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http://dx.doi.org/10.1289/ehp.1307662
Received: 17 September 2013
Accepted: 13 August 2014
Advance Publication: 15 August 2014

NIH National Institute of Environmental Health Sciences

Incense Use and Cardiovascular Mortality among Chinese in Singapore: The Singapore Chinese Health Study

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Acknowledgment: We thank Siew-Hong Low of the National University of Singapore for supervising the fieldwork of the Singapore Chinese Health Study, and Kazuko Arakawa and

Renwei Wang for the development and maintenance of the cohort study database. We also thank the Ministry of Health, Singapore for assistance with the identification of mortality via database linkages.

Funding: This study was supported by National Institutes of Health (grant numbers R01-CA55069, R35-CA53890, R01-CA80205 and R01-CA98497).

Competing Financial Interests: The authors declare they have no actual or potential competing financial interests.

Abstract

Background: Incense burning is common in many parts of the world. Although it is perceived that particulate matter from incense smoke is deleterious to health, there is no epidemiologic evidence linking domestic exposure to cardiovascular mortality.

Objective: We examined this association in the Singapore Chinese Health Study.

Methods: We enrolled a total of 63,257 Singapore Chinese aged 45-74 years during 1993-1998. All participants were interviewed in person to collect information about lifestyle behaviors, including the practice of burning incense at home. We identified cardiovascular deaths via record linkage with the nationwide death registry through December 31, 2011.

Results: In this cohort, 76.9% were current incense users and the majority of current users (89.9%) had burnt incense daily for 20 years and longer. Relative to non-current users, current users had a 12% higher risk of cardiovascular mortality [multivariable adjusted hazard ratio (HR) = 1.12; 95% CI: 1.04, 1.20]. The HR was 1.19 (95% CI: 1.03, 1.37) for mortality due to stroke and 1.10 (95% CI: 1.00, 1.21) for mortality due to coronary heart disease. The association between current incense use and cardiovascular mortality appeared to be limited to participants without a history of cardiovascular disease at baseline (HR = 1.16; 95% CI: 1.07, 1.26) but not those with a history (HR = 1.00; 95% CI: 0.86, 1.17). In addition, the association was stronger in never smokers (HR = 1.12; 95% CI: 1.02, 1.23) and former smokers (HR = 1.19; 95% CI: 1.00, 1.42), than in current smokers (HR = 1.05; 95% CI: 0.91, 1.22).

Conclusions: Long-term exposure to incense burning in the home environment was associated with an increased risk of cardiovascular mortality in the study population.

Introduction

It has been widely acknowledged that ambient air pollution is a significant risk factor for cardiovascular morbidity and mortality (Chen et al. 2008). However, with the exception of secondhand smoke exposure (Dunbar et al. 2013), the effect of indoor air pollution on the cardiovascular system is less clear. Growing evidence suggests that indoor biomass combustion from solid fuels is associated with elevated blood pressure (Baumgartner et al. 2011; Clark et al. 2011; Dutta et al. 2011; McCracken et al. 2007) and higher risk of coronary heart disease (CHD) (Lee et al. 2012). However, with social and economic development, the use of coal and other solid fuels has been decreasing in many countries. Very few studies have investigated incense burning as a source of indoor air pollution and a risk factor for cardiovascular disease (CVD). Incense burning at home for ritual or religious purpose is a common practice among Chinese populations in China (Tse et al. 2011), Taiwan (Liao et al. 2006), and Singapore (Friborg et al. 2008), as well as in populations of India (Dewangan et al. 2013) and Arabian Gulf countries (Cohen et al. 2013). Many studies on the composition of particulate matter (PM) from incense burning or smothering have identified airborne particles and associated organic components, which are potential air pollutants deleterious to health (Chiang and Liao 2006; Chiang et al. 2009; Chuang et al. 2013; Cohen et al. 2013; Dewangan et al. 2013; Fang et al. 2002; Fang et al. 2003; Ho and Yu 2002; Jetter et al. 2002; Lin et al. 2012; Lombardozzi et al. 2010; Lung and Hu 2003; Lung et al. 2003; Manoukian et al. 2013; Yang et al. 2012).

We have previously shown that incense use was significantly associated with an increased risk of upper respiratory tract cancer in a population-based cohort of middle-aged and elderly people in Singapore using data from the Singapore Chinese Health Study (Friborg et al. 2008). In the present study, we aimed to examine the association between incense use and cardiovascular

mortality risk using the same cohort. We also differentiated between mortality due to CHD and stroke, given the potential differences in the pathophysiology of these two diseases (Hyvärinen et al. 2010; Wilhelmsen et al. 2005). This cohort provides an opportunity to evaluate the association in a population where incense use is very common for many households (Friborg et al. 2008), while the prevalence of outdoor air pollution (Velasco and Roth 2012) and indoor solid fuel use (Desai et al. 2004) is very low.

Methods

Study population

We conducted this study using data from the population-based prospective cohort, the Singapore Chinese Health Study (SCHS), which was established between April 1993 and December 1998. We recruited 63,257 Chinese adults, aged 45-74 years, from the residents in government-built housing estates, where 86% of the Singapore population resided during the period of recruitment (Hankin et al. 2001). We limited our recruitment to two major dialect groups of Chinese in Singapore, the Hokkien and Cantonese, who originated from the contiguous provinces of Fujian and Guangdong, respectively, in the southern part of China. The Institutional Review Board of the National University of Singapore approved this study, and all recruited participants gave informed consents.

Data collection

The trained interviewers conducted the face-to-face interviews using a structured, scanner-readable questionnaire at recruitment, and obtained information on demographics, height, weight, cigarette smoking, habitual physical activity, sleep hours, medical history (e.g., physician-diagnosed hypertension, diabetes, CHD, and stroke), alcohol drinking and dietary

intake (by a validated 165-item food frequency questionnaire). For cigarette smoking, the participants were asked, “Have you ever smoked at least one cigarette a day for 1 year or longer” and defined as “never-smokers” for those who answered “no”, “former smokers” for those who answered “yes, but I quit smoking”, and “current smokers” for those who answered “yes, and I currently smoke”. Former and current smokers were then asked about number of cigarettes smoked per day, number of years of smoking, and number of years of quitting (only in former smokers).

We did not collect information on passive smoking at baseline, but at follow-up I visit conducted between 1999 and 2004 (Butler et al. 2006), a total of 52,322 participants were re-interviewed and provided responses on whether they were exposed to secondhand smoke at home or at work on a daily basis.

Ascertainment of incense exposure

At baseline, we asked our participants if their household ever burnt incense (yes, no), and if “yes”, information was inquired on the number of years of burning (10 years or less, 11-20 years, 21-30 years, 31-40 years, 41 years or more). We asked the participants if they had burnt incense for the past one year and those who answered “yes” were defined as current users, and were further asked for the frequency of burning (a few times per year, a few times per month, a few times per week, daily), as well as the placement of the altar (bedroom, other bedroom, living room, dining room, or kitchen) and the intensity of burning (during the night only, during the day only, intermittently during the day, at all times). We did not update information on incense use during subsequent follow-up interviews.

Ascertainment of mortality

We identified deaths through record linkage with the Singapore Registry of Births and Deaths. For the current analysis, we updated mortality data every year through December 31, 2011. By law in Singapore, all deaths in the country must be registered and reported to the Registry of Births and Deaths. Linkage is done by perfect matching of the unique National Identification Card Number, and verified by name. We have re-contacted the participants in two follow-up visits (1999-2004 and 2006-2010). During these follow-up interviews, to our best knowledge, only 47 participants from this cohort were known to be lost to follow-up due to migration out of Singapore or for other reasons. This suggests that emigration among participants was negligible in this cohort and that vital statistics were virtually complete.

The main contributing causes of death were coded according to the International Classification of Diseases, Ninth Revision; codes 390-459 were used for cardiovascular deaths, codes 410-414 for CHD deaths, and codes 430-438 for stroke deaths. Codes for cardiovascular deaths include all CHD and other heart disease, stroke, hypertension, diseases of arteries, arterioles and capillaries.

Statistical analysis

We counted person-years from date of recruitment to date of death, loss to follow-up, or December 31, 2011, whichever occurred first. We used Cox proportional hazards regression methods to calculate the hazard ratio (HR) of incense use and cardiovascular mortality risk. All Cox regression models included the following covariates collected at recruitment: age, year of recruitment (1993-1995, 1996-1998), gender, dialect (Hokkien, Cantonese), education (no formal education, primary school, secondary school or higher), body mass index (BMI; < 20.0, 20.0-

23.9, 24.0-27.9, ≥ 28.0 kg/m^2), alcohol drinking (none, monthly, weekly, daily), years of smoking (never, < 20, 20-39, and ≥ 40 years), dose of smoking (never, ≤ 12, 13-22, 23-32, or ≥ 33 cigarettes/day), years since quitting smoking (never, < 1 year, 1-4 years, 5-19 years, ≥ 20 years), moderate activity (< 0.5, 0.5-3.9, or ≥ 4.0 hours/week), duration of sleep (hours/day), daily energy intake (kcal/day, quartiles), dietary intakes of vegetables, fruits, polyunsaturated fatty acids (grams/day, quartiles), as well as self-reported history of physician-diagnosed cancer, hypertension, diabetes, CHD, and stroke. We performed tests for trend by entering ordinal categorical variables as continuous variables in the Cox regression models. Based on *a priori* hypotheses, we stratified the analysis by self-reported history of physician-diagnosed CHD/stroke as well as by smoking status (never, former, or current smoker) at baseline. We also tested interactions between incense use and gender, and education level (no formal education, primary school only, or ≥ secondary school) using the likelihood ratio test; and we further conducted stratified analysis if significant interactions were found. We also conducted a sensitivity analysis that included further adjustment for secondhand smoking among individuals who participated in the follow-up I visit (n = 52,322).

We estimated population attributable risk (PAR) based on the following formula: PAR%=100×Pe(HR–1)/(Pe[HR–1]+1), where Pe was the prevalence of the exposure (incense use) in the study population and HR was derived from Cox regression models. Statistical computing was conducted using SAS version 9.1 (SAS Institute Inc., Cary, NC) statistical software package. All P values were two-sided and those <0.05 were considered statistically significant.

Results

Incense use was relatively common at baseline in this cohort of middle-aged and elderly Chinese living in Singapore, with 76.9% reporting current use of incense at home (77.4% in men and 76.4% in women), and another 13.1% reporting previous use but not in the past one year (former users, n = 8,259). Only 10% of the cohort members were never-users. Among 48,620 current users, the majority (89.9%) had used it daily for more than 20 years, the altar was mainly placed in the living room (91.9%), and the incense was kept burning intermittently during the day for most of the study participants (80.8%) (Supplemental Material, Table S1). As shown in Table 1, the current users were more likely to be Hokkiens (55.8%) than Cantoneses (44.2%). Compared to non-current users, current users were less educated, more likely to be ever smokers, and less likely to be physically active. They also had a lower dietary intake of fruits and polyunsaturated fatty acids. Otherwise, both groups were similar in age, BMI, gender distribution, prevalence of self-reported history of physician-diagnosed comorbidities (hypertension, CHD, stroke, and cancer), intake of alcohol and daily duration of sleep.

During a mean follow-up time of 14.7 [standard deviation (SD) 4.1 years], we documented 5,043 cases of cardiovascular deaths in this cohort, including 2,851 CHD deaths and 1,381 fatal stroke cases. The mean age at death was 72.4 (SD 8.3) years for CVD, 72.1 (SD 8.2) years for CHD and 73.0 (SD 8.3) years for stroke, and the mean follow-up time was 8.9 (SD 4.8) years.

Table 2 shows the relative risk estimates of cardiovascular mortality by incense use. Compared to never users, the adjusted HR was increased in current users but not in former users. Particularly for stroke mortality, never and former users had similar risk. Hence, never and former users were grouped together as non-current users in subsequent analyses. After adjusting

for established and potential risk factors of CVD, current incense users had a significant 12% increase in risk of cardiovascular mortality (HR = 1.12; 95% CI: 1.04, 1.20) compared with non-current users. In particular, we estimated a 10% higher risk of CHD mortality (HR = 1.10; 95% CI: 1.00, 1.21) and a 19% increase in stroke mortality (1.19; 1.03, 1.37) in current users. Taking into consideration both the frequency and duration of incense use, there was a statistically significant 12% increase in risk estimated for daily exposure of more than 20 years compared to non-current users (HR = 1.12; 95% CI: 1.04, 1.21), but associations were not significant in other groups. Estimated associations were similar for daily exposure of 20-40 years and more than 40 years, and the vast majority (87%) of those who reported using incense for more than 20 years had actually done so for more than 40 years. Hence, these two groups were combined in subsequent analyses.

We estimated a significant interaction between incense use and baseline CHD/stroke history for cardiovascular mortality (p for interaction = 0.02), but not for CHD or stroke mortality (p = 0.15 and 0.28, respectively) (Table 3). Current incense use was positively associated with cardiovascular mortality in participants without a baseline history of CHD and stroke (HR = 1.16; 95% CI: 1.07, 1.26), but not in those with baseline history of CHD or stroke (HR = 1.00; 95% CI: 0.86, 1.17). No significant interaction was found between incense use and gender (p for interaction = 0.24 for cardiovascular mortality).

The HRs of cardiovascular mortality adjusted for all covariates except cigarette smoking and education level were biased away from the null (HR = 1.20; 95% CI: 1.12, 1.29 for current use compared with non-use), indicating that smoking and education level were major confounding factors in our analysis (Supplemental Material, Table S2). In stratified analysis by smoking status (Table 3), current incense use was associated with a 12% (HR = 1.12; 95% CI: 1.02, 1.23)

and a 19% (HR = 1.19; 95% CI: 1.00, 1.42) increase in risk of cardiovascular mortality in never and formers smokers, respectively. Conversely, the association was weak and not statistically significant in current smokers (HR = 1.05; 95% CI: 0.91, 1.22; *p* for interaction = 0.27). In stratified analysis by education level (Table 3), the associations persisted in those with primary school of education (HR = 1.14; 95% CI: 1.02, 1.27) or secondary school levels and above (HR = 1.25; 95% CI: 1.09, 1.44), but not in those without formal education (HR = 0.98; 95% CI: 0.86, 1.11; *p* for interaction = 0.03).

We repeated our analysis by using never users as the reference group, associations with the frequency and duration of incense use were attenuated for cardiovascular and CHD mortality (HR for current daily use >20 years 1.06; 95% CI: 0.97, 1.17; and 1.05; 95% CI: 0.92, 1.10; respectively) but were similar for stroke mortality (HR for current daily use >20 years 1.19; 95% CI: 0.98, 1.44) (Supplemental Material, Table S3). The HRs for former use and current use compared with never use that were stratified by history of cardiovascular disease at baseline, smoking status, and education level were generally consistent with HRs for current versus non-current use (Supplemental Material, Table S4).

In a sensitivity analysis with further adjustment for secondhand smoking among the sub-group of individuals who participated in the follow-up I interview conducted between 1999 and 2004 (n = 52,322), the results were not materially changed (Supplemental Material, Table S5). Compared with never-incense users, there was a statistically significant 19% (HR = 1.19; 95% CI: 1.04, 1.36) increase in risk of cardiovascular mortality for current incense users after adjusting for daily exposure to secondhand smoking.

Given the high prevalence of incense use in this population, we further calculated the PAR of incense use for the outcomes. In this cohort, we estimated that 7.1% of CHD deaths and 12.1% of stroke deaths could be attributed to current daily use of incense over a period of more than 20 years. Among never smokers, the estimated PARs for CHD and stroke deaths increased to 8.6% and 15.8%, respectively.

Discussion

In this large population-based cohort of middle-aged and elderly Chinese adults in Singapore, we found that long-term exposure to incense burning at home on a daily basis for more than 20 years was associated with increased risk of cardiovascular mortality. Incense use was associated with both CHD and stroke mortality based on models adjusted for multiple lifestyle and comorbidity factors, and associations were primarily present among never and former smokers, and among those without a baseline history of cardiovascular disease, and among those with primary school and above education level.

Worldwide, global industrialization has resulted in an increase in air pollution levels. Hence, for the last few decades, ambient air pollution has been studied for its deleterious effects on health, including the impact on cardiovascular disease, the leading cause of death in industrialized countries (Chen et al. 2008). A review of all studies published between 1950 and 2007 found suggestive evidence that ambient air pollution exposure may be a risk factor for cardiovascular mortality, and exposure to $PM_{2.5}$ was associated with an increased risk of cardiovascular mortality (range: 12% to 14% per 10-$\mu g/m^3$ increase) (Chen et al. 2008). With regard to stroke mortality, a number of time-series studies have estimated small but substantially significant associations with short-term elevated air pollution (including measures of PM, nitrogen dioxide,

carbon monoxide, and ozone) (Brook et al. 2010). For long-term exposure, estimates from the Women's Health Initiative showed significant increases in risk of both nonfatal (HR = 1.28; 95% CI: 1.02, 1.61) and fatal stroke (HR = 1.83; 95% CI: 1.11, 3.00) per 10-μg/m^3 increase in $PM_{2.5}$ (Miller et al. 2007). Two cohort studies in Europe reported that outdoor air pollution from road traffic was positively associated with fatal stroke (Andersen et al. 2012), and mortality in stroke survivors (Maheswaran et al. 2010). Therefore, our findings are generally consistent with findings from studies of ambient air pollution.

However, while many previous studies have focused on outdoor air pollution, few have explored the relation between cardiovascular outcomes and indoor air quality (Mortimer et al. 2012). One study in rural India (Dutta et al. 2011) and one study in rural China (Baumgartner et al. 2011) reported that biomass fuel use was positively associated with blood pressure. A randomized intervention study in Guatemalan women reported that transitioning from an open fire to an improved biomass stove was associated with reductions in blood pressure and ST segment depression (McCracken et al. 2011; McCracken et al. 2007). A recent cross-sectional analysis of over 14,000 Chinese adults suggested that household air pollution from solid fuel use was positively associated with hypertension, diabetes, CHD and stroke, after adjustment for potential confounders (Lee et al. 2012). An early cohort study of 957 men in Shanghai reported that compared to gas fuel, indoor air pollution from coal fumes was associated with an increased risk of stroke mortality during a 12-year follow-up period (HR = 2.55; 95% CI: 1.30, 5.03) (Zhang et al. 1988). As described above, these previous studies mainly focused on solid fuel use but not the other sources of indoor air pollutants.

To our knowledge, our study is the first to provide epidemiologic evidence that chronic exposure to daily incense burning in the home environment may increase the risk of cardiovascular

mortality. Worldwide, incense burning for ritual or religious purposes is a common practice in many countries and regions. For example, a study in the United Arab Emirates found that 86% of individuals used incense at least once a week and 44% of them used it daily (Yeatts et al. 2012). A study in Hong Kong reported a prevalence of 55%-65% for incense use (Tse et al. 2011), and our current study reported a prevalence of 77% for current incense use. Many studies have analyzed emissions from burning of incense and identified volatile organic compounds and particulate matter that could be deleterious to health (Chiang and Liao 2006; Chiang et al. 2009; Chuang et al. 2013; Cohen et al. 2013; Dewangan et al. 2013; Fang et al. 2002; Fang et al. 2003; Ho and Yu 2002; Jetter et al. 2002; Lin et al. 2012; Lombardozzi et al. 2010; Lung and Hu 2003; Lung et al. 2003; Manoukian et al. 2013; Yang et al. 2012). This includes fine particulate matter that could raise the indoor concentrations of $PM_{2.5}$ to concentrations far exceeding the outdoor standards specified by the World Health Organization (WHO) guideline (Dewangan et al. 2013; Fang et al. 2002; Lee and Wang 2003; Jetter et al. 2002), as well as volatile compounds that include polycyclic aromatic hydrocarbons, oxygenated monoterpenes, esters and formaldehydes (Chiang and Liao 2006; Cohen et al. 2013; Ho and Yu 2002; Lombardozzi et al. 2010; Lung and Hu 2003; Lung et al. 2003; Manoukian et al. 2013; Yang et al. 2012). A study in Taiwan estimated similar size-integrated source emission rates between cooking and incense burning, and each contributed about 30% of indoor particle levels for particle sizes from 0.5 to 5 μm (Liao et al. 2006).

In this study, we found that the association between incense use and cardiovascular mortality was weaker in current smokers than in never and former smokers. We hypothesize that this occurred because current smokers are already exposed to the pollutants from cigarette smoke, and incense burning confers little additional harmful effects on the vascular system on top of

cigarette smoking. Previous studies comparing the quantity of particulate matter and the emission of aerosol particles and gaseous pollutants have reported that indoor air pollution from incense burning is comparable to that from cigarette smoking (Dewangan et al. 2013; Miller et al. 2007). In fact, a study found that burning incense could generate even larger quantities of particulate matter (an average of greater than 45mg/g burned) than burning cigarettes (about 10 mg/g burned) (Mannix et al. 1996).

Experimental studies conducted on rats showed that long-term exposure to incense smoke was associated with adverse metabolic changes of increased triglycerides and decreased HDL-cholesterol concentrations and a transient increase of leptin levels (Alokail et al. 2011). An *in vitro* study reported that the size and composition of particles from incense burning in temples were both important factors in inducing cytokine production and reducing nitric oxide formation in human coronary artery endothelial cell cultures (Lin et al. 2008). An *in vitro* study also reported that the expression levels of inflammatory biomarkers were increased in human lung epithelial cells exposed to smoke components formed from incense burning (Cohen et al. 2013). Incense particles also had substantial oxidative potential measured by the plasmid scission assay as an *in vitro* marker for the oxidative potential (Chuang et al. 2013). In addition, other mechanisms that may link exposure to ambient particulate matter with cardiovascular disease include the initiation of low-grade inflammation (Pope et al. 2004), induction of vascular thrombogenesis via the effects of particulate matter on blood coagulability and vasospasm (Louwies et al. 2013; Lucking et al. 2008; Peters et al. 1997), dysregulation of cardiac autonomic system that leads to arrhythmias (Liao et al. 2009; Pope et al. 1999; Pope et al. 2004), higher resting cerebrovascular resistance and lower cerebral blood flow velocity (Wellenius et al. 2013).

The strengths of the present study include its population-based design, large number of relatively homogenous participants, detailed information on lifestyle factors that were established or potential risk factors of cardiovascular mortality, and medical history obtained through in-person interviews. All exposure information, including self-reported history of physician-diagnosed comorbidities, was collected on an average of 8.9 years prior to outcomes. We had virtually complete ascertainment of data on mortality given that, to date, the number of participants lost to follow up was negligible. There are several unique characteristics of this population which made the study exceptional: the use of incense was quite common in the cohort and the majority of the participants had used incense for more than 20 years; Singapore is a small country with very low levels of outdoor air pollution (Velasco and Roth 2012), and there was almost no solid fuel use as recorded in a WHO report (Desai et al. 2004). Taken together, the other sources of air pollution were therefore negligible or similar for all participants in this cohort. Thus we had the unique opportunity to evaluate the association between incense use and cardiovascular mortality in this population.

Our findings should be interpreted with some limitations kept in mind. First, we only measured incense exposure at recruitment and no information was captured during the follow-up. However, given that the majority of exposed individuals reported long-term exposure on a daily basis, and the fact that the burning of incense is related to religious or ritual practices, the number of participants who had changed their habits subsequently would be small. Second, the medical conditions were self-reported at baseline, and we did not have accurate information on incident cardiovascular disease during the follow-up period. Third, we did not measure the exact indoor air pollution status for each household, and we did not collect the information on the type of incense use and other practices that may influence indoor air pollution (e.g., opening of

windows, use of air conditioners). Nevertheless, because of the prospective design of the study, the measurement errors and misclassifications of exposure are mostly non-differential in nature in relation to the outcome of interest. Hence we believe that it is most likely that any impact due to change in incense exposure or imperfect measure would be an underestimation of the risk estimate. Finally, due to observational nature of the study, residual or unmeasured confounding is still possible, and causality should be inferred with caution. Since incense use is related to religious and cultural practice, it is possible that study participants who use incense differ from those who do not in other characteristics that may be unmeasured confounders in our analysis.

Conclusion

To our knowledge, our study is the first to provide epidemiologic evidence that long-term exposure to indoor air pollution from incense burning may substantially contribute to the risk of cardiovascular mortality at the population level. We estimate that approximately 8% of CHD deaths and 12% of stroke deaths in the study population could be attributed to incense use. Considering the worldwide prevalence of incense burning, findings of this study have significant public health implications. Burning incense at home is linked to religious and ritual practice, and it is not our intention to discourage this activity. However, it is important to educate users on approaches to limit adverse health effects, and future studies should be undertaken to identify the least harmful types of incense and strategies to reduce exposure and improve indoor air quality when using incense.

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Table 1. Baseline characteristics of cohort members by current use of incense in the Singapore Chinese Health Study.[a]

Characteristics	**Current users (n = 48,620)**	**Non-current users (n = 14,637)**
Age at baseline (years)	56.5 ± 8.0	56.4 ± 8.2
Body mass index (kg/m^2)	23.2 ± 3.3	22.9 ± 3.2
Gender		
Males	21647 (44.5)	6307 (43.1)
Females	26937 (55.5)	8330 (56.9)
Dialect		
Cantonese	21487 (44.2)	7797 (53.3)
Hokkien	27133 (55.8)	6840 (46.7)
Level of education		
No formal education	15000 (30.8)	2333 (15.9)
Primary school (1-6 years)	22985 (47.3)	5065 (34.6)
Secondary and above	10635 (21.9)	7329 (49.5)
Cigarette smoking		
Never smokers	32976 (67.8)	10954 (74.8)
Former smoker	5346 (11.0)	1647 (11.3)
Current smokers	10298 (21.2)	2036 (13.9)
Alcohol		
None/monthly	42925 (88.3)	13021 (88.9)
Weekly	3940 (8.1)	1166 (8.0)
Daily	1755 (3.6)	450 (3.1)
Weekly moderate activity		
< 0.5 hours/week	38444 (79.1)	10828 (74.0)
0.5-3.9 hours/week	6406 (13.2)	2382 (16.3)
≥ 4.0 hours/week	3770 (7.7)	1427 (9.7)
History of diabetes mellitus	4486 (9.2)	1210 (8.3)
History of hypertension	11481 (23.6)	3573 (24.4)
History of coronary heart disease	1942 (4.0)	656 (4.5)
History of stroke	706 (1.5)	241 (1.7)
History of cancer	1440 (3.0)	496 (3.4)
Sleep duration (hours/day)	7.0 ± 1.1	7.0 ± 1.1
Diet vegetables and related juices (g/day)	109.0 ± 62.8	115.6 ± 65.8
Diet fruits and related juices (g/day)	192.9 ± 163.8	234.1 ± 182.3
Diet fiber (g/day)	12.4 ± 5.7	13.7 ± 6.0
Diet polyunsaturated fat (g/day)	8.6 ± 4.7	9.7 ± 5.2

[a]The data were shown as mean ± standard deviation or number (percent). There were no missing data for the variables.

Table 2. Incense use and cardiovascular mortality in the Singapore Chinese Health Study (1993-2011).[a]

Exposure	Persons	Person-years	CVD deaths	CVD HR (95% CI)	CHD deaths	CHD HR (95% CI)	Stroke deaths	Stroke HR (95% CI)
Status of incense use								
Never use	6378	95964	485	1.00	277	1.00	122	1.00
Former use	8259	119400	502	0.91 (0.80, 1.03)	286	0.90 (0.76, 1.06)	131	0.98 (0.77, 1.26)
Current use	48620	711397	4056	1.06 (0.96, 1.16)	2288	1.03 (0.91, 1.18)	1128	1.18 (0.97, 1.43)
p for trend				0.03		0.21		0.03
Non-current use	14637	215364	987	1.00	563	1.00	253	1.00
Current use	48620	711937	4056	1.12 (1.04, 1.20)	2288	1.10 (1.00, 1.21)	1128	1.19 (1.03, 1.37)
Frequency and duration of incense use								
Non-current use	14637	215364	987	1.00	563	1.00	253	1.00
Current, less than daily use	3574	52580	289	1.04 (0.91, 1.18)	156	0.98 (0.82, 1.17)	80	1.12 (0.87, 1.45)
Current, daily use for up to 20 years	1313	20156	64	1.08 (0.83, 1.39)	33	0.99 (0.70, 1.41)	18	1.11 (0.69, 1.80)
Current, daily use for > 20 years	43733	638660	3703	1.12 (1.04, 1.21)	2099	1.11 (1.01, 1.23)	1030	1.20 (1.04, 1.38)
p for trend				0.002		0.01		0.01
Current, daily use for 20-40 years	5867	91508	403	1.11 (0.99, 1.25)	226	1.08 (0.92, 1.27)	114	1.22 (0.97, 1.54)
Current, daily use for > 40 years	37866	547152	3300	1.12 (1.04, 1.21)	1873	1.12 (1.01, 1.23)	916	1.20 (1.04, 1.38)

CHD: coronary heart disease; CI: confidence interval; CVD: cardiovascular disease; HR: hazard ratio.

[a]The estimates were generated using Cox proportional hazards models, with adjustment for age at recruitment, year of recruitment (1993-1995, 1996-1998), gender, dialect (Hokkien, Cantonese), education (no formal education, primary school, secondary school or higher), body mass index (BMI; < 20.0, 20.0-23.9, 24.0-27.9, ≥ 28.0 kg/m^2), alcohol drinking (none, monthly, weekly, daily), years of smoking (never, < 20 years, 20-39 years, ≥ 40 years), dose of smoking (never, ≤ 12, 13-22, 23-32, ≥ 33 cigarettes/day), years since quitting smoking (never, < 1 year, 1-4 years, 5-19 years, ≥ 20 years), moderate activity (< 0.5, 0.5-3.9, ≥ 4.0 hours/week), duration of sleep (hours/day), daily energy intake (kcal/day), dietary intakes of vegetables, fruits, fiber, polyunsaturated fatty acids (grams/day, quartiles), as well as self-reported history of physician-diagnosed hypertension, diabetes, cancer, CHD and stroke.

Table 3. Incense use and cardiovascular mortality in the Singapore Chinese Health Study: stratified by baseline history of cardiovascular disease or smoking at baseline (1993-2011).[a]

Exposure	Persons	Person-years	CVD deaths	CVD HR (95% CI)	CHD deaths	CHD HR (95% CI)	Stroke deaths	Stroke HR (95% CI)
Stratified by baseline CHD or stroke[b]								
Without baseline CHD or stroke								
Non-current use	13774	204917	757	1.00	421	1.00	203	1.00
Current use	46082	681316	3378	1.16 (1.07, 1.26)	1847	1.13 (1.01, 1.26)	972	1.24 (1.06, 1.45)
With baseline CHD or stroke								
Non-current use	863	10447	230	1.00	142	1.00	50	1.00
Current use	2538	30081	678	1.00 (0.86, 1.17)	441	1.04 (0.85, 1.27)	156	1.06 (0.76, 1.48)
Stratified by smoking status[c]								
Never smokers								
Non-current use	10954	165511	582	1.00	314	1.00	160	1.00
Current use	32976	499294	2144	1.12 (1.02, 1.23)	1137	1.10 (0.96, 1.25)	672	1.26 (1.05, 1.51)
Former smokers								
Non-current use	1647	22125	169	1.00	100	1.00	37	1.00
Current use	5346	71726	651	1.19 (1.00, 1.42)	407	1.25 (1.00, 1.57)	154	1.18 (0.81, 1.71)
Current smokers								
Non-current use	2036	27728	236	1.00	149	1.00	56	1.00
Current use	10298	140377	1261	1.05 (0.91, 1.22)	744	1.00 (0.83, 1.20)	302	1.03 (0.77, 1.38)
Stratified by education level[d]								
No formal education								
Non-current use	2333	33063	272	1.00	151	1.00	74	1.00
Current use	15000	215540	1650	0.98 (0.86, 1.11)	884	0.93 (0.78, 1.11)	519	1.13 (0.88, 1.45)
Primary school level								
Non-current use	5065	73625	383	1.00	223	1.00	94	1.00
Current use	22985	336371	1844	1.14 (1.02, 1.27)	1068	1.10 (0.95, 1.27)	484	1.30 (1.04, 1.63)
Secondary school level or above								
Non-current use	7239	108676	332	1.00	189	1.00	85	1.00
Current use	10635	159485	562	1.25 (1.09, 1.44)	336	1.28 (1.06, 1.53)	125	1.17 (0.88, 1.55)

CHD: coronary heart disease; CVD: cardiovascular disease; CI: confidence interval; HR: hazard ratio.

[a]The *p* for interactions between incense use (binary variable) and baseline CHD/stroke (binary variable) were 0.02, 0.15, and 0.28 for CVD, CHD, and stroke mortality, respectively. The *p* for interactions between incense use (binary variable) and smoking status (three categories: never, former and current smokers) were 0.27, 0.21, and 0.21 for CVD, CHD, and stroke mortality, respectively. The *p* for interactions between incense use (binary variable) and smoking status (three categories: no formal education, primary school level and secondary school level or above) were 0.03, 0.03, and 0.81 for CVD, CHD, and stroke mortality, respectively. [b]The estimates were generated using Cox proportional hazards models, with adjustment for age at recruitment, year of recruitment, gender, dialect, education, body mass index, alcohol drinking, years of smoking, dose of smoking, years since quitting smoking, moderate activity, duration of sleep, daily energy intake, dietary intakes of vegetables, fruits, fiber, polyunsaturated fatty acids, self-reported history of physician-diagnosed hypertension, diabetes, and cancer. [c]The estimates were generated using Cox proportional hazards models, with adjustment for age at recruitment, year of recruitment, gender, dialect, education, body mass index, alcohol drinking, moderate activity, duration of sleep, daily energy intake, dietary intakes of vegetables, fruits, fiber, polyunsaturated fatty acids, self-reported history of physician-diagnosed hypertension, diabetes, cancer, CHD and stroke. [d]The estimates were generated using Cox proportional hazards models, with adjustment for age at recruitment, year of recruitment, gender, dialect, body mass index, alcohol drinking, years of smoking, dose of smoking, years since quitting smoking, moderate activity, duration of sleep, daily energy intake, dietary intakes of vegetables, fruits, fiber, polyunsaturated fatty acids, self-reported history of physician-diagnosed hypertension, diabetes, cancer, CHD and stroke.