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Tolerance for and potential indicators of second-hand smoke exposure among nonsmokers: A comparison of self-reported and cotinine verified second-hand smoke exposure based on nationally representative data

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ABSTRACT

Objective: We assessed the extent to which self-reported exposure to SHS underestimates the actual exposure to SHS and what factors are associated with a tolerance for SHS exposure in the Korean setting where the smoke-free policy is incomplete.

Methods: Information on socio-demographic characteristics, alcohol drinking and smoking was collected for 7948 nonsmokers aged ≥19 years from the fourth Korea National Health and Nutrition Examination Survey, 2008–2009. Self-reported and cotinine verified SHS exposures were compared. Potential factors associated with cotinine verified but not self-reported SHS exposures were assessed using a logistic regression model.

Results: Self-reported SHS exposure significantly underestimated the actual SHS exposure as determined by cotinine verification (kappa coefficient: 0.1066). At younger age, frequent alcohol drinking in females and a longer smoking duration in males were positively associated with cotinine verified exposure but not with the self-reported SHS exposure; they were also positively associated with cotinine verified exposure irrespective of self-reported SHS exposure.

Conclusions: Our findings show a tolerance for smoking in Korea. The current partial ban on smoking does not fully protect people from exposure to SHS. Smoking should be banned in all public places. In addition, efforts to de-normalize smoking in the Korean culture need to be strengthened.

Introduction

Second-hand smoke (SHS) is considered one of the world's most critical environmental health hazards. SHS is classified as a group 1 carcinogen because it contains thousands of harmful chemicals that have clear associations with severe health outcomes, such as respiratory diseases, cardiovascular diseases and cancer (Callinan et al., 2010; The U.S. Department of Health and Human Services, 2006; WHO and IARC, 2004). Many countries have made efforts to minimize the harmful effects of SHS exposure by developing educational campaigns to increase public awareness and by adopting smoke-free policies. However, in 2004, approximately 40% of the world's children and one-third of the nonsmoking adults were reported to still be exposed to SHS. These proportions are the highest in the Western Pacific Region, where the exposure rate among men, women and children is greater than 50% (Eriksen et al., 2012).

In the Republic of Korea, which has one of the highest prevalence of smoking in Asia (46.7% of males and 7.1% of females in 2009), self-reported SHS exposure has been increasing among nonsmokers, including among females and children (42.1% in males and 31.6% in females in 2007; 45.9% in males and 33.8% in females in 2010) (KCDC and MW, 2011; Lee and Ha, 2011).

Since the enactment of the National Health Promotion Act in Korea in 1995, smoke-free policies have led to the designation of non-smoking areas in several settings, such as large buildings, theaters, stores, hospitals, schools, concert halls, gyms and public transportation. Some restaurants, game rooms, and some outdoor areas were also included in the stationary smoke-free areas when the law was revised in 2010 and 2012. However, restaurants smaller than 150 m^2, entertainment venues, and other enclosed areas where SHS exposure is quite frequent and high, are exempted from this law. Therefore, because of the incomplete smoke-free policy and the related SHS exposure in Korea, there is a need to identify and apply accurate assessments of SHS exposure in order to correctly determine the level of exposure and to develop appropriate prevention strategies.

Self-reported questionnaire information has been commonly used to assess SHS exposure mainly in a qualitative manner; however, the

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use of biomarkers (i.e., cotinine) to measure SHS exposure has been gaining momentum as the awareness of the health risks of SHS exposure increases (Benowitz, 1996; Simoni et al., 2006). Even if the outcomes of two different measures of SHS exposure (i.e., self-reported and cotinine-verified) have corresponded significantly in most previous studies (Baheiraei et al., 2012; Simoni et al., 2006; Thompson et al., 1990; Yano, 2005), other studies have reported poor agreement or have suggested that data based on self-report need to be verified by a biomarker analysis to increase the accuracy of SHS exposure estimates (Johnson-Kozlow et al., 2010; O'Connor et al., 1995; Paek et al., 2009; Sasaki et al., 2011; Wong et al., 2013). It has been shown to be difficult to distinguish exposed from non-exposed non-smokers by self-reporting alone. There is no gold-standard questionnaire that can be used to verify SHS exposure. In some populations accustomed to living in environments less exposed to SHS exposure, exposure to SHS is easily recognized, and the accuracy of self-report might be improved. However, the use of self-reported SHS exposure alone may lead to the underestimation of SHS exposure in some populations because the awareness and perception of SHS might be affected by different levels of social tolerance for smoking. A high prevalence of smoking and a high tolerance to SHS exposure could make people less likely to recognize the exposure, which could lead to inaccurate self-assessments of SHS exposure in some populations. This tolerance and the resulting inaccurate assessments of SHS exposure could cause more harm to nonsmokers and could be a barrier to strengthening smoke-free policies. For this reason, in countries where there is a high prevalence of smoking, such as Russia, China, Japan, Korea and other Asian countries (OECD, 2013), it is necessary to estimate the national level of SHS exposure using both self-report and biomarkers, such as cotinine concentration, in order to compare outcomes, to obtain accurate data on SHS exposure and to contribute scientific evidence to support smoke-free policies. Cotinine, a major nicotine metabolite, is considered an accurate quantitative measure of recent exposure to tobacco smoke (Jarvis et al., 1987; Wong et al., 2013). It can be measured in various biological samples, including urine, and has a half-life of 16–20 h (Wong et al., 2013). In this context, the aims of this study are 1) to compare self-reported SHS exposure with corresponding urinary cotinine concentrations among non-smokers; and 2) to investigate factors associated with cotinine verified but not self-reported SHS exposure as well as cotinine verified exposure irrespective of self-reported SHS exposure. This study uses a nationally representative sample from the Korean population.

Methods

Data and study variables

Information for 20,277 males and females was initially collected from the data of the fourth Korea National Health and Nutrition Examination Survey (KNHANES IV), carried out in 2008 and 2009. KNHANES IV used a stratified multistage probability sampling method based on geographical area and housing type (the implicit stratification variable was the ratio of the population by age) to obtain a representative sample of the Korean population. After excluding individuals aged under 19 years (n = 5206), self-reported current smokers (n = 3171), and those with incomplete information on the status of self-reported smoking experience (n = 803) and urinary cotinine concentration (n = 3149), 7948 adult nonsmokers (never and former smokers) were included in the present analysis. The study was approved by the Institutional Review Board of the National Cancer Center of Korea (IRB number: NCCNCS-13-735).

Information on socio-demographic characteristics such as sex, age (years: 19–29, 30–39, 40–49, 50–59, and ≥60), marital status (married, single), education (duration in years: ≤6, 7–9, 10–12, and ≥12), monthly household income (10,000 KRW/month: <200, 200–399, and ≥400) and employment (employed, unemployed) were included. Information on alcohol drinking (non-drinker, drinker: 1 time per month, 2–4 times per month, and >2 times per week), self-reported SHS exposure (non-exposed, exposed: 0 h per day, <1 h per day, and ≥1 h per day), smoking duration (never smoker, <10, 10–19, 20–29, and ≥30 years), urinary cotinine concentration (<5 ng/ml, ≥5 ng/ml), and self-reported smoking status (never: smoked <100 cigarettes during their lifetime, former: smoked ≥100 cigarettes during their lifetime but currently do not smoke, current: smoked ≥100 cigarettes during their lifetime and currently smoke) was also derived from the data of KNHANES IV.

Respondents who answered "<1 h or ≥1 h" to the question, "How many hours per day are you exposed to SHS at work or at home?" were categorized as the self-reported SHS exposure group; those who answered "0 h" to the same question were not. Urine samples which were collected in mid-pee, were kept in the refrigerator at 2–8 °C for 2 days at most and were analyzed by tandem mass spectrometry with the Tandem mass API 4000 (Applied Biosystems, Carlsbad, California, USA) and by gas chromatography and mass spectrometry with the Perkin Elmer Clarus 600T (PerkinElmer, Turku, Finland) (KCDC and MW, 2011). The respondents with a urinary cotinine concentration of 5 ng/ml or more were classified as the cotinine verified SHS exposure group (Moyer et al., 2002). The limit of detection (LOD) and the limit of quantitation (LOQ) for urinary cotinine were 0.01 ng/ml and 0.03 ng/ml, respectively.

Statistical analysis

The kappa coefficient was used to evaluate the agreement between self-reported and cotinine verified SHS exposure in nonsmokers who had both questionnaire data and urinary cotinine concentration available. The adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of cotinine verified SHS exposure were calculated for potential factors associated with SHS exposure in the multiple logistic regression analyses. The data were analyzed using Survey Procedures in SAS (SAS Institute, Inc., Cary, North Carolina, USA), version 9.2.

Results

Of the 7948 subjects, 61.2% (n = 5320) were female and 38.8% (n = 2628) were male. The mean age of all of the subjects was 45.9 years (standard error of the mean (SE): ±0.34 years; range: 19–93). The geometric mean (GM) urinary cotinine concentration was 2.42 ng/ml (GSE: ±1.08) and was higher in males (3.48, GSE: ±1.10 ng/ml) than in females (1.92, GSE: ±1.09 ng/ml). Of the total study sample, 53.7% had a cotinine verified SHS exposure (using a threshold of 5 ng/ml), but only 36.1% had a self-reported SHS exposure. The self-reported SHS exposure rate was relatively low among both males and females. The correspondence between the self-reported and cotinine verified SHS exposures was low (kappa value: 0.1066, 95% CI [0.1062, 0.1070]) (Table 1).

As shown in our multiple logistic regression model, which was adjusted for all variables as appropriate, younger age among both genders, alcohol drinking among females, and having a former smoking experience among males were all positively associated with a cotinine verified SHS exposure at a statistically significant level. A significant linear trend by age group among both genders, the frequency of drinking alcohol among females (p = 0.0071), and a period of former smoking among males (p = 0.0004) was also observed with the highest odds in subjects aged 19–29 years among both genders (OR for females: 1.99, 95% CI [1.37, 2.89]; OR for males: 1.82, 95% CI [1.15, 2.89]), as well as drinking alcohol more than two times per week among females (OR = 1.64, 95% CI [1.15, 2.33]), and having smoked for 30 years or more among males (OR = 2.02, 95% CI [1.37, 2.99]) (Table 2).

The number of subjects who reported exposure to SHS was higher in the cotinine verified SHS exposure group among both females and males compared with the cotinine verified non-SHS exposure group. A