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Switching from Cigarettes to Heated Tobacco Products in Japan—Potential Impact on Health Outcomes and Associated Health Care Costs

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Abstract: Background: Health expenditure in Japan is rising due to an ageing society while simultaneously pressure is mounting to increase spending in other areas such as defense, all in the context of a stagnating economy. Easing pressures on the health care sector through smoking-related cost reductions could thus be a cornerstone to mitigate the looming fiscal threat. Public health policy has encouraged cessation, but this approach has seen limited success. Focusing on cessation alone therefore may not be a sustainable policy strategy and other, new solutions need to be found to reduce smoking-related costs. **Methods:** Using a status-quo simulation based on hospital resources data derived from the Japanese Ministry of Health, Labour and Welfare, we examine the impact of heated tobacco products (HTPs) on the prevalence of four smoking attributable diseases (chronic obstructive pulmonary disease (COPD), ischemic heart disease (IHD), stroke and lung cancer) and related direct health care costs. Base case scenario assumes a switching rate from combustible smokers to HTPs of 50%. A risk reduction rate of 70% was applied. A sensitivity analysis was performed to determine the impact of parameter changes on output. **Results:** Our results indicate that 50% of smokers switching to use HTPs instead of combustible tobacco products could reduce the number of patients of the four smoking attributable diseases considered by 12 million cases equivalent to 454 billion JPY in savings. Prefectures located in the north and south of Japan would benefit most. **Conclusion:** Considering the heterogeneous prevalence rates across population groups and prefectures, a one-size-fits-all, centralized approach to tobacco control is not effective. Health authorities should strategically use multiple interventions to address smoking related health risks and costs. Switching to HTPs should be encouraged in parallel to smoking cessation, and educational efforts should aim to increase the awareness on health risks, especially among younger people.

Keywords: heated tobacco products; Japan; health resource utilization; smoking

Introduction

Japan's health care system has been very strong, delivering long life expectancy at relatively low cost [1]. However, costs have risen in recent years and are projected to increase further due to expensive medical advances and the ageing population [2]. Japanese citizens currently expect to reach an age of 82 among men and 88 among women in 2020, increasing to 85 among men and 91 among women by 2060 [3]. Seniors do not necessarily burden the economy though – if fit and healthy, elderly adults represent a valuable and often-utilized asset, for example for additional labor or childcare assistance [4]. However, health care spending scales up when seniors become ill, especially since this increases the likelihood of them requiring social care, for example through nursing homes [5,6].

While increasing health expenditures were not a major concern in times of economic growth, the stagnating economy and increasing inflation challenge the public as well as private medical care

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sector. The pressure on hospital management intensifies, adding to the existing issues of skilled labor force shortages and high mental loads of medical professionals. Thus, Japanese hospitals need to become more cost-efficient and reduce the number of patient admissions [7]. This demand has been already acknowledged by the government and health professionals [8,9]. The Japan Vision: Health Care 2035 included the roadmap to a "Tobacco-free" Tokyo Olympics 2020 and a "Tobacco-free" society by 2035, suggesting a policy option for tobacco tax increase.[8]

Although the Japanese health sector performs well above the OECD average, several factors put pressure on hospital resources. These include high air pollution mortality, and myocardial infarctions mortality [10]. To improve health outcomes, reducing behavioral risks such as alcohol abuse and smoking should be prioritized. Minimizing smoking-related risks should be a cost-effective measure and initial success has already been shown in Japan. While up to 77% of male adults smoked cigarettes in the 1950s, overall prevalence declined to 17% in 2019[11,12]. This may be due to introduction of strict measures for reducing smoking in public places in combination with the Japanese enthusiasm for technological innovations. Japan was one of the earliest markets in which alternatives to traditional combustible cigarettes were made available in the form of Heated tobacco products (HTPs).

By heating tobacco using a complex battery-powered device system, the inhalation of burnt contaminants that are cancerogenic can be avoided and the toxicological absorption into a smoker's body or the environment may be significantly reduced [13,14]. Other advantages involve less odor and higher social acceptability [15,16]. Both characteristics are attractive to the Japanese population, especially urban and well-off citizens. Given its singularity in Japan – the government has not yet legalized any other similar non-combustible products, such as snus, nicotine pouches, or liquid alternatives – the Japanese HTP market can be considered as a model for analyzing the comparative risks related to HTP or combustible smoking. Four HTP producers compete in the Japanese market with four different technology platforms, which fosters innovation in the Japanese HTP market [17]. Despite this market evolvement on the supply side, demand slowed down in the past years. In 2019, prevalence of HTP use was 3%. Of all tobacco users, only 7% of males and 5% of females consume both cigarettes and HTPs [18]. Both – the low share of dual use and a rapidly declining smoking prevalence since HTP introduction – point to the substitution potential of HTPs. This hypothesis is backed by a Japanese study finding that HTPs contributed to reducing cigarette sales [19].

Nevertheless, smoking prevalence still was at 17% in 2019, causing a significant number of preventable disease incidents. Reducing smoking prevalence would help mitigate pressure on health costs and hospital resources. Measures to target specific subgroups may be essential, especially that still resist the overall trend towards for smoking cessation. For example, smoking prevalence was 27% among male adults in 2019 and among low-educated men and women 58% and 35% respectively in 2016 [20]. In addition, smoking behavior differs substantially between regions, potentially being correlated with economic strength, demography, and cultural differences. Smoking prevalence remains the highest in Hokkaido (27% in 2016) and Tohoku (21%), that are in the north of Japan, while Chugoku (21%), Shikoku (21%) and Kyushu (21%) are located in the south-west [21].

Based on real world population data and published epidemiological data, we will examine the implications of switching to HTPs on health outcomes in the form of patients of non-communicable diseases attributable to smoking. To the best of our knowledge, despite the exceptional opportunity resulting from the special market situation, this research has not yet been performed in Japan.

Methods

The research consists of three steps. First, based on a literature review, we establish the association between cigarette smoking and smoking induced diseases such as lung cancer, cardiovascular diseases, or COPD, and health care cost. Then, based on a literature review we determine the impact of switching from cigarettes to HTPs on associated health hazard. This literature includes published epidemiological data and studies on the potential of HTPs. Finally, changes in risks are translated into corresponding changes in health outcomes, survival rates, and associated changes in health care costs.

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Smoking Attributable Function

A literature review was conducted on the disease burden related to smoking and the reduced disease burden associated with HTP use instead of smoking. To estimate the burden of disease of smoking, epidemiologists rely on the Population Attributable Fraction (PAF) which is the country-specific proportion of incidents, attributable to a certain risk factor. As the risk factor of interest is smoking, the PAF can then be called Smoking Attributable Fraction (SAF). In order to determine the number of patients who developed a disease due to smoking, we use disease-specific relative risks from meta-studies by Thun et al. (2000) and Gandini et al. (2008).[45,46] With that we do not rely on a single source for relative risks, which tend to vary over studies. To estimate Japan's Population Attributable Fractions, we follow the approach used in "The Preventable Risk Integrated Model" a WHO-supplied tool from Scarborough et al. (2016). To do this, we calculate the number of patients by smoking status and disease, weighted by their respective relative risks.[37]

Risk Reduction Potential of HTPs

Published evidence was used to determine the effect of so called reduced-risk products, particularly HTPs. A study by Forster et al. (2017) indicates an absolute risk reduction of 97% [22]. The authors investigated the nine toxicants proposed by the WHO Study Group on Tobacco Product Regulation (TobReg) for mandated reduction in cigarette emissions. They find an overall average reduction of 97.1%. Li et al. (2019) estimated 80% fewer harmful constituents in the releases from HTPs [23]. There is a number of studies that found the content of HTP smoke containing 70–95% of the concentration of nicotine and toxicant exposure found in traditional cigarette smoke [24,25]. [26,27] Another study conducted by Nutt et al. (2014) employed a rather unusual method: a multi-criteria decision analysis model of the relative importance of different types of harm related to the use of nicotine-containing products [28]. This expert-based analysis concluded that the risk related to the use of HTPs is 96% lower compared to cigarettes. The study by Zhang et al. (2023) showed significantly lower exhaled levels of carbon monoxide with HTPs compared to cigarettes [29]. Lower toxicant levels are confirmed by Bekki et al. (2017) of the National Institute of Public Health Japan who found HTP smoke containing one hundredth of carbon monoxide compared to combustible cigarette smoke [30].

Translating Reduced Emissions into Health Impacts

Given the recent introduction of HTPs, there is no longitudinal epidemiologic study allowing the analysis of the impact of reduced emissions on individual or public health. However, public health researchers suggest that beneficial health impacts are plausible. The Dutch National Institute for Public Health and the Environment (RIVM) derives the change in cumulative exposure (CCE) of HTPs and cigarettes, which is then translated into an estimate of the health impact – a change in expected life span [31]. Assuming an absolute risk reduction of 90%, the life expectancy of HTP consumers would be closer to the life expectancy of non-smokers than to smokers. In a detailed modeling assessment, Stephens (2017) compared relative harmfulness of different nicotine products with a model based on exposure data and cancer potencies [32]. The calculated lifetime cancer risk of the HTP was one to two orders of magnitude lower compared to combustible cigarettes. The meta-studies of Znyk et al. (2021), Uphadyay et al. (2023) and Yayan et al. (2024) provide literature reviews about the impact of Reduced-Risk Products on the individual and public health [33–35]. Among other health impacts, Znyk et al. (2021) found that HTP use is correlated with a decreased risk of lung cancer and cardiovascular diseases. Yayan et al. (2024) noted that respiratory damage caused by e-cigarettes and cardiovascular health consequences could be less severe compared to conventional cigarettes.

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Model Input

Based on the literature review outlined above, we populate our model with the parameters reported in Table 1. Smoking prevalence on national level is taken from the Report of the 2019 National Health and Nutrition Survey (NHNS) by the Japanese Ministry of Health, Labor and Welfare. Further, to obtain smoking prevalence rates on prefecture level, we utilize smoking prevalence rates from NHNS 2016 and extrapolate these based on the 2019 NHNS data. Current number of inpatient and outpatient visits and associated direct health care costs of chronic obstructive pulmonary disease (COPD), ischemic heart disease (IHD), stroke, and lung cancer are employed from the Handbook of Health and Welfare Statistics, which is also established by the Ministry of Health, Labor and Welfare. The considered health care costs include inpatient and outpatient visit costs, as well as medical care expenditures of preparation by pharmacy and medical care expenditures in general. Two parameters are critical for estimating the effect of switching from cigarettes to HTPs; the switching rate and the degree of risk reduction. The risk reduction for smokers switching to HTPs is set to 70% in the base case scenario. The base case scenario assumes a switch rate of 50%, i.e. a half of smokers switch to HTPs while the other half continues using traditional tobacco products.

For the cost, results will be reported for Japan and on a prefectural level. Given a residual excess health risk in the initial period when smokers quit, we apply a conservative health risk reduction.

Table 1. Modelling assumptions and data input for baseline scenario.

	Assumptions	**Source**
Number of smoking attributable patients in status quo	47,922,652	Own calculations based on [36,40,45,46,73]
COPD	5,858,979	
IHD	8,218,702	
Stroke	26,049,067	
Lung cancer	7,795,904	
Relative Risks of current smokers		[37,45,46]
COPD	11.57	
IHD	2.91	
Stroke	3.12	
Lung cancer	8.96	
Annual smoking attributable health care costs in status quo in million JPY	1,777,635	Own calculations based on [36,38,40,45,46,73]
COPD	124,967	
IHD	305,947	
Stroke	853,841	
Lung cancer	492,879	
Risk Reduction after switching to HTP	70%	[39,50]
Smoking Prevalence	15.4%	[40,73]
Switching Rate	50%	[41]

COPD: chronic obstructive pulmonary disease; IHD: Ischemic heart disease; HTP: Heated Tobacco Products; JPY: Japanese Yen (1 JPY=0.0066 US Dollar as of April 2024).

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At a later stage we also conduct a deterministic sensitivity analysis to accommodate the uncertainty around some of the model parameters. Specifically, we vary the degree of risk reduction (50% and 90%), switching rate to HTPs (25% and 75%), smoking prevalence (10.4% and 20.4%), and health care costs (inpatient and outpatient visit costs vs. total health care costs excluding expenses for dental care) (Table 2).

Table 2. Assumptions Deterministic Sensitivity Analysis.

	Lower End		**Upper End**	
	Assumption	Reference	Assumption	Reference
Risk Reduction Level	50%	[42]	90%	[43,44]
Relative Risks				
COPD	*9.17*	[45]	*14.57*	[45]
IHD	*2.61*	[45]	*3.26*	[45]
Stroke	*2.47*	[45]	*3.87*	[45]
Lung cancer	*6.73*	[46]	*12.10*	[46]
Switching Rate	25%		75%	
Smoking Prevalence	10.4%	[40]	20.4%	[40]
Health Costs	Inpatient & outpatient visit costs	[38]	Total health care costs excluding dental medical care	[38]

Results

Reported at Table 3, the annual number of smoking attributable patients would be reduced by more than 12 million cases (-26%) in the baseline scenario. Stroke cases as well as IHD cases would be reduced by -29%, i.e. more than seven million less stroke cases and more than two million less IHD cases than those in in the status quo.

Table 3. Number of smoking attributable patients (in thousand).

	Status Quo	**Baseline Scenario**	***Δ***	***In %***
Total	**47,923**	**35,462**	***12,460***	***-26%***
Lung Cancer	7,796	6,275	*1,521*	*-20%*
Ischemic Heart Disease (IHD)	8,219	5,802	*2,416*	*-29%*
Stroke	26,049	18,524	*7,525*	*-29%*
Chronic Obstructive Pulmonary Disease (COPD)	5,859	4,861	*998*	*-17%*

Savings in associated health care costs are summarized in Table 4. According to our estimates, total health care costs of smoking attributable diseases could decline from 1,778 bn JPY to 1,324 bn JPY (-26%). The highest savings of approximately 247 bn JPY (-29%) could be generated by the reduced numbers of stroke cases.

Table 4. Smoking attributable health care costs (in Million JPY).

	Status Quo	**Baseline Scenario**	***Δ***	***In %***
Total	**1,777,635**	**1,323,593**	***454,042***	***-26%***
Lung Cancer	492,879	396,744	*96,135*	*-20%*
Ischemic Heart Disease (IHD)	305,947	215,997	*89,951*	*-29%*
Stroke	853,841	607,169	*246,672*	*-29%*
Chronic Obstructive Pulmonary Disease (COPD)	124,967	103,683	*21,284*	*-17%*

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The regional breakdown of savings is reported in figure 1. To account for differences in population size, cost savings are displayed in million JPY per 100,000 people with darker colors representing increased savings. Prefectures located in the north and south of Japan could benefit significantly more from smokers switching to HTPs compared to the middle and eastern prefectures.

Figure 1. Savings in health costs by prefecture (in Million JPY per 100.000 people).

Figure 2 reports the results of the sensitivity analysis for expected cost savings. Switching rate and risk reduction are the two parameters that influence the results of the baseline scenario most. With a risk reduction of 90%, cost savings could amount to 607 bn JPY. Similar savings of 730 bn JPY could be achieved with a switching rate of 75% and base-case risk reduction. For health care costs we use costs for inpatient and outpatient visits as our lower bound and total health care costs excluding dental care as our upper bound. A variation in smoking prevalence would influence the results of the baseline scenario marginally.

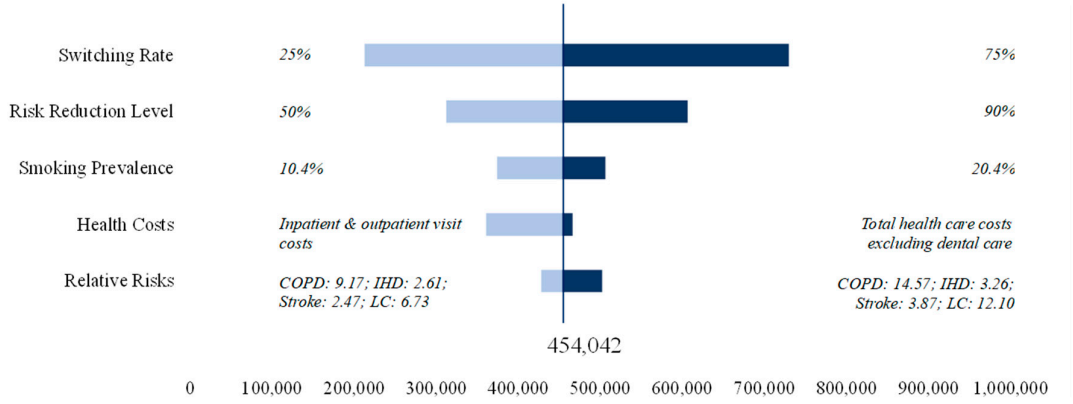

Figure 2. Sensitivity analysis for health cost savings (Million JPY).

Discussion

The Japanese health care system has long been acclaimed for its performance in terms of delivering the world's longest average life expectancy at relatively low cost [47]. However, in recent years, Japan has been struggling with rising health care costs, mainly due to its 'super ageing' population [48]. Even now, hospital doctors suffer from overwork and burnouts [49]. Considering further increase in life expectancy in the future decades, health costs are expected to rise significantly. One way for the Japanese government to decrease the share of its GDP that is spent on health care is

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to reduce risks related to smoking. Switching smokers to HTPs seem to offer an effective means for reducing health care risks and related health care cost.

Similar to other countries, public health policy traditionally focuses on smoking cessation, and cessation treatments have been covered under universal health insurance in Japan since 2006. In April 2006, Chuikyo (Central Social Insurance Medical Council), which is an advisory body to the Minister of Health, Labor and Welfare that deliberates on revisions to Japan's health insurance system and medical fees, included outpatient smoking cessation guidance (nicotine dependence management fee) in the National Formulary. This was the first time in history that the Chuikyo had decided on insurance coverage based on cost-effectiveness considerations. The following four points were discussed at that time: 1) Verification of cost-effectiveness was required for insurance coverage, 2) Domestic economic evaluation research was required, 3) It was not about reducing costs, and good cost-effectiveness is accepted, and 4) Model analysis is not regarded as evidence [50]. However, the discussions within the government stagnated regarding the cost-effectiveness evaluation until the trial implementation of cost-effectiveness evaluation in 2016 [51].

One recent example is the CureappSC digital smoking cessation app that received reimbursement in November 2020 [52]. The app is used together with a portable device that measures carbon monoxide concentration in a patient's breath [53]. However, actual adoption is limited in Japan[54] Even though public health policy encourages cessation on many communication levels, this approach has seen limited success.

One reason is that many smokers do not necessarily find smoking cessation desirable even if they are aware of the risk it imposes on health. In Japan, only one quarter of smokers actually want to quit [55]. Moreover, approximately 86% of those that reported to quit smoking relapse back into their harmful behavior [56]. Exclusive policy focus on cessation therefore may not be a sustainable strategy and other, new solutions need to be found to reduce smoking-related disease burdens – such as facilitating a switch to risk-reduced products such as HTPs.

Our model indicates a reduction in the incidence of smoking attributable diseases and a related reduction in cost. According to our baseline estimates, a 50% switch of smokers to HTPs could reduce the number of smoking attributable diseases such as lung cancer or heart diseases by 12 million patients annually. The associated savings in direct health care costs would amount to 454 bn JPY a year (3 billion USD) or -26%.

The impact estimated through our model for the Japanese context compares well to other reports. Igarashi A, et al. (2016) estimate 6% lower medical costs if the smoke cessation drug varenicline would increasingly be used for cessation [57]. In comparison, our model predicts HTP-related health care cost reduction of 26%. The difference can be explained due to the low cessation success rate of varenicline, of which only 14% of individuals undergoing a quit attempt succeed [58]. Our estimated reduction in health outcomes for Japan also point to similar findings when compared to studies conducted in other countries [59–62].

At a regional level, highest potential savings could be realized in the prefectures in the South and West of Japan, for instance within Shikoku or Kyushu islands (e.g. Kochi and Kagoshima). These rather rural areas have a lower regional gross product but a high smoking prevalence. Physician shortages in those remote areas are of increasing concern [63,64]. Reducing physician utilization by reducing health risks may be one effective remedy. Considering the heterogeneous prevalence rates across population groups and the uneven age and working population distribution across prefectures, a one-size-fits-all, centralized approach to tobacco control may not be the best answer for the Japanese government. To leave no one behind, health authorities need to employ multiple tools for reducing the negative health impacts of smoking – including both cessation and behavioral change with a device innovation such as switching to HTPs.

Policy Implications

Implementing cost-efficient measures beneficial to public health and economy should be the primary goal of the Japanese government. Despite strict policies, smoking behaviors have not been eliminated completely in Japan. Encouraging smokers to switch from smoking traditional cigarettes

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to reduced-risk products and preventing young adults from initiating tobacco use may be complimentary and effective policies to reduce the negative health consequences and health care cost. In addition, raising awareness of the health risks associated with each tobacco product enables the consumer to make an informed, independent and rational choice.

Most importantly, price controls in the form of tobacco taxes have proven to be the most effective regulatory measure [65]. A well-designed tobacco tax mix should favor reduced-risk products to incentivize smokers to switch. A harm-based approach by taxing according to the external health risk of a product may be justified [66]. The current tax plans of the Japanese government collide with this theorem, however, as they neglect any differences in harm and seem to maximize fiscal returns instead of maximizing the strategic impact on health [67]. Finally, investing into longitudinal epidemiological studies remains important to gain more knowledge about the health risks of reduced-risk products [68]. This allows governments to enable evidence-based regulatory decisions.

Limitations

The simulation rests on several assumptions that are central to the model outcomes. Mainly, we assume the HTPs are a substitute for traditional tobacco products. Although this assumption is backed by the literature, results would change if HTPs would attract non-smokers. In that case population risks would rather increase than decrease with unintentional consequences for health outcomes and costs. In addition, long term risks of HTPs are not yet fully assessed. While the applied rate of 70% risk reduction seems reasonable, some long-term harms might be underestimated. Another assumption is, that reduction in toxicological risks as shown in several studies represents a meaningful reduction in effective health risks for the users. However, we also might have underestimated some of the benefits of switching to HTPs. For instance, a Japanese study conducted during COVD-19 found out that compared with cigarette-only users, HTP-only users were more likely to quit smoking all together **[69].**

Another reason why our study might underestimate the benefits from switching is that only four smoking attributable diseases were considered. Smoking also increases the risk for many other illnesses such as psoriasis, rheumatoid arthritis, or inflammatory bowel disease which were not covered in our analysis **[70–72]**. Furthermore, only direct health care costs were taken into consideration for our cost estimates. However, indirect costs such as productivity losses are even more relevant. Globally, the total burden of smoking was estimated to be 1,852 billion USD (in purchasing power parity) in 2012. Only 467 billion USD (25%) of this amount can be associated with health care expenditures **[73].**

Conclusions

This analysis for Japan indicated that switching from smoking to heated tobacco products could be associated with annual savings of 26% or 454 bn JPY. The second finding involves the number of 12 million prevented patients, both inpatients and outpatients. Saved hospital resources could be more efficiently allocated to relieve the burden on nursing staff and would most likely be used for patients with non-smoking related illnesses.

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