Secondhand Smoke and Streptococcal Infection in Young Children Under Japan's Voluntary Tobacco-Free Policy

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ABSTRACT

Introduction

The tobacco-free policy in Japan lags those of most developed countries. Evidence is required to promote strong implementation of existing policies. This study aimed to assess whether second-hand smoke (SHS) exposure influences the incidence of streptococcal infection in young children, to further support the need for effective tobacco-free policies in Japan.

Methods

This study used medical administrative claim and health check data of the Japan Health Insurance Association Fukuoka branch. Participants were beneficiaries' dependents under 4 years old. We defined exposure as SHS from beneficiaries' smoking, each year during 2011-2014. The outcome was incidence of streptococcal infection, diagnosed with and without laboratory testing. Logistic regression analysis was performed to yield odds ratios (ORs) of associations with the outcome and 95% confidence intervals (CIs).

Results

This study included a total 5,743 children. The proportion of all participants with a record of streptococcal infection was 4.2% (n=244). The results of logistic regression analysis between streptococcal infection and SHS exposure showed a significantly higher association (OR 1.39, 95% CI 1.07–1.80, $P<0.05$) if all cases were included and an insignificant association with diagnoses using testing (OR 1.20, 95% Cl 0.80–1.80, P=0.39).

Conclusion

This study showed that 60% of streptococcal infections in young children were diagnosed without testing, and SHS increased this incidence regardless of testing. We report new findings regarding the effect of SHS on infection in young children, to support implementation and promotion of tobacco-free policies by the Japanese government not only in public spaces but also at home.

INTRODUCTION

Tobacco use kills more than 7 million people a year worldwide. More than 6 million of these deaths are the result of direct tobacco use and around 890,000 are among nonsmokers who are exposed to secondhand smoke (SHS), which is currently the world’s single greatest cause of preventable death.[1,2] It has been reported that 40% of children, 33% of male nonsmokers, and 35% of female nonsmokers were exposed to SHS worldwide in 2004.[3] In Japan in 2015, 18.2% of people smoked and 18.9% people were exposed to SHS at home in one month.[4] About 70% of children under 3 years old neither attend daycare nor kindergarten in Japan;[5] therefore, these children mostly spend their time at home and are likely to be exposed to SHS if their family members smoke.

Tobacco smoke contains over 4000 toxic chemicals, including human carcinogens.[2,] It is well known that tobacco smoking harms human health. Similarly, SHS contributes to mortality as a result of cardiovascular disease, lower respiratory infection, asthma, lung cancer, and so forth. A total 47% of deaths owing to SHS occur in women and 26% in men worldwide.[3] It is especially important to focus on the effects of SHS in children because 28% of premature deaths from SHS occur in children worldwide.[3] Many studies have reported that SHS increases the incidence of many diseases in children, such as asthma,[3,6] lower respiratory infection,[3,7,8] otitis media,[3,7] and sudden infant death syndrome.[8,9]

The World Health Organization Framework Convention on Tobacco Control (WHO FCTC) is the first global public health treaty, adopted in 2003 and entered into force in 2005. Article 8 of the WHO FCTC lays out guidelines for the adoption and implementation of effective measures to provide protection from exposure to tobacco smoke in indoor workplaces, public transport, indoor public spaces and, as appropriate, other public spaces.[10] Comprehensive smoke-free legislation is in place in 55 countries, covering nearly 1.5 billion people or 20% of the world's population as of 2016.[11] Progress in adopting smoke-free laws has been particularly impressive in low- and middle-income countries.[11] Within this global movement, the policies for protection from exposure to tobacco smoke in Japan are among some of the weakest, especially for developed countries.[12] Current policies in Japan to prevent exposure to SHS rely on voluntary regulation by business managers and building owners.[13] Under these circumstances, the Olympic Games will be held in Tokyo in 2020. Since the tradition of a tobacco-free Olympics began at the 1988 Winter Olympic Games in Calgary, Alberta, Canada, all Olympic Games have been declared tobacco-free, and WHO has worked with the International Olympic Committee to ensure that tobacco and other harmful products are not unwittingly promoted through sports.[14] Thus, Japan is at risk of violating longstanding Olympic policies. Weak relationships among government, administration, the medical community, and the public make it difficult to settle conflicts of interest.[15] It is necessary to promote tobacco-free policies in countries with poor enforcement, such as Japan. For this, strengthening the evidence for tobacco control is critical.

The National Epidemiological Surveillance of Infectious Diseases Program has been operated as a statutory measure in Japan.[16] This program has established an appropriate system, in cooperation with physicians and other healthcare workers, to prevent the outbreak and spread of various infectious diseases by ensuring that policies are enforced for the effective and appropriate prevention, diagnosis, and treatment of infectious diseases through accurate monitoring and analysis of information on the occurrence of infectious diseases, and through prompt provision and public disclosure of findings from such monitoring and analysis to the general public and healthcare workers.[16] This system was established to design appropriate measures against infectious diseases by monitoring the detection status and identifying the characteristics of circulating pathogens, through collection and analysis of information on these pathogens.[16] Group A streptococcal (GAS) pharyngitis is one of the target infections required to be reported weekly by pediatric sentinel sites.[16] GAS infection is prevalent among children, especially those of school age. GAS is responsible for 20%–30% of cases of pediatric acute pharyngitis and can cause acute rheumatic fever.[17] It has been reported that exposure to tobacco smoke decreases innate and acquired immunity[18] and increases the *Streptococcus pneumoniae* carriage rate.[19] However, there have been no reports on the association between SHS and incidence of streptococcal infection, including GAS pharyngitis, among young children who spend most of their time at home and are more exposed than school-age children to family members who smoke in the home.

It is important to provide evidence to support the enforcement of tobacco-free policies by government, especially considering that children experience greater effects of SHS exposure than adults because children do not understand the harm caused by SHS and cannot protect themselves from SHS. Thus, this study aimed to assess whether SHS influences the incidence of streptococcal infection, which is prevalent among young children, to support the enactment of effective tobacco-free policies in Japan.

METHODS

Study population and design

The Japan Health Insurance Association is the largest employee's health insurance association in Japan. This association covers health care for employees of medium-sized or small companies and their dependents. As of March 2015, this was equivalent to 29.3% of the population of Japan,[20] and the Fukuoka branch had 1,809,115 beneficiaries and family members.[21] The Japan Health Insurance Association maintains medical administrative claim and health check data of its beneficiaries, and these data were used in this study. Health check data includes BMI, blood pressure, blood testing results, and so forth. Questionnaires are administered during health checks and responses are included in the health check data. The portion of the questionnaire that queries beneficiaries regarding smoking includes the yes/no question, "Do you smoke habitually? (smoking more than a total 100 cigarettes after the first time smoking or smoking for more than 6 months, and smoking in the previous one month)" among beneficiaries.

The participants in this study were beneficiaries' dependents who were born after the date of the beneficiaries' health check in fiscal year 2011, i.e., children under 4 years old as of March 31, 2015, who spent most of their time at home, and who could be tracked through March 31, 2015. We defined exposure as SHS owing to smoking by beneficiaries who answered "yes" to the question regarding their smoking on the questionnaire. The exposed group consisted of dependents of beneficiaries who reported that they smoked in all years from fiscal years 2011 to 2014; the unexposed group comprised dependents of beneficiaries who reported not smoking during all these years. This study finally included 5,743 children. We excluded dependents of beneficiaries whose smoking status changed after fiscal year 2011, those who did not undergo a health check during all study periods in the four fiscal years, and those not eligible for this health insurance.

Administrative claim and health check data were deidentified by constructing specific databases using a work station with no connection to any networks. This study was approved by the Institutional Review Board of Kyushu University (Clinical Bioethics Committee of the Graduate School of Healthcare Sciences, Kyushu University).

Outcomes

The outcome was incidence of streptococcal infection. Streptococcal infection was defined as having a record of streptococcal infection in the medical claim data, with no suspicion of other diseases, between the date of beneficiaries' health check in fiscal year 2011 and March 31, 2015. GAS pharyngitis is recorded as streptococcal infection on medical administrative data records in Japan. Several diseases are caused by *Streptococcus*[17,22] such as pharyngitis, pyoderma, invasive streptococcal disease, and others.[23] Each of these is assigned a separate code, except pharyngitis, so they can be distinguished from streptococcal pharyngitis. If a disease is recorded as streptococcal infection, it can be considered streptococcal pharyngitis. We also examined the records of diagnostic laboratory tests for streptococcal infection such as throat swabs, rapid diagnostic tests for group A beta-hemolytic streptococcus, and cultures.

According to the "Clinical Practice Guideline for the Diagnosis and Management of GAS Pharyngitis: 2012 Update by the Infectious Diseases Society of America", swabbing the throat and testing for GAS pharyngitis by rapid antigen detection test (RADT) and/or culture should be performed because clinical features alone cannot reliably discriminate between GAS and viral pharyngitis, except when overt viral features like rhinorrhea, cough, oral ulcers, and/or hoarseness are present. In children and adolescents, negative RADT tests should be backed up by a throat culture (strong recommendation, high-quality evidence).[17] However, diagnostic studies are not indicated for children under 3 years old because acute rheumatic fever is rare in this population, and the incidence and classic presentation of streptococcal pharyngitis are uncommon in this age group.[17] GAS might be diagnosed using clinical features alone without any testing because there is no guideline for GAS in Japan. Therefore, this study assessed records with and without testing and showed the proportion of diagnosis with testing.

Statistical analysis

SQL server 2014 was used to extract the data and Stata version 14.2 (StataCorp LP, College Station, TX, USA) was used for all analyses.

Logistic regression analysis was performed to yield odds ratios (ORs) for the association between SHS and the outcome, with 95% confidence intervals (CI). The evaluated potential confounders were participant's gender and age, and beneficiary's standardized monthly income and gender. Participants were divided into groups according to age in years as of March 31, 2015; standardized monthly income was divided into three groups: less than USD 2,900, USD 2,900–3,500, and USD 3,500 and above (1 USD = 110 JPY). Participants in the control group who had no record of streptococcal infection included both those who underwent laboratory testing and those who did not.

RESULTS

This study included a total 5,743 participants, comprising the SHS group with 2,465 participants and the no SHS group with 3,278 participants. There were more male participants than female ones and 96.3% of beneficiaries were male. Demographic information of participants is shown in Table 1. The proportion of all participants with records of streptococcal infection was 4.2% (n=244); this proportion was 5.0% (n=123) in the SHS group and 3.7% (n=121) in the control group (P=0.02 with chi-squared test). The proportion of all participants who underwent laboratory testing and were diagnosed with streptococcal infection was 1.7% (n=97); this proportion was 1.9% (n=46) in the SHS group and 1.6% (n=51) in the control group (P=0.34 with chi-squared test). Approximately 40% of all participants with streptococcal infection were diagnosed using laboratory testing (Table 1).

We conducted logistic regression analysis for streptococcal infection using the variables of participant's gender and age; and beneficiary's standardized monthly income, gender, and smoking status (SHS). The results, including diagnoses of streptococcal infection made without laboratory testing, are shown in Table 2. The association between streptococcal infection and SHS was significantly higher than that with no SHS (OR 1.39, 95% CI 1.07–1.80, P<0.05). Age showed significantly higher ORs with older age (Table2). Participant's gender, and beneficiary's standardized monthly income and gender were not significant.

We conducted a similar analysis for only those participants with streptococcal infection diagnosed using testing (Table 3). SHS was not significant, with OR 1.20 (95% CI 0.80–1.80, P=0.39). Using participant age 0 as reference, age showed significantly higher ORs with older age, except for age 1 year. Participant's gender, and beneficiary's standardized monthly income and gender were not significant, similar to the results when including participants diagnosed without testing.

DISCUSSION

In this study, we examined whether exposure to SHS increases streptococcal infection among young children. Streptococcal infection is prevalent in children aged 5–15 years[17] and being in school is an environment associated with higher prevalence. Therefore, we restricted study participants to those under 4 years old (younger than school age) to assess the effects of exposure to SHS at home. Our study results showed that 4.2% of our participants were diagnosed with streptococcal infection, even though this disease is more prevalent among children over 5 years old. In addition, exposure to SHS had a significantly higher association with streptococcal infection than no exposure to SHS among children who were diagnosed with and without laboratory testing. However, this association was insignificant in participants who underwent testing because testing is not necessary to diagnose streptococcal infection, which might affect the differences in our results. Previous studies have suggested that exposure to SHS in children appreciably worsens some infections, such as lower respiratory infection[3,7,8] and otitis media.[3,7] Our study results add new evidence of the effect of SHS in significantly increasing the frequency of streptococcal infection among young children. SHS exposure might be associated with physiologic evidence of systemic biochemical alterations in children and

SHS-exposure-related mechanisms of harm such as reduced mucociliary activity, decreased clearance of inhaled substances, and abnormal vascular and epithelial permeability.[24] Therefore, our results appear to offer relevant evidence of the adverse physiologic effects of SHS in the study population. Our findings add to the evidence supporting more rigorous implementation of tobacco-free policies in countries like Japan.

Our findings with respect to the outcome (streptococcal infection) diagnosed with laboratory testing showed an association with SHS exposure (OR 1.20), but this was not significant. Only 40% of all cases of streptococcal infection were diagnosed with laboratory testing. This suggests that most diagnoses of streptococcal infection are made using only clinical features and not testing because there is no guideline for streptococcal infection published in Japan. Also, according to the guideline of the Infectious Diseases Society of America, diagnostic studies are not indicated for children under 3 years old because acute rheumatic fever is rare in this population, and the incidence and classic presentation of streptococcal pharyngitis are uncommon in this age group.[17] For these reasons, we found a lower number of streptococcal infections diagnosed with testing, and the results were not significant. We cannot rule out that participants who did not actually have streptococcal infection may have been included in the group of participants diagnosed without testing. However, this would be non-differential misclassification bias because streptococcal infection without testing can be diagnosed among children both with and without exposure to SHS; therefore, we considered that it did not affect the results with respect to SHS exposure.

Regarding other variables, age showed significant differences with older age. Older children are more likely diagnosed with streptococcal infection than younger children[25]; therefore, our results would be relevant. Standardized monthly income was not an independent significant factor in our study, although it has been reported that SHS exposure decreases with increased income level.[26] The beneficiary's gender was also not significant because the beneficiaries in this study were all employees, so they might not be at home during the day regardless of whether they were male or female. However, SHS was significantly associated with streptococcal infection with and without laboratory testing among children in this study; therefore, we can conclude that children might have been affected by smoking even if smokers were not at home during the day time.

The present study results suggest that it is important to encourage beneficiaries to stop smoking, to protect their young children from disease and help them to lead healthy lives. We suggest that implementation of smoke-free legislation through government policies is needed, to encourage cessation among smokers, even at home. SHS might also cause higher rates of infection, so it is important to create an environment with public policies that benefit young children by reducing exposure to these harmful agents. Our study results showed no significant differences between income levels. However, tobacco use disproportionately affects lower socioeconomic groups and is increasingly prevalent in poorer communities;[27] therefore, comprehensive tobacco control based on WHO FCTC Article 8 is necessary, to eliminate health disparities among children with respect to passive smoking. It has been reported that the prevalence of children exposed to SHS at home declines substantially after the enactment of smoke-free legislation.[28,29] In addition, comprehensive smoke-free housing policies, regardless of the policy type, support positive changes in smoking behavior, such as reduced smoking and quitting.[30] Thus, it is critical to implement comprehensive tobacco control not only in public spaces but also in the home and in spaces such as cars.

The present study has some limitation. First, there was not a significant association among children who were tested for streptococcal infection, so other factors might be responsible for the association. For example, we can assume that if some doctors always diagnose streptococcal infection using testing, the participants diagnosed with testing would mostly be patients of these doctors. Second, we identified beneficiaries' smoking status using health check data records, but we could not obtain information about other family members' smoking status and the degree of exposure to SHS in study participants. In addition to whether the beneficiary smokes, aspects that should be considered when evaluating SHS exposure at home include whether people smoke inside the house and whether the children are looked after by caregivers who smoke.[31] Even if beneficiaries who smoked do not smoke indoors, it is possible that participants were exposed to third-hand smoke. Also, the proportion of children exposed to SHS at home is significantly higher if their parents have very low educational levels, in comparison with parents who are more highly educated.[32] In this study, however, we did not obtain information on parents' education level. Another limitation is that we obtained beneficiaries' smoking status from health check data and self-report questionnaires completed by beneficiaries. It is possible that smokers reported that they were nonsmokers because they hoped to avoid receiving health guidance following poor results of their health check. Furthermore, users of electronic nicotine delivery system (ENDS) might have reported being nonsmokers on the questionnaire owing to a perception that ENDS are harmless.[33] For these reasons, our results might have underestimated the effect of SHS. The tobacco vapor product "Ploom TECH" became available for the first time in 2016, only in Fukuoka, Japan. Thus, we consider that this product would be more prevalent in the study area than in other parts of the country. A variety of these products are commonly sold in Japan.[34,35] ENDS also include harmful chemicals and are considered to have many of the effects of passive smoking.[36,37] Therefore, health check questionnaires developed by the government should be modified to ensure that smokers do not self-report as being nonsmokers.

CONCLUSION

The present work revealed that 4.2% of study participants under 4 years old were diagnosed with streptococcal infection, including diagnoses without laboratory testing, and streptococcal infection was significantly associated with exposure to SHS. Thus, SHS exposure in young children appears to increase the incidence of streptococcal infection. It is therefore critical for some countries with weak policies, such as Japan, to implement tobacco-free policies not only in public spaces but also at home.

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Table 1 Participant characteristics and streptococcal infections among participants

Variable	Second-hand smoke		No second-hand smoke		Total	
Total	2465		3278		5743	
Sex						
Male	1268	(51.4)	1683	(51.3)	2951	(51.4)
Female	1197	(48.6)	1595	(48.7)	2792	(48.6)
Age(Years)						
0	769	(31.2)	967	(29.5)	1736	(30.2)
1	561	(22.8)	802	(24.5)	1363	(23.7)
2	692	(28.1)	943	(28.8)	1635	(28.5)
3	443	(18.0)	566	(17.3)	1009	(17.6)
Beneficiary's sex						
Male	2410	(97.8)	3123	(95.3)	5533	(96.3)
Female	55	(2.2)	155	(4.7)	210	(3.7)
Standardized monthly income*						
Under USD2900	778	(31.6)	994	(30.3)	1772	(30.9)
USD 2900-3500	1003	(40.7)	1279	(39.0)	2282	(39.7)
USD 3500 and more	684	(27.7)	1005	(30.7)	1689	(29.4)
Streptococcal Infections						
No	2342	(95.0)	3157	(96.3)	5499	(95.8)
Yes	123	(5.0)	121	(3.7)	244	(4.2)
Streptococcal Infections with detection tests						
No	2342	(98.1)	3157	(98.4)	5499	(98.3)
Yes	46	(1.9)	51	(1.6)	97	(1.7)

*1USD=110JPY

Table 2 Results of logistic regression analysis for streptococcal infection, including diagnoses without laboratory testing

Variables	OR	95%CI
Sex		
Male	1.00	
Female	1.28	0.98-1.67
Age(Years)		
0	1.00	
1	5.44	2.22-13.30
2	19.32	8.45-44.16
3	35.95	15.74-82.10
Standardized monthly income		
Under USD2900	1.00	
USD 2900-3500	0.92	0.66-1.26
USD 3500 and more	0.94	0.67-1.32
Beneficiary's sex		
Male	1.00	
Female	0.84	0.41-1.71
Second-hand smoke		
No	1.00	
Yes	1.39	1.07-1.80

Table 3 Results of logistic regression analysis for streptococcal infection, including only diagnoses with laboratory testing

Variables	OR	95%CI
Sex		
Male	1.00	
Female	1.31	0.87-1.98
Age(Years)		
0	1.00	
1	5.17	0.58-46.34
2	37.06	5.06-271.35
3	113.31	15.67-819.31
Standardized monthly income		
Under USD2900	1.00	
USD 2900-3500	0.98	0.60-1.61
USD 3500 and more	0.95	0.58-1.56
Beneficiary's sex		
Male	1.00	
Female	1.52	0.36-6.42
Second-hand smoke		
No	1.00	
Yes	1.20	0.80-1.80