological distress, regardless of their active smoking status. For women, participants with SHS had a slightly higher urinary Na/K ratio and were more likely to be current drinkers with an ethanol intake of ≥23 g/day. Over 109 204 person-years for men and 156 287 person-years for women, 788 and 328 deaths were ascertained for men and women, respectively.

Association of active smoking status with risk of all-cause mortality

Online supplemental table 3 presents HR and 95% CIs for all-cause mortality according to active smoking status. For men, compared with never-smokers, past smoking exhibited a significantly higher risk of all-cause mortality (HR, 1.34 [95%CI, 1.10 to 1.64]). Current smokers had a higher risk of all-cause mortality as the number of cigarettes smoked increased (HR, 1.82 (95% CI, 1.06 to 3.11) for 1–9 cigarettes/day; HR, 2.42 (95% CI, 1.84 to 3.18) for 10–19 cigarettes/day; and HR, 2.58 (95% CI, 2.03 to 3.28) for ≥20 cigarettes/day). For women, past smoking was not associated with all-cause mortality (HR, 0.92 (0.58 to 1.44)). The risk of all-cause mortality increased with the number of cigarettes smoked, although it was statistically significant only for current smokers of ≥20 cigarettes/day (HR, 1.32 (95% CI, 0.54 to 3.25) for 1–9 cigarettes/day; HR, 1.64 (95% CI, 0.91 to 2.94) for 10–19 cigarettes/day; and HR, 3.61 (95% CI, 1.98 to 6.57) for ≥20 cigarettes/day). PAFs of past smoking and current smoking were 28.0% for men and 2.3% for women.

Association of active smoking status and SHS with risk of all-cause mortality

First, an interaction analysis between smoking status and SHS on all-cause mortality was performed. However, no statistically significant interactions were observed. Thus, to estimate the impact of smoking, including SHS, on all-cause mortality, we classified participants into 10 categories by active smoking status and SHS. The HR and 95% CIs for all-cause mortality according to active smoking status and SHS are shown in online supplemental table 4 for men and online supplemental table 5 for women. Among never-smokers, SHS was not statistically associated with all-cause mortality for men (HR, 1.27 (95% CI, 0.84 to 1.93)). For women, SHS had a significantly higher risk of all-cause mortality among never-smokers (HR, 1.36 (95% CI, 1.00 to 1.84)). Past smoking was associated with a higher risk of all-cause mortality regardless of SHS among men (HR, 1.39 (95% CI, 1.11 to 1.73) without SHS; and HR, 1.48 (95% CI, 1.10 to 2.00) with SHS). However, since we did not observe deaths from past smoking with SHS among women, we could not examine the effect of SHS on past smoking. For men, current smoking was associated with a higher risk of all-cause mortality, and current smokers of ≥20 cigarettes/day with SHS had the highest HR for all-cause mortality (HR 2.93 (95% CI, 2.17 to 3.94)). For women, most of the current smokers had a higher risk of all-cause mortality. Total PAFs of SHS, past smoking and current smoking were 31.3% for men and 8.4% for women. The group of participants with ex-smoker and SHS contributed the most to the overall PAF in men. For women, the group of participants who are never-smokers with SHS contributed the most to the overall PAF.

A similar trend was observed after stratifying the analysis for SHS at home and at work (online supplemental table 6 and 7). After stratifying by fasting blood sample or non-fasting blood sample, the results were substantially unchanged (online supplemental table 8). In the complete case analysis, the results were substantially unchanged (online supplemental table 9). Additionally, their results remained unchanged after the exclusion of participants who died during the first 3 years of follow-up.

DISCUSSION

This community-based Japanese cohort study presented the impact of past smoking, active smoking and SHS in the Japanese general population. We demonstrated that (1) for women, SHS increased the risk of premature death even among never-smokers; (2) regardless of SHS, past smoking is associated with a higher risk of all-cause mortality; (3) when considering only smoking status, 28.0% and 2.3% of all-cause mortality for men and women, respectively, were attributable to cigarette smoking. However, when SHS was considered, PAFs increased to 31.3% for men and 8.4% for women.

Comparison with other studies

Previous studies have shown that past and active smoking are associated with premature death.[3 7–14 16–21] A recent study indicated that past and current smoking exhibited a higher risk of all-cause mortality among men. However, current smoking of >20 cigarettes/day is associated with a higher risk of premature death for women, consistent with previous studies.[3 7–14 16–21] Furthermore, when past smoking, active smoking and SHS were integrated, past smoking was associated with a higher mortality risk in men, even in the absence of SHS. For women who were never-smokers, the risk of premature death was higher, although it was not statistically significant. These findings align with previous studies that reported SHS is positively associated with all-cause mortality.[1 2 4] Thus, our study supports the WHO framework's emphasis on protecting people from tobacco smoking.[5]

Many studies have revealed the PAF of active smoking on health outcomes. In a previous study in the UK, 27% of deaths in men and 11% of deaths in women were attributed to smoking.[13] In the USA, smoking accounted for 28.6% of all cancer deaths.[15] In China, 19.6% of men's deaths and 2.8% of women's deaths were attributed to past and active smoking.[17] Furthermore, the Global Burden of Disease Study 2019, as well as several previous large prospective cohort studies in Japan, showed that cigarette smoking is responsible for >20% of all-cause mortality in men and >5% in women.[7 9–11] However, despite the impact of SHS and active smoking on several health outcomes, most previous studies did not consider SHS.[8–17] Only a few studies estimated the PAF on active smoking and SHS; however, these studies only considered SHS in never-smokers.[18–21] Given that all individuals, regardless of smoking status, are likely to be exposed to SHS, those studies may underestimate the impact of smoking on health-related outcomes.

In this study, men had higher PAF values than women. PAF is calculated based on the HR and the exposure distribution. In Japan, it is well-known that smoking rates are significantly higher in men than in women.[41] In fact, in this study, men had a higher proportion of current smoking and passive smoking than women. This disparity in smoking prevalence likely contributes to the observed sex differences in PAF values.

Meaning of study and public implication

In addition to SHS, demonstrating the impact of active smoking on premature mortality provides meaningful information for public health and health policy. We showed that the estimated PAFs of all-cause mortality are 28.0% for men and 2.3% for women using only information on smoking status. However, these values increased to 31.3% for men and 8.4% for women when information on active smoking and SHS was integrated, indicating that a substantial proportion of deaths is attributable to active smoking and SHS. This study revealed that smoking continues to contribute to a substantial proportion of premature deaths, suggesting that previous studies underestimated the impact of smoking on all-cause mortality. Tobacco control measures, such as tobacco taxation, smoke-free legislation and anti-tobacco media campaigns, are effective ways to reduce smoking prevalence.[42] Tobacco prices in Japan have increased owing to gradual tax hikes; however, they appear to be low relative to the country's wealth.[43] Furthermore, the Japanese government finally approved its first national smoking ban inside public facilities; nevertheless, it is not comprehensive and does not apply to private places, such as homes and vehicles.[44] The Japan National Health and Nutrition Survey revealed that partial smoking bans significantly increased exposure to SHS in households and workplaces, suggesting that smoking bans displaced smokers from public to private places.[45] Therefore, strict smoking restriction laws in private and public places, as well as increasing tobacco prices, are required to prevent premature deaths and extend healthy life expectancy.

Strengths and limitations of the study

The strength of our study lies in the use of a large population-based prospective cohort. To the best of our knowledge, this is the first study to compare the PAF of active smoking with that of both active smoking and SHS on all-cause mortality. However, this study has several limitations.

First, we did not assess heated tobacco and electronic cigarettes. Heated tobacco emits smoke that contains similar harmful constituents as conventional tobacco cigarette smoke, but without the smoke and ash, and with reduced odour.[46] Thus, participants exposed to SHS from heated and electronic cigarettes may underestimate the impact of SHS on mortality. Second, we could not examine the association between SHS and cause-specific mortality owing to the lack of data regarding this. Third, we did not collect data on long-term exposure to SHS. Childhood SHS exposure has been associated with CVD, respiratory disease mortality and all-cause mortality[47–49]; thus, our study might have underestimated the impact of SHS on premature death. Fourth, the proportion of past smoking among women was low, and death could not be ascertained, especially among women with past smoking records exposed to SHS; therefore, we could not estimate the risk of premature death. Fifth, we did not account for the years since quitting smoking. Several studies have shown that the risk of death for those with past smoking decreases to the level of nonsmokers within 10–15 years of smoking cessation.[9 50] Therefore, further long-term follow-up with larger studies is required to clarify whether SHS increases the risk of premature death regardless of the duration of smoking cessation.

CONCLUSIONS

In conclusion, our community-based Japanese prospective cohort study revealed that cigarette smoking, including SHS, increases the risk of all-cause mortality, and a substantial proportion of deaths remains attributable to smoking and SHS. Since PAF increased by integrating information on active tobacco smoking and SHS, the impact of smoking on all-cause mortality may be underestimated in PAFs calculated by previous epidemiological studies that did not consider SHS. Thus, information on SHS is essential to reveal the full impact of smoking on health outcomes. The current study strongly supports the public health notion of the importance of avoiding smoking and preventing SHS.

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Funding This work was supported by grants from the Tohoku Medical Megabank Project of the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) and the Japan Agency for Medical Research and Development [AMED; JP22tm0124005]. This study used a supercomputer system provided by the Tohoku Medical Megabank Project, founded by AMED [grant number: JP21tm0424601].

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was reviewed and approved by the Ethics Committee of ToMMo, Tohoku University (first edition: 2012-4-617, latest edition: 2021-4-113, the Chief and institution: Nobuo Fuse, Tohoku Medical Megabank Organization). At IMM, the first approval by the Ethics Committee of Iwate Medical University was on 4 April 2013 (HGH25-2, the Chief and institution: Yasushi Ishigaki, Iwate Medical University). Our ethics statement was approved fro all local ethics committees. The latest approval (revised 17th edition) was made on 14 December 2023. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. All data will be available after contacting: masato.takase.c3@tohoku.ac.jp.

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