Relationship between personal care products usage and triclosan exposure: the second Korean National Environmental Health Survey (KoNEHS 2012–2014)

Minkyu Park¹, Seyoung Kim¹, Yeji Kim¹, Do Jin Nam¹, Jae-Hong Ryoo¹ and Sinye Lim¹,²*

Abstract

Background: We aimed to find the exposure level of triclosan (TCS), a known endocrine disruptor, related to the use of personal care products using a nationally representative data of the general population in Korea.

Methods: This study included data of 6288 adults aged 19 years and older (2692 men, 3596 women), based on the Second Korean National Environmental Health Survey (KoNEHS 2012–2014). The data were divided according to gender. The frequency and proportion of each variable were determined by dividing participants into two groups based on the top 75th percentile concentration of urinary TCS (male: 1.096 μg/g creatinine, female: 1.329 μg/g creatinine). Odds ratios (ORs) were calculated using logistic regression analysis for the high TCS exposure and low TCS exposure groups.

Results: Overall, the proportion of participants using personal care products was higher in women than in men. There was a significantly higher proportion of participants in the high TCS exposure group with younger age, higher education and income levels and with more frequent use of fragrance products, hair care products, body cleansers, cosmetics, and antimicrobial agents. In both men and women, ORs tended to increase with increased frequency of use of hair care products, body cleansers, and cosmetics before and after adjustment.

Conclusions: Our findings demonstrate that as the frequency of use of personal care products increases, urine TCS concentration increases. Because TCS is a well-known endocrine disruptor, further studies are needed and explore other health effects with exposure to TCS in general population in Korea.

Keywords: Triclosan, Personal care products, Korean National Environmental Health Survey

Background

Triclosan (TCS), chemical name 5-chloro-2-(2,4-dichlorophenoxy)phenol, is a synthetic antimicrobial and antifungal agent, which is widely used throughout the world. TCS is used mainly as a disinfectant in soaps, detergents, toothpaste, mouthwash, fabrics, deodorant, shampoo, and plastic additives, and it is used in many personal care products, animal products, and industry and household products [1].

TCS is absorbed into the body through the mouth and skin [2]. TCS is absorbed at a rate of nearly 100% in the oral cavity, with a half-life of 10–20 h; less than 10% is absorbed via the transdermal route, with a half-life of 1.4–2.1 days. Absorbed TCS is detected mainly in plasma, urine, and breast milk [3]; it is mostly excreted in the urine [4]. According to a pharmacokinetic study, after oral administration of 4 mg TCS, most was excreted in the urine within the first 24 h and levels had recovered to baseline within 8 days after administration [5]. These results demonstrate that urinary TCS concentrations can be used as a biomarker of TCS exposure [6]. There have been several studies indicating that

* Correspondence: drforest@hanmail.net
¹Department of Occupational and Environmental Medicine, Kyung Hee University Medical Center, Seoul, South Korea
²Department of Occupational and Environmental Medicine, School of Medicine Kyung Hee University, Seoul, Korea
TCS is known to be an endocrine disruptor that is structurally similar to polychlorinated biphenyls, bisphenol A, dioxins, and thyroid hormones [9]. TCS increases estradiol (E2) and progesterone secretion [10], has a similar effect as estrogen [11], and can induce hypothyroxinemia [12]. Moreover, in experiments with mice, rats, and hamsters, TCS has been associated with liver tumors [4]. Contact dermatitis, photosensitivity, contact dermatitis, skin irritation, and other conditions have also been reported in association with TCS [13, 14].

Because of these health problems, various regulations have recently been established in relation to TCS in many countries. Various studies on TCS exposure levels have also been carried out. However, studies on TCS levels in Korea and related factors have not yet been conducted. In this study, we used a nationally representative data for the general population in Korea to analyze the level of TCS exposure in the general population according to the frequency of use of personal care products, which are the main exposure source of TCS.

Material and methods

Study participants

This study was based on data of the Second Korean National Environmental Health Survey (KoNEHS 2012–2014). According to Article 14 of the Environmental Health Act, the KoNEHS is conducted every 3 years to investigate the human exposure levels of harmful environmental factors in the Korean population, explore the influencing factors, and continuously investigate the spatial and temporal distribution and change in these factors [15].

The survey area consisted of 16 cities and provinces nationwide. For the survey sample, the enumeration districts of the National Population and Housing Census 2010 were used for the sample population with the initial stratification classified by local administration. Secondary stratification was according to socioeconomic factors, using stratified multistage cluster sampling applied with proportional allocation of the square root of the population to extract 400 sample enumeration districts [16]. Approximately 15 people from each sample enumeration district were surveyed, targeting a total of 6478 Koreans aged 19 years and older. The survey consisted of an environmental exposure-related questionnaire, clinical testing, and analysis of harmful environmental substances in biological samples [15].

In this study, after excluding 190 participants with missing urinary TCS concentration data, 6288 participants (2692 men, 3596 women) were included from among a total of 6478 participants.
Statistical analysis
The frequency and proportion of each variable were presented after stratification by gender to determine the general characteristics of participants. First, participants were divided into a high TCS exposure group and low TCS exposure group, based on the top 75th percentile concentration of urinary TCS (male: 1.096 μg/g creatinine, female: 1.329 μg/g creatinine). The frequency and proportion of each variable were then determined by gender. Chi-square tests were performed to analyze the difference in the distribution of each variable. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using logistic regression for the high TCS exposure and low TCS exposure groups. Unadjusted models are presented and a multivariate adjusted model was adjusted for age, BMI, socioeconomic variables, and health behavior-related variables. IBM SPSS version 19 for Windows (SPSS Inc., Chicago, IL, USA) was used for statistical analysis and the statistical significance level was set at $p < 0.05$.

Results
The distribution of the independent variables in the present study was as follows (Table 1). A total 2692 (42.8%) participants were male, and 3596 (57.2%) were female. A greater percentage of men than women were college graduates or higher, and more men than women were current drinkers and smokers. In terms of fragrance products, hair care products, nail care products, antimicrobial agents, and air fresheners usage, more than half of men and women responded that they rarely used these products. More than half of men said they rarely used cosmetics and body cleansers, whereas more than half of women reported using these products once a week.

Urine TCS concentration was determined according to high and low TCS exposure groups, based on the upper 75th percentile concentration; the distribution of independent variables is presented in Table 2. The average age in the high TCS exposure group was significantly lower than that in the low exposure group. Furthermore, the urinary TCS concentration tended to decrease as age increased (See Additional file 1: Table S1). For both genders, the proportions of college graduates and participants with household income in the third quartile or higher, were significantly greater in the high TCS exposure group than in the low exposure group; the proportions of current drinkers and participants who vigorously exercised were also higher in the high TCS exposure group. Distribution by frequency of use of personal care products showed that for both genders, perfumes, hair care products, body cleansers, cosmetics, and antimicrobial agents were used more frequently in the high TCS exposure group than in the low exposure group. Additionally, more women in the high TCS exposure group reported more frequent use of nail care products.

Logistic regression analysis was applied to determine the degree of association between the frequency of personal care products use and urinary TCS concentration according to low TCS and high TCS exposure groups (Table 3). In the case of men, fragrance products, hair care products, body cleansers, and cosmetics showed significantly higher ORs for use more than once a week versus rarely use: 1.52 (95% CI 1.16–1.98), 1.50 (95% CI 1.19–1.87), 1.67 (95% CI 1.33–2.08), and 1.60 (95% CI 1.19–2.15), respectively. In the case of women, hair care products, body cleansers, and cosmetics showed significantly higher ORs for use more than once a week versus rarely use of these products: 1.20 (95% CI 1.01–1.42), 1.28 (95% CI 1.04–1.58), and 1.33 (95% CI 1.08–1.65), respectively. Interestingly, ORs were higher in men than in women.

Discussion
In this study, general characteristics for high urinary TCS concentration were younger age, higher educational level, higher household income level, drinkers, and vigorous exercise group. In a previous study in Canada, higher urinary TCS concentrations were found among women with higher education and income levels, with higher TCS exposure levels in those over 25 years of age in those under age 25 years [19]. In the United States (US), a study among the general population showed that the higher the income, the higher the concentration of urinary TCS, in relation to age, with the highest concentrations among participants in their 30s; concentrations then gradually decreased with age [2]. On the other hand, according to a study conducted in Korea in 2009, older age and lower income levels were associated with higher urinary TCS concentration with no significant difference [20]. Explanations for the differing results among studies may be owing to differences in lifestyles, such as different frequency of use of TCS-containing consumer products; additional research is needed to clarify these differences in study findings [20]. There has been no confirmation of the common trend found among studies regarding characteristics of drinking, smoking, exercise, and BMI of participants. The high TCS exposure among young adults aged 20–30 years is important in that it can be associated with pregnancy and childbirth. TCS is an endocrine disruptor and several animal studies have found that it can affect thyroid hormone homeostasis [1]. Because thyroid hormones are essential for development of the fetal nervous system and differentiation of the brain, deficiency of thyroid hormones can cause fetal neurodevelopmental problems [21–23].
Table 1 Basic characteristics according to sociodemographic factors and several exposure factors to triclosan in study population

| Category                        | Total (n = 6288) | Male (n = 2692) | Female (n = 3596) |
|---------------------------------|------------------|----------------|------------------|
| Triclosan level (μg/L)          | 0.35 (0.35–1.21) | 0.35 (0.35–1.09) | 0.35 (0.35–1.33) |
| Age (years)                     | 51.6 (15.1)      | 51.7 (15.5)     | 51.4 (14.8)      |
| BMI (kg/m²)                     | 243 (3.4)        | 246 (3.2)       | 241 (3.5)        |
| Education ≤ Middle school       | 2207 (35.1)      | 762 (28.3)      | 1445 (40.2)      |
| High school                     | 1901 (30.2)      | 822 (30.5)      | 1079 (30.0)      |
| ≥ College                       | 2180 (34.7)      | 1108 (41.2)     | 1072 (29.8)      |
| Marital status                  |                  |                |                  |
| Single                          | 632 (10.0)       | 346 (12.9)      | 286 (7.9)        |
| Married                         | 4992 (79.4)      | 2213 (82.2)     | 2779 (77.3)      |
| Others                          | 664 (10.6)       | 133 (4.9)       | 531 (14.8)       |
| Household income                |                  |                |                  |
| 1st quartile                    | 1767 (28.1)      | 769 (28.6)      | 998 (27.8)       |
| 2nd quartile                    | 2900 (46.1)      | 1261 (46.8)     | 1639 (45.6)      |
| 3rd quartile                    | 1563 (24.9)      | 634 (23.6)      | 929 (25.8)       |
| 4th quartile                    | 58 (0.9)         | 28 (1.0)        | 30 (0.8)         |
| Smoking                         |                  |                |                  |
| None                            | 4147 (66.0)      | 742 (27.6)      | 3405 (94.7)      |
| Ex-smoker                       | 1028 (16.3)      | 964 (35.8)      | 64 (1.8)         |
| Current-smoker                  | 1013 (17.7)      | 986 (36.6)      | 127 (3.5)        |
| Alcohol                         |                  |                |                  |
| None                            | 2153 (34.2)      | 429 (15.9)      | 1724 (47.9)      |
| Ex                              | 412 (6.6)        | 274 (10.2)      | 138 (3.9)        |
| Current                         | 3723 (59.2)      | 1989 (73.9)     | 1734 (48.2)      |
| Exercise                        |                  |                |                  |
| No                              | 3307 (52.6)      | 1309 (48.6)     | 1998 (55.6)      |
| Moderate                        | 709 (11.3)       | 284 (10.6)      | 425 (11.8)       |
| Vigorous                        | 2272 (36.1)      | 1099 (40.8)     | 1173 (32.6)      |
| Fragrance products              |                  |                |                  |
| Rarely                          | 5023 (79.9)      | 2269 (84.3)     | 2754 (76.6)      |
| < Once a week                   | 403 (6.4)        | 122 (4.5)       | 281 (7.8)        |
| ≥ Once a week                   | 862 (13.7)       | 301 (11.2)      | 561 (15.6)       |
| Hair care products              |                  |                |                  |
| Rarely                          | 3838 (61.1)      | 1948 (72.4)     | 1890 (52.5)      |
| < Once a week                   | 732 (11.6)       | 251 (9.3)       | 481 (13.4)       |
| ≥ Once a week                   | 1718 (27.3)      | 493 (18.3)      | 1225 (34.1)      |
| Body cleansers                  |                  |                |                  |
| Rarely                          | 2958 (47.0)      | 1902 (70.7)     | 1056 (29.4)      |
| < Once a week                   | 110 (1.8)        | 46 (1.7)        | 64 (1.8)         |
| ≥ Once a week                   | 3220 (51.2)      | 744 (27.6)      | 2476 (68.8)      |
| Cosmetics                       |                  |                |                  |
| Rarely                          | 3154 (50.2)      | 2381 (88.5)     | 773 (21.5)       |
| < Once a week                   | 252 (4.0)        | 81 (3.0)        | 171 (4.8)        |
| ≥ Once a week                   | 2882 (45.8)      | 230 (8.5)       | 2652 (73.7)      |
| Nail care products              |                  |                |                  |
| Rarely                          | 5325 (84.7)      | 2681 (99.6)     | 2644 (73.5)      |
| < Once a week                   | 678 (10.8)       | 8 (0.3)         | 670 (18.6)       |
| ≥ Once a week                   | 285 (4.5)        | 3 (0.1)         | 282 (7.9)        |
| Antimicrobial agents            |                  |                |                  |
| Rarely                          | 5234 (83.2)      | 2320 (86.2)     | 2914 (81.0)      |
| < Once a week                   | 213 (3.4)        | 57 (2.1)        | 156 (4.4)        |
| ≥ Once a week                   | 841 (13.4)       | 315 (11.7)      | 526 (14.6)       |
| Air freshener                   |                  |                |                  |
| Rarely                          | 4673 (74.3)      | 2017 (74.9)     | 2656 (73.9)      |
| < Once a week                   | 231 (3.7)        | 73 (2.7)        | 158 (4.4)        |
| ≥ Once a week                   | 1384 (22.0)      | 602 (22.4)      | 782 (21.7)       |

Data are mean (standard deviation), median (interquartile range), or number (%)
Table 2  Basic characteristics of study population in both high\(^a\) (the top 75th percentile) and low urinary concentration of triclosan group by gender

| Category               | Male |                      | Female |                      |
|------------------------|------|-----------------------|--------|-----------------------|
|                        | Low  | High                  | p value| Low                   | High                  | p value |
| Age (years)            | 52.6 | 49.0                  | < 0.0001| 52.3                 | 48.8                  | < 0.0001 |
| BMI (kg/m\(^2\))       | 24.5 | 24.7                  | 0.219  | 24.1                 | 23.9                  | 0.034   |
| Education              | ≤ Middle school | 618 (30.6)  | 144 (21.3) | < 0.0001 | 1162 (43.1) | 283 (31.4) | < 0.0001 |
|                        | High school   | 633 (31.4)  | 189 (28.0) |            | 783 (29.0)   | 296 (32.9) |            |
|                        | ≥ College      | 765 (38.0)  | 343 (50.7) |            | 751 (27.9)   | 321 (35.7) |            |
| Marital status         | Single        | 234 (11.6)  | 112 (16.6) | 0.003     | 187 (6.9)    | 99 (11.0)  | < 0.0001  |
|                        | Married        | 1678 (83.2) | 535 (79.1) |            | 2088 (77.5) | 691 (76.8) |            |
|                        | Others         | 104 (5.2)   | 29 (4.3)   |            | 421 (15.6)   | 110 (12.2) |            |
| Household income       | 1st quartile  | 598 (29.6)  | 171 (29.3) | 0.039     | 790 (29.3)   | 208 (23.1) | < 0.0001  |
|                        | 2nd quartile   | 947 (47.0)  | 314 (46.4) |            | 1223 (45.4) | 416 (46.2) |            |
|                        | 3rd quartile   | 451 (22.4)  | 183 (27.1) |            | 663 (24.6)   | 266 (29.6) |            |
|                        | 4th quartile   | 20 (1.0)    | 8 (1.2)    |            | 20 (0.7)     | 10 (1.1)   |            |
| Smoking                | None          | 552 (27.4)  | 190 (28.2) | 0.898     | 2551 (94.6) | 854 (94.9) | 0.135     |
|                        | Ex-smoker      | 721 (35.8)  | 243 (35.9) |            | 43 (1.6)     | 21 (2.3)   |            |
|                        | Current smoker | 743 (36.8)  | 243 (35.9) |            | 102 (3.8)    | 25 (2.8)   |            |
| Alcohol                | None          | 333 (16.5)  | 96 (14.2)  | < 0.0001  | 1323 (49.1) | 401 (44.5) | 0.036     |
|                        | Ex            | 227 (11.3)  | 47 (6.9)   |            | 96 (3.6)     | 42 (4.7)   |            |
|                        | Current        | 1456 (72.2) | 533 (78.9) |            | 1277 (47.3) | 457 (50.8) |            |
| Exercise               | No            | 1007 (49.9) | 302 (44.7) | 0.029     | 1538 (57.0) | 460 (51.1) | 0.005     |
|                        | Moderate       | 215 (10.7)  | 69 (10.2)  |            | 300 (11.1)   | 125 (13.9) |            |
|                        | Vigorous       | 794 (39.4)  | 305 (45.1) |            | 858 (31.9)   | 315 (35.0) |            |
| Fragrance products     | Rarely        | 1740 (86.3) | 529 (78.3) | < 0.0001  | 2106 (78.1) | 648 (72.0) | < 0.0001  |
|                        | < Once a week  | 83 (4.1)    | 39 (5.8)   |            | 192 (7.1)    | 89 (9.9)   |            |
|                        | ≥ Once a week  | 193 (9.6)   | 108 (15.9) |            | 398 (14.8)   | 163 (18.1) |            |
| Hair care products     | Rarely        | 1510 (74.9) | 438 (64.8) | < 0.0001  | 1442 (53.5) | 442 (49.9) | 0.113     |
|                        | < Once a week  | 179 (8.9)   | 72 (10.6)  |            | 360 (13.3)   | 121 (13.9) |            |
|                        | ≥ Once a week  | 327 (16.2)  | 166 (24.6) |            | 824 (33.2)   | 331 (36.8) |            |
| Body cleansers         | Rarely        | 1496 (74.2) | 406 (60.1) | < 0.0001  | 858 (31.8)   | 198 (22.0) | < 0.0001  |
|                        | < Once a week  | 13 (1.6)    | 13 (1.9)   |            | 49 (1.8)     | 15 (1.7)   |            |
|                        | ≥ Once a week  | 487 (24.2)  | 257 (38.0) |            | 1789 (66.4) | 687 (76.3) |            |
| Cosmetics              | Rarely        | 1814 (90.0) | 567 (83.9) | < 0.0001  | 629 (23.3)   | 144 (16.0) | < 0.0001  |
|                        | < Once a week  | 56 (2.8)    | 25 (3.7)   |            | 136 (5.0)    | 35 (3.9)   |            |
|                        | ≥ Once a week  | 146 (7.2)   | 84 (12.4)  |            | 1931 (71.6) | 721 (80.1) |            |
| Nail care products     | Rarely        | 2007 (99.5) | 674 (99.7) | 0.604     | 2024 (75.1) | 620 (68.9) | 0.001     |
|                        | < Once a week  | 6 (0.3)     | 2 (0.3)    |            | 469 (17.4)   | 201 (22.3) |            |
|                        | ≥ Once a week  | 3 (0.2)     | 0 (0.0)    |            | 203 (7.5)    | 79 (8.8)   |            |
| Antimicrobial agents   | Rarely        | 1763 (87.4) | 557 (82.4) | 0.004     | 2215 (82.2) | 699 (77.7) | 0.008     |
|                        | < Once a week  | 38 (1.9)    | 19 (2.8)   |            | 114 (4.2)    | 42 (4.7)   |            |
|                        | ≥ Once a week  | 215 (10.7)  | 100 (14.8) |            | 367 (13.6)   | 159 (17.6) |            |
| Air fresheners         | Rarely        | 1517 (75.3) | 500 (73.9) | 0.55      | 2014 (74.7) | 642 (71.3) | 0.13      |
|                        | < Once a week  | 57 (2.8)    | 16 (2.4)   |            | 113 (4.2)    | 45 (5.0)   |            |
|                        | ≥ Once a week  | 442 (21.9)  | 160 (23.7) |            | 569 (21.1)   | 213 (23.7) |            |

\(^a\) Male: ≥1.096 μg/g creatinine, female: ≥1.329 μg/g creatinine, data are mean (standard deviation), or number (%)

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According to the analysis of the relationship between the frequency of use of personal care products and urinary TCS concentration, we found that the frequency of use of hair care products, body cleansers, and cosmetics were consistently related to urinary TCS concentration in both men and women. In the upper 75th percentile of urinary TCS concentration, the proportion of more frequent products use was higher than among participants with rarely products use and ORs were higher in participants who used these products more often. Similar results were found in a study of breastfeeding mothers in Sweden. Mothers who used personal care products containing TCS showed significantly higher breast milk and plasma TCS concentrations than those who did not use these products [8]. In addition, men showed higher ORs than women. Men tend to use less personal care products compared to women, which may be the cause of the larger differences between used and unused groups. These results suggest that personal care products are a major source of TCS exposure.

As a result of analyzing a list of the raw materials of cosmetics reported to the Korea Food & Drug Administration (KFDA) by domestic manufacturers in 2015, 127 of the 100,190 (0.13%) cosmetics products manufactured in Korea were found to have used TCS [24]. It has been found that TCS is mainly used in products that are rinsed off after use, such as body cleansers and foam cleansers [24]. According to US data in 2010, 28 of 3359 eye make-up products, 10 of 4345 facial make-up products, 226 of 3070 body cleansing products, 3 of 5242

| Table 3 | Odds ratios (OR) and 95% confidence intervals (CI) relating personal care products usage of high urinary concentration of triclosan (male: ≥ 1.096 μg/g creatinine, female: ≥1.329 μg/g creatinine) compared to low urinary concentration of triclosan |
|---------|----------------------------------------------------------|
| Category | Male | | | Female | | | |
| | Unadjusted | Multivariate adjusted model | | | Unadjusted | Multivariate adjusted model | | |
| | | | | | | | | |
| Fragrance products | | | | | | | |
| Rarely | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| < Once a week | 1.55 (1.04–2.29) | 1.39 (0.93–2.07) | 1.51 (1.15–1.97) | 1.27 (0.97–1.67) | |
| ≥ Once a week | 1.84 (1.43–2.38) | 1.52 (1.16–1.98) | 1.33 (1.09–1.63) | 1.05 (0.84–1.30) | |
| Hair care products | | | | | | | |
| Rarely | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| < Once a week | 1.39 (1.03–1.86) | 1.39 (1.03–1.87) | 1.08 (0.86–1.36) | 1.21 (0.96–1.54) | |
| ≥ Once a week | 1.75 (1.41–2.17) | 1.50 (1.19–1.87) | 1.19 (1.01–1.41) | 1.20 (1.01–1.42) | |
| Body cleansers | | | | | | | |
| Rarely | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| < Once a week | 1.45 (0.76–2.78) | 1.20 (0.62–2.32) | 1.33 (0.73–2.41) | 1.20 (0.66–2.20) | |
| ≥ Once a week | 1.95 (1.61–2.34) | 1.67 (1.33–2.08) | 1.66 (1.39–1.99) | 1.28 (1.04–1.58) | |
| Cosmetics | | | | | | | |
| Rarely | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| < Once a week | 1.43 (0.88–2.31) | 1.21 (0.74–1.98) | 1.12 (0.74–1.70) | 1.04 (0.68–1.58) | |
| ≥ Once a week | 1.84 (1.39–2.45) | 1.60 (1.19–2.15) | 1.63 (1.33–1.99) | 1.33 (1.08–1.65) | |
| Nail care products | | | | | | | |
| Rarely | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| < Once a week | 0.99 (0.20–4.93) | 1.06 (0.21–5.30) | 1.40 (1.16–1.69) | 1.26 (1.04–1.53) | |
| ≥ Once a week | – | – | 1.27 (0.97–1.67) | 1.13 (0.85–1.50) | |
| Antimicrobial agents | | | | | | | |
| Rarely | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| < Once a week | 1.58 (0.91–2.77) | 1.43 (0.81–2.52) | 1.17 (0.81–1.68) | 0.98 (0.67–1.42) | |
| ≥ Once a week | 1.47 (1.14–1.90) | 1.27 (0.98–1.65) | 1.37 (1.12–1.69) | 1.17 (0.95–1.44) | |
| Air fresheners | | | | | | | |
| Rarely | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | |
| < Once a week | 0.85 (0.49–1.50) | 0.82 (0.47–1.46) | 1.25 (0.87–1.79) | 1.20 (0.84–1.72) | |
| ≥ Once a week | 1.10 (0.89–1.35) | 0.96 (0.78–1.20) | 1.17 (0.98–1.41) | 1.03 (0.85–1.24) | |

Multivariate adjusted model: adjusted with age, BMI, education, marital status, household income, alcohol intake, exercise, and smoking
Infants and young children are highly susceptible to toxic substances as they have rapid rates of body organ development and their processes of detoxification of toxic substances are less developed [27]. Therefore, additional research is needed to determine whether current levels of regulation are appropriate for these susceptible populations.

The limitations of this study are as follows. First, we did not identify the usage amount of personal care products, only the frequency of use. Second, we did not consider the simultaneous use of other personal care products, use of other personal care products not included in the survey, and other TCS exposure factors apart from personal care products. Third, in about 60% of participants, urinary TCS concentration was measured below the detection limit. However, it did not affect the statistical analysis of this study. Fourth, the health effects of increased urinary TCS concentration were not analyzed. Despite these limitations, this study suggested the exposure level of TCS and the relationship with use of personal care products, which are major exposure sources of TCS using a representative data in Korean population.

Regulation of TCS was initiated in Korea in 2015 and it is expected that the effect of reduction of TCS exposure by the regulation will be confirmed through the analysis of third KoNEHS data, which was conducted in 2015–2017 and not publically released yet. Furthermore, children over three years old were included in the study population in the third KoNEHS, therefore, the TCS exposure level and health effects could be studied in the susceptible population. Based on future studies, it could confirm the effect of the regulation and suggest another more powerful policy to minimize TCS exposure in Korean population.

**Conclusion**

This study found out the association of the use of personal care products and the concentration of urinary TCS in general population in Korea. According to this study, the levels of urinary TCS were higher in female, younger people, and higher-income people. Because TCS is a well-known endocrine disruptor and several health problems related with exposure to TCS have suggested, further studies are needed to monitor the trend of urinary TCS level and explore other health effects with exposure to TCS in general population in Korea using a representative data for general population.

**Additional file**

**Additional file 1**: Medians (interquartile range) of Urinary TCS concentration according to age. The urinary TCS concentration tended to decrease as age increased. (XLSX 11 kb)
Abbreviations
BMI: Body mass index; CI: Confidence interval; KoNEHS: Korean National Environmental Health Survey; OR: Odds ratio; TCS: Triclosan

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Availability of data and materials
The data of the KoNEHS is opened to the public, therefore, any researcher can be obtained after request from the website http://metanarastat.kr/metasvc/SvcMetaDocDtaPopup.do?confmNo=106027&inputYear=2012.

Authors’ contributions
MP designed this study and wrote a draft of this manuscript. SK, YK, and DJN analyzed the data. JR provided technical support. SL performed critical revision of the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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