Evaluating trends in cigarette and HTP use in Japan and measurement issues in the National Health and Nutrition Survey

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ABSTRACT

Introduction Studies have reported that the rapid rise in heated tobacco product (HTP) sales in Japan accompanied an accelerated decline in cigarette sales. However, these studies do not distinguish whether those who previously smoked cigarettes became dual users with HTPs (smoking fewer cigarettes) or instead switched completely to HTPs. If HTPs present lower health risks than cigarettes, replacing cigarettes with HTPs is more likely to improve public health than cigarette users continuing as dual users.

Methods To evaluate the role of HTP introduction relative to smoking prevalence, we examine trends in cigarette prevalence as related to trends in HTP use using Japan's National Health and Nutrition Survey (NHNS) from 2011 to 2019. We develop measures of relative changes in smoking prevalence use by age and gender in the pre-HTP and post-HTP periods. We then analyse prevalence data by year using joinpoint regression to statistically distinguish changes in trend.

Results Compared with the pre-HTP 2011–2014 period, cigarette prevalence decreased more rapidly during the post-HTP 2014–2017 period, particularly among younger age groups. However, the changing format of NHNS questions limits our ability to determine the impact on smoking prevalence, particularly after 2017.

Conclusions While suggesting that HTPs helped some people who smoke to quit smoking, this study also shows the difficulties in eliciting accurate survey responses about product use and distinguishing the impact of a potentially harm-reducing product in an environment subject to rapidly evolving patterns of use.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Cigarette use in Japan declined dramatically as heated tobacco product (HTP) use increased. However, it is not clear whether reduced cigarette use resulted from those who previously smoked cigarettes continuing HTP use as dual users or instead resulted from those who smoked cigarettes completely switching to HTPs.

WHAT THIS STUDY ADDS

⇒ Our analysis shows accelerating declines in age 20+ male and female smoking prevalence in 2014–2017 relative to 2011–2014 in Japan. The accelerated decline was most pronounced for males aged 20–49, the ages with the highest reported HTP use.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our analysis suggests a potential role of HTPs in reducing smoking prevalence in Japan. However, it also shows the difficulties in eliciting accurate survey responses that distinguish the impact of a potentially harm-reducing product in an environment subject to rapidly evolving patterns of use, especially when surveys make frequent changes to the questions.

INTRODUCTION

Heated tobacco products (HTPs) were introduced into Japan in late 2014.[1] Studies[1 2] report that the rapid rise in HTP sales was followed by a dramatic decline in cigarette sales. However, these studies do not distinguish whether the reduction in Japan's cigarette sales resulted primarily from those continuing to smoke cigarettes as dual users of cigarettes and HTPs or whether they switched completely to HTP use.

To the extent that HTPs pose less health risk than conventional cigarettes,[3 4] switching from cigarette to HTP use provides the potential to improve public health. However, if HTP use leads primarily to dual-use, the public health impact of HTP market expansion is challenging to quantify; dual-use has fewer health advantages than exclusive HTP use and could delay cessation from cigarette use.[5–8] Even rising exclusive HTP use could result in adverse public health effects if the people who switch from cigarettes to HTPs would have otherwise quit cigarettes without using HTPs. Marketing of HTPs as a reduced-risk product might also encourage inappropriate use by those who previously or never smoked cigarettes.[7] Thus, while previous studies indicate that increased HTP sales were associated with major reductions in cigarette sales, monitoring current smoking prevalence trends in Japan is crucial in evaluating HTP's role in replacing cigarette use and thereby gauging public health impacts.

We analyse smoking trends in Japan's yearly National Health and Nutrition Survey (NHNS) to evaluate how HTP usage growth may have influenced trends in smoking prevalence by age and gender. To gauge changes in trend, we develop measures of the relative change in smoking prevalence for the pre-HTP and post-HTP periods and

compare the post-HTP period to the pre-HTP period. We also apply joinpoint regression to statistically distinguish changes in smoking prevalence trends. In conducting our analysis, we consider the limitations of the data and methodology and discuss the information needed to better gauge the impact of HTPs on cigarette use.

METHODS

NHNS is an annual nationally representative survey that tracks Japan's smoking prevalence. Between 2003 and 2018, the NHNS was conducted as an in-home interview before switching to online administration in 2019 (the last available survey year).[9 10] The survey each year had at least 5700 participants aged 20+.[9 10] The participants included eligible households and family members in 300 areas of Japan, stratified and randomly extracted from general census areas.[11] The following households and family members were excluded from this survey: households in which the heads were foreigners or members were provided delivered food meals, one-person households in a live-in situation provided with meals, persons unable to eat regular meals or having meals together, those absent from the household or studying away from home and those admitted to social welfare facilities or healthcare. Additional information about the 2011–2019 NHNS data regarding the number of households selected, the number of participants in the lifestyle questionnaire, the number of never and current (every day or some days) cigarette users and the number of HTP users in 2018 and 2019 can be found in online supplemental 1.

Questions regarding cigarette use have varied across survey waves (see online supplemental 2). From 2003 to 2010, current smoking was defined as having smoked every day or some days in the past month and having smoked at least 100 cigarettes lifetime or smoked for at least 6 months. In 2011, the 'lifetime 100-cigarette or 6-month smoking' criterion was dropped. Further, a series of changes in questions were implemented in 2012 and 2013, focusing on those who reported smoking every day or some days in the past month.[12] In 2018 and 2019,[11] NHNS began asking those who smoked to indicate each product used, including cigarettes, HTPs and other products (pipes, cigars and e-cigarettes). The changes in questions in 2018, in particular, may have caused some of those who smoke that had previously classified themselves as cigarette smokers to switch to other product categories.

Using NHNS, we first examine trends in smoking prevalence and changes in policies to identify an appropriate initial year for gauging trends. We then distinguish subperiods based on HTP use patterns. For each subperiod, we consider trends in cigarette use by gender and age group, measured as relative changes in smoking prevalence: [(smoking prevalence$_t$–smoking prevalence$_{t-1}$)/smoking prevalence$_{t-1}$]. We compare trends in a pre-HTP (control) period to post-HTP trends to gauge the net impacts of HTPs.

We supplement these descriptive analyses with joinpoint regressions using a statistical package developed by the US National Institute of Health.[13] This method scans the data to identify statistically significant changes in trend (joinpoints). We also fitted joinpoint-jump models,[14] which simultaneously considers a potential step-change related to 2018 modifications in NHNS survey questions in addition to trend changes.

RESULTS

Trends, policies and the NHNS Survey

Figure 1 shows a downward trend in smoking prevalence from 2003 to 2005, coinciding with the implementation of stricter tobacco control policies in Japan.[15] Between 2006 and 2009, smoking prevalence remained relatively constant but then dropped sharply with a 33% cigarette tax increase in 2010.[16] One+ and two+ year cessation rates rose to 8.5% in 2010 following the tax increase and then fell in 2011–2012 to their previous 2005–2008 levels,[17] and policies remained relatively stable through 2019.[18] In addition, NHNS dropped the use

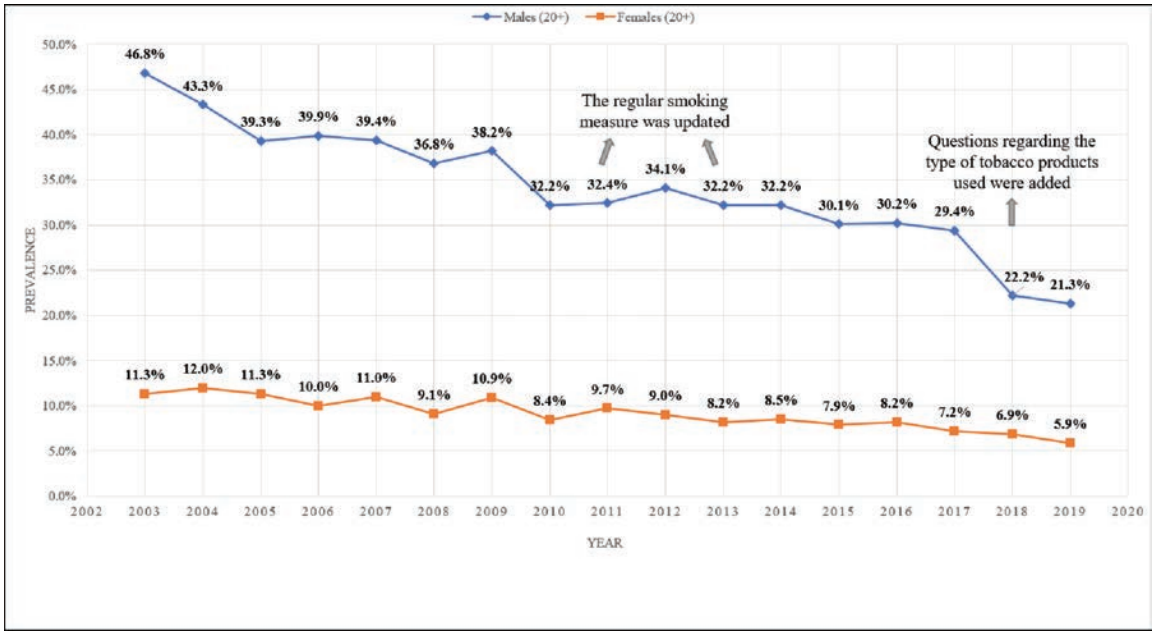

Figure 1 Japan's cigarette smoking prevalence for males and females ages 20+. HTP, heated tobacco product; JASTIS, Japan 'Society and New Tobacco' Internet Survey.

Table 1 NHNS 2011 smoking prevalence with relative changes in 2011–2014, 2014–2017 and 2017–2019, by age and sex

Males							
Ages	**20–29**	**30–39**	**40–49**	**50–59**	**60–69**	**70+**	**Ages 20+**
2011 smoking prevalence	39.2%	43.9%	40.2%	37.3%	29.3%	16.6%	32.4%
Relative change from 2011 to 2014	−6.4%	0.9%	10.0%	−2.4%	10.9%	−9.0%	−0.6%
Relative change from 2014 to 2017	−27.5%	−10.4%	−10.4%	−8.2%	−5.8%	7.3%	−8.7%
Relative change from 2017 to 2019	−24.7%	−46.2%	−38.7%	−23.6%	−12.9%	−13.0%	−27.6%
Females							
Ages	**20–29**	**30–39**	**40–49**	**50–59**	**60–69**	**70+**	**Ages 20+**
2011 smoking prevalence	12.8%	16.6%	16.5%	10.2%	6.4%	3.0%	9.7%
Relative change from 2011 to 2014	−8.6%	−13.9%	−22.4%	20.6%	−1.6%	−16.7%	−12.4%
Relative change from 2014 to 2017	−46.2%	−40.6%	−3.9%	−20.3%	15.9%	16.0%	−15.3%
Relative change from 2017 to 2019	−21.9%	−56.5%	−37.2%	2.0%	−0.3%	3.2%	−18.3%

NHNS, National Health and Nutrition Survey.

of the 'lifetime 100-cigarette or 6-month smoking' criterion in 2011, potentially having an impact on the individuals who would be considered people who smoke. With the change in questions in 2011 and relatively stable tobacco control policies since 2011 (thereby reducing any confounding effect of HTPs with tobacco control policies), we chose 2011 as the initial year of our analysis.

Figure 1 shows little change in cigarette prevalence for 2011-2014, followed by a decline from 2014-2017, and then more rapid change in from 2018-2019. HTPs were introduced in 2014.[1] Based on an online survey (JASTIS), HTP prevalence increased from 0.3% in January– Feb 8.0% in 2018 and 11.3% in 2019,[19] and then fell to 10.9% in 2020.[20] Per capita HTP sales also increased rapidly through 2018 followed by limited growth.[2] Because of the change in questions asked in 2018 (i.e., probed the specific products "smoked."), we distinguish three subperiods for the relative change analysis: 1) 2011-2014, prior to HTP entry; 2) 2014-2017, a period of rapid increase in HTP use; and 3) 2017-2019, when HTP use reached relatively high levels.

Changes in smoking prevalence

Table 1 shows 2011 smoking prevalence (by age and sex) and relative changes for 2011–2014, 2014–2017 and 2017–2019. In 2011, adult (ages 20+) smoking prevalence was 32.4% for males and 9.7% for females. Adult smoking prevalence decreased imperceptibly for males and by 12.4% for females from 2011 to 2014. In comparison, smoking prevalence declined by 8.7% for males and 15.3% for females from 2014 to 2017 and by 27.6% for males and 18.3% for females from 2017 to 2019. By age group, smoking prevalence was highest among those aged 20–49. Except for males ages 70+ and females ages 40–49 and 60+, male (female) relative reductions in smoking prevalence from 2014 to 2017 were larger than for 2011–2014. Comparing 2014–2017 to 2011–2014 for males (females), we obtain −27.5% vs −6.4% (−46.2% vs −8.6%) for ages 20–29, −10.4% vs 0.9% (−40.6% vs −13.9%) for ages 30–39, −10.4% vs 10% (−3.9% vs −22.4%) for ages 40–49 and −8.2% vs −2.4% (−20.3% vs 20.6%) for ages 50–59. Of note, the 2014–2017 relative reductions are greatest at younger ages. Relative reductions are larger in 2017–2019 for ages 30–39 and 40–49 for both sexes and males ages 50–59. However, the larger 2017–2019 reductions may reflect modifications in the survey questions in 2018.

Joinpoint analyses

Results from the joinpoint analysis in log form are shown in online supplemental 3. We first conducted a trend analysis, in which changes in trend could be distinguished. The simple trend analysis showed an increased accelerated decline in male smoking prevalence beginning in 2016 for all adults and for the 30–39, 40–49 and 50–59 age groups. For females, a change in trend was detected for ages 30–39. When a 2018 step change (jump) was added to the trend joinpoint to distinguish the impact of changes in survey questions from changes in trend, the step change was generally significant and changes in the trend line were no longer detected.

DISCUSSION

The NHNS data indicate an accelerated decline in adult male and female smoking prevalence in 2014–2017 relative to 2011–2014. The 2014–2017 period corresponds to when HTP use first began in Japan. The 2014–2017 decline in smoking prevalence was most pronounced for males aged 20–49, the ages with the highest reported HTP use.[21 22] The NHNS also indicates larger relative reductions for males ages 30–49 and females ages 40–49 in 2017–2019 than in 2014–2017. However, while a joinpoint analysis indicates a major change in trend in 2016 when only trend analysis is considered, the change in trend becomes insignificant when a 2018 step function (reflecting a major change in the 2018 survey questions) is added to the joinpoint analysis. The results are also subject to other limitations.

The NHNS is subject to frequent changes in the questions asked. The survey changed from measuring established cigarette use by those who had smoked 100 cigarettes lifetime before 2011 to any past month cigarette use in 2011 (study start date).[12] This change may have affected interviewee's responses in 2011 and also in later years. The absence of post-2010 criteria for established cigarette use also raises concerns that the measure may not reflect regular use, as relevant to public health impacts.[23]

Another important change in questions occurred in 2018 when the NHNS first asked those who smoked about the use of specific products. A US youth survey asking respondents to Choose All (products) That Apply (CATA) yielded 38%–58% lower cigarette smoking prevalence estimates than an otherwise identical survey asking separate yes-no questions about each potential (forced) product.[24] With the CATA approach, NHNS respondents may have limited their product choice only to those viewed as most important (eg, most regularly used). For example,

forced choice surveys by Philip Morris International (PMI)[25] and the Japan 'Society and New Tobacco' Internet Survey (JASTIS)[26] yield respective smoking prevalence estimates of 16.0% and 17.2% in 2019 compared with 13.1% from NHNS, suggesting a downward bias of 20% in 2019 NHNS estimates. In addition, a JASTIS study[27] found considerable denial of 'tobacco product use' relative to responses about specific products. While HTP use is distinguished from cigarette use in the NHNS starting in 2018, it is not clear whether those using HTPs viewed that use as distinct from cigarette use, particularly in years previous to 2018. Further research is warranted on consumer's perceptions of the term smoking,' and how those perceptions may affect prevalence estimates.

An indication of potential measure problems is the relatively high proportion of the population that distinguished themselves as exclusive rather than dual users. The 2019 NHNS had more than 75% of all HTP users as exclusive HTP users[11] while online surveys[20–22 28] conducted at about the same time find a larger proportion of dual users. Two of these studies[22 28] also found that increased HTP use was associated with increased dual relative to exclusive HTP use. However, dual use is generally defined as any past-30 day use in previous studies[20–22 28] and may thus not reflect regular use patterns but instead reflect a temporary state leading to transitions to exclusive HTP use, exclusive cigarette use or no use.

Another concern is the limited number of time points in NHNS before and after the introduction of HTPs. We chose the pre-HTP trend period based on the similarity of questions asked in the NHNS to later years and the absence of major policy change, and thus our results may depend on the definition of the pre-HTP period. In addition, the apparent conflicting findings in the online surveys and the 2018–2019 NHNS may reflect changing patterns of HTP relative to cigarette use. Those who smoked cigarettes and switched to exclusive HTP use in earlier years (eg, up to 2018) may be the individuals most inclined to quit smoking,[8] leaving people who smoke cigarettes and use HTPs less likely to quit cigarettes in later years.[29 30]

A final limitation of this study is the failure to explicitly control for other factors that may influence trends in cigarette use, such as e-cigarette use, changes in affordability and tobacco control policies. While nicotine-containing e-cigarettes have only been legally available in Japan by prescription,[31 32] they may be mistaken for HTPs and thereby influence smoking prevalence trends. Affordability depends on cigarette and HTP prices relative to income[33 34] and is likely to be a particularly important factor for youth and young adults.[35–37] While the period from 2011 to 2017 was devoid of major policy changes, Japan passed a smoke-free air law in 2018[38] and implemented cigarette and HTP tax increases in 2018–2019.[39] While our study focused on aggregate trends, future research should consider individual behaviour, similar to e-cigarette and cigarette demand studies,[40–43] in order to better distinguish transitions between HTP and cigarette use and to consider the impact of affordability and public policies on those transitions.

While HTP use appears to have had minimal impact on cigarette sales in some European countries,[44 45] increased use of alternative products was initially associated with reduced cigarette use in Japan, like in many other high-income nations.[23 46–48] Since tobacco companies face limited competition from companies that do not sell cigarettes, incumbent cigarette firms have a greater ability to influence both the cigarette and alternative product markets to meet their own goals.[49] The largest firms in 2013 had market shares of 60% (Japan Tobacco), 23% (PMI) and 12% (BAT).[50] PMI initially had incentives to introduce their HTPs as a way of gaining customers from JT. However, this strategy triggered competition from their competitors to launch their own HTPs with heavy advertising.[51] Recognising the instability, the companies may have reverted to a more coordinated, less competitive strategy towards cigarettes.[49 52] The relative stability of cigarette market shares through 2022 (Japan Tobacco International 58%, PMI 23% and British American Tobacco 14%) is indicative of the limited competition.[53] However, with high profitability of HTPs stemming from proprietary technology,[54] cigarette companies may have refocused their marketing to HTP sales.

While our analysis of trends using the NHNS is subject to limitations, other studies obtain results broadly consistent with our findings of accelerated declines in smoking prevalence from 2014 to 2017. An NHNS age-period-cohort (APC) analysis[55] showed increased relative reductions in male smoking prevalence in 2014–2017 compared with previous years. Another APC analysis using the larger Comprehensive Survey of Living Conditions (CSLC, N=720 000 in 2019)[56–58] showed increased adult male (female) smoking prevalence from 2010 to 2013, but relative reductions of 7.7% (11.2%) for 2013–2016 and 7.4% (7.4%) for 2016–2019, with the largest relative reductions for those aged 20–29 and 30–39 in both subperiods. Notably, the CSLC specifically asks, 'How many cigarettes do you smoke on an average per day?,' thereby associating smoking more directly with cigarette use. The NHNS results are also consistent with an observed 15% increase in annual relative reductions in cigarette sales during 2014–2017, coinciding with the most rapid increase in HTP growth.[1 2] Thus, Japan provides an important case study of potential impacts of an alternative nicotine delivery product.

CONCLUSIONS

Data from the NHNS indicate that cigarette use declined from 2014 to 2017 as HTP use increased. However, the changing format of survey questions regarding cigarette and later HTP use in NHNS precludes our ability to determine with confidence the relationship between smoking and HTP prevalence, especially since 2017. In addition, the impact of HTPs may have changed after 2017, suggesting the importance of continual monitoring of the role of potentially harm-reducing products. In conclusion, while this study suggests a role of HTPs in reducing smoking prevalence, it also shows the difficulties in eliciting accurate survey responses that distinguish the impact of a potentially harm-reducing product in an environment subject to rapidly evolving patterns of use, especially when surveys continually introduce changes to core questions.

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