ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

DETERMINING EXPOSURE FACTORS OF NON-HUMAN HYGIENE DISINFECTANTS TO ESTIMATE CONSUMER EXPOSURE

J-H. Kim*[1], D-G. Ha[2,3] & M-Y. Hwang[1]

[1]Division of Chemical Research, National Institute of Environmental Research, Hwangyeong-ro 42, Seo-gu, Incheon, 22689, South Korea

[2]K-STAT Research, Banpodaero 24-gil 76, Seocho-gu, Seoul, 06650, South Korea

[3]Graduate School of Governance, Sungkyunkwan University, Sungkyunkwanro 25-2, Jongno-gu, Seoul, 03063, South Korea

ABSTRACT

In order to assess the exposure and health risks associated with the use of non-human hygiene disinfectants, we investigated the valuable exposure pattern of public consumers and the exposure amount to non-human hygiene disinfectants based on household use. The first step was to characterize the range of disinfectant products and their major ingredients currently available in retail markets. Next, an extensive online survey across all cities and provinces in Korea was carried out and 5001 participants completed the web-based questionnaires. Furthermore, laboratory evaluations were conducted to measure the actual level of exposure (g/use).This database presents the usage characteristics for each disinfectant, which includes its use frequency, per application duration, and per application quantity divided by application types as useful exposure factors.

Among the application types, liquid type was used more frequently than products in other types. We focused more on inhalation exposure from products (and/or their application types such as aerosol spray, trigger spray types) that affect indoor air. This study provides valuable information on the individual exposure factors and the inhalation exposure database that may be useful to conduct exposure assessments and to manage household non-human hygiene disinfectants.

KEYWORDS: Non-human Hygiene Disinfectants, Use Frequency, Application Duration, Application Quantity.

1. INTRODUCTION

Disinfectant products, belong to the 'biocides' category, are used to control or to prevent growth of micro-organisms i.e. bacteria, virus, yeast, and fungi. There is a great diversity in use and application types (formulations) for the products, which are used both by professionals and non-professionals (public consumers). Some of the disinfectants are available to consumers for private use; other products are only available for professional use. The categories of disinfectant products could be divided as human hygiene (directly applied to human) and non-human hygiene disinfectants. There are liquid types, spray types, granulates, powders, tablets, gel types, gasses and others. All of these product forms imply a different type of exposure, whereby differences can occur in the exposure phase (mixing and loading, during or after exposure) and the rout of exposure (inhalation, dermal, and oral)[1].The consumers or non-professional only users are not aimed at exposure for people who professionally work with disinfectants. The pattern of use by consumers is very diverse and the products are often used in and around the house, whereby exposure can still take place long after application. Private consumers generally use the large number of consumer disinfectant products currently in Korea. The disinfection could be defined to high-level disinfection, intermediate disinfection, and low-level disinfection according to the activity of a disinfectant process. High-level disinfection can be expected to destroy all microorganisms, with the exception of large numbers of bacteria spores. Intermediate disinfection inactivates Mycobacterium tuberculosis, vegetative bacteria, most viruses, and most fungi, and does not necessarily kill bacteria spores. Low-level disinfection can kill most bacteria, some viruses, and some fungi, and cannot be relied on to kill resistant microorganisms such as tubercle bacilli or bacterial spores [2].According to users of disinfectants, the differences in products and products use between the consumer and those using disinfectant products professionally must be taken into account. This study described only exposure for users using household non-human hygiene disinfectant products which are available to the consumers for private use. Household disinfectant use is widespread in Korea. Inhalation of aerosolized water to indoor air that contained biocides from a humidifier led to serious lung injuries in Korea[3-4].The Ministry of Environment (KMOE) enacted 'The Korean Biocidal Products Regulation (KBPR)' that concerns the placing on the market and use of biocidal products, which are used to protect humans, materials or articles against harmful organisms, by the action of the active substances contained in the biocidal product. According this regulation, all biocidal products should undergo exposure and risk assessments to evaluate health and environmental hazards caused by their use.

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

In case of disinfectant products, KMOE are regulating the non-human hygiene disinfectants and the Korean Food and Drug administration (KFDA) are regulating the human-hygiene disinfectants. Prior research has documented that within-home exposures are generally major contributors to personal exposures because of the greater time spent in the home [5]. The exposure assessment is the component of a risk assessment of hazardous substances. The disinfectant products of exposure are estimates of exposure of defined subjects to each substance by periods and exposure pathway [6-7]. In order to carry out exposure assessments for household use of disinfectant products, information on exposure factors (e.g., the frequency of use, the exposure time, andthe amount exposed per application) are necessary [8].

The purpose of this study was to develop a representative database on exposure factors for non-human hygiene disinfectant products by non-professional use. These exposure information data determined in this study will be useful in establishing improved safety guidelines for disinfectant products, conducting accurate assessments of consumer exposure and better assessing risk to human health.

2. MATERIALS AND METHODS

2.1 Non-human hygiene disinfectant products survey

In order to identify and characterize the range of non-human hygiene disinfectant products currently available in retail markets, a private survey company (Kstat Research Ltd.)conducted an extensive online non-human hygiene disinfectant products survey. The searching was divided into 4 main categories, such as 1) products in market, 2) purpose of products, 3) their application types such as trigger spray type, trigger foam type, aerosol spray type, and several other types, and 4) used active ingredients (the labeling of products. The active ingredients in non-human hygiene disinfectant products are generally listed with all other ingredients on the product label to ensure appropriate product use by consumers.

2.2 Disinfectants household usage

Survey company conducted an extensive online survey across all cities and provinces in Korea regarding household non-human hygiene disinfectant usage. The survey company had participant panel pool in all provinces and 15 metropolitan areas. To achieve our target of statistically significant 5001 survey respondents considering the demographic characteristics, an initial e-mail was sent to approximately 60000 to 75000 public panel members, 12 times ~ 15 times participants of 5001purpose cases. If an e-mail recipient agreed to participate in the survey and had experience using at least one of the identified household insecticide products, they were sent a web link directing them to the online survey questionnaire. Until the 5001 cases purpose number of respondents was obtained, ‘agree to take part in survey study’ was continued. A total of 5001 households completed the survey questionnaire. Additionally, sex balanced respondents with an equal distribution of age groups were selected using quota sampling methods. The survey questionnaire forms were designed to collect data for human exposure assessment study of active biocidal ingredients exposed through non-human hygiene disinfectant products used by consumer. The questionnaires consisted of purchasing/using information of disinfectants as follows: list of disinfectant products used at home and the frequency of use, estimation of quantitative exposed duration to disinfectant products, quantitative amount of disinfectant products used, and demographic data. All statistical analyses were conducted using SPSS version 22.0. Differences with a P value of less than 0.05 were considered to be statistically significant unless noted otherwise. As a statistical analysis method to verify the difference between survey data, one-way AVOVA was carried out.

2.3 Disinfectants exposure analysis

In order to quantify potential exposure to household non-human hygiene disinfectants, survey respondents were asked to report their frequency of use and their duration of use by products and application type. According to the characteristics of non-human hygiene disinfectants, different question forms were used about the frequency of use (use frequency per period) and the duration of use (use times divided by application types). Furthermore, the survey questionnaire included questions on the amount of each disinfectant product that was used, and different questions were given for the specific application types. For the trigger spray and the trigger foam types, the number of squeezes (triggering task) per application was determined; for aerosol spray and aerosol spray foam types, the spraying time (time for which the button on the product is pressed) per application was noted. For liquids, the amount of product used was estimated based on a common 50mL liquor glass [9] and for wipe

ISSN: 2394-7659
IMPACT FACTOR- 3.775

International Journal of Engineering Researches and Management Studies

type tissues, the number of sheets used per application was determined. For solid and powder types, the amount of product used was estimated based on the number of tea-spoon.

2.4. Disinfectants respiratory exposure time

We investigated the respiratory exposure time spent applying the inhalable application types of disinfectant products. The inhalable application types were defined as trigger spray type, trigger foam type, aerosol spray type, and aerosol spray foam type. In case of trigger and aerosol spray types products, users could be exposed to the maximum amount of product while operating the trigger action and pressing the button (on the aerosol spray products); furthermore, the users could face continuous exposure to the product used while performing the tasks that it is used for. We investigated the time spent operating the trigger (number of triggering action per use) in the trigger spray type products and the time spent pressing the button on the aerosol spray type products (sec/use). In order to calculate the total time of spraying during triggering action, we purchased the studied trigger spray type disinfectant products and measured the time taken for the triggering action. We compared the difference in the weight of the trigger spray type disinfectant products before and after use at room temperature. In case of aerosol spray type disinfectant products, generated mass (g/sec) was calculated.

2.5. Disinfectants exposure amounts

In order to calculate the actual exposure amount of respondents to disinfectant products per use, we purchased various retail disinfectants with different application types. Experiments were conducted to estimate an accurate amount of use per application. For trigger and aerosol spray type disinfectants, we measured the time spent operating the trigger and the time spent pressing the button on the aerosol spray product. Additionally, the exposure amount of trigger and aerosol spray disinfectants to users was also calculated as the generated mass (g/s). The generated mass (g/s)or the amounts of products used (g/use) were measured by weighing used amounts. To calculate the exposure amount of trigger and aerosol spray disinfectant products, the following simple equation was used:

Used and exposed amount of trigger spray type products (g/use) = [numbers of triggering action (time/use)] × [generated mass (g/one triggering action)]

Used and exposed amount of aerosol spray type products (g/use) = [time of pressing button (sec/use)] × [generated mass (g/sec)]

Used and exposed amount of other type products (g/use) = [weight of products before use (g/use)] − [weight of products after use (g/use)]

We used a report from the Netherland' National Institute for Public Health and the Environment (RIVM) to estimate the mass generated with spray products (trigger and aerosol types). In the report, the mass generation rate was determined by squeezing the product trigger 10 times for about 6 seconds (trigger type) or spraying the product for 10 seconds (aerosol spray type); the weight of the product was measured before and after use [10].

3. RESULTS

3.1. Household non-human hygiene disinfectants characteristics

A market survey was conducted to the retail non-human hygiene disinfectant products were common in the Korean market. In this study, we considered mainly consumer exposure by using non-professional disinfectant products. Based on the results, we created categories divided by intended use (i.e., the purpose of product) e.g., disinfectant for kitchen, bathroom, fungi in bathroom, and indoor-air. These products were also divided to groups by application type, including trigger sprays type and aerosol spraystype; liquids; powders, gels, fumigation, and others. In case of inhalable application types of products, there were trigger spray (and foam) type, aerosol spray (and foam) type, fumigation type, device type (spraying mist to air). In other application types, there were liquid type, powder type, gel type, foam making powder type, stationery type, tissue type, and device type (**Table 1**).In total, 668 disinfectant products were searched. The most popular application types were liquid and trigger spray type.All of these application types imply a different type of exposure (mixing, making mist, loading, during or after exposure) and the different routes of exposure (inhalation and dermal).

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

Table 1Non-human hygiene disinfectants characteristics in retail market

Uses and purpose by non-professional users
Disinfectants for kitchen (including disinfection for kitchen utensils) Disinfectants for bathroom Disinfectants & removers for fungi in bathroom Disinfectants for drainage at home Disinfectant for toilet & toilet seat Disinfectants for air-conditioner(Use at home/Use in vehicle) Disinfectants for children's goods Disinfectants for companion animals Other multi-purpose disinfectants Disinfectants for air
Formulation variables: - Formulation ofspraying mist: Trigger spray type, Trigger foam type, Aerosol spra y type, Aerosol spray foam type, Fumigation type, Device type(spraying mist to a ir) => more high respiratory exposure potential - Non-spraying formulation: Liquid type, Powder type, Gel type, Tissue type, Soli d type

3.2. Active ingredients

The online product survey identified a variety of active ingredients used in retail disinfectant products. Disinfectants are based on a variety of active ingredients e.g., aldehydes, quaternary ammonium compounds, oxygen releasers, alkylamine, or alcohols. **Table 2** showed the list of active ingredients intentionally used in non-professional disinfectant products. The list contains a wide range of chemicals, from simple inorganic molecules to relatively complicated molecules (e.g. polymerized quaternary ammonium compounds). Prevalently used ingredients in disinfectant products were benzalkonium chloride, C12-C14-alkyl(ethylbenzyl) dimethylammonium chloride, ethyl alcohol, sodium hypochlorite, and sodium hydrogen carbonate (>10%, frequency of ingredients used in 668 disinfectant products).These results addressed that the household exposure of disinfectant products can present the exposure of biocidal active ingredients to product users. The biocidal active ingredients used in disinfects can have potent biological and toxicological activity. The biological and toxicological properties of these ingredients are important for the health effect to insecticide users [11].

Table 2 List of active ingredients intentionally used in non-professional disinfectants

Active ingredients in non-professional & consumer disinfectant products	CAS No.	Active ingredients in non-professional & consumer disinfectant products	CAS No.
Adipic acid	124-04-9	Isopropyl alcohol	67-63-0
Alcohols, C12-C15, ethoxylate	68131-39-5	Imidazolidinyl urea	39236-46-9
C12-C14-Alkyl(ethylbenzyl) dimethylammonium chloride	85409-23-0	4-Isopropyl-3-methylphenol	67-71-0
Amine oxide	1643-20-5	Malic acid	617-48-1
C12-18-Alkyldimethylbenzyl ammonium chloride	68391-01-5	D-Malitol	585-88-6
Benzalkonium chloride	68424-85-1	Methyl sulfonyl methane	67-71-0
Benzethonium chloride	121-54-0	4,4'-methylenebis(N-sec-butylcyclohexamine)	154279-60-4
Bentonite	1302-78-9	Octyldecyldimethylammonium chloride	32426-11-2
Butylene glycol	107-88-0	Potassium hydroxide	154279-60-4
Calcium hypochlorite	7778-54-3	Peroxyacetic acid	79-21-0
Cresol (mixture of isomer)	1319-77-3	Permethrin	52645-53-

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

			1
Chloroxylenol	1321-23-9	Propylene glycol	1310-58-3
Chlorhexidinegluconate solution	55-56-1	Potassium cocoate	61789-30-8
Copper sulfate	7758-98-7	2-Phenoxyethanol	57-55-6
Cetylpyridinium chloride	6004-24-6	Sodium hypochlorite	7681-52-9
4-Chloro-3,5-dimethylphenol	88-04-0	Sodium hydrogen carbonate	70693-62-8
Dodecyl dimethyl ammonium chloride	7173-51-5	Sodium dichloroisocyanurate	2893-78-9
Dichloro-m-xylenol	133-53-9	Sodium gluconate	7758-19-2
Di-octyl dimethyl ammonium chloride	5538-94-3	Sodium xylene sulfonate	1310-73-2
Dimethyl(pentadecyl)amine oxide	68955-55-5	Sodium carbonate peroxyhydrate	497-19-8
Ethyl alcohol	64-17-5	Sorbitan fatty acid ester	1300-72-7
Ethylenediaminetetraacetic acid	60-00-4	Sodium hydroxyl acetate	15630-89-4
2-Ethyl-1,3-hexanediol	94-96-2	Sodium cilicate	527-07-1
Glutaraldehyde	111-30-8	Sodium bromide	68154-33-6
Hydrogen peroxide	7722-84-1	Trichloroisocyanuric acid	87-90-1
		Triethanolamine	102-71-6

3.3. Survey study of retail non-human hygiene disinfectants

Online-survey approach investigated the available data for the exposure assessment of consumers. The summary of questionnaire for online-survey was shown in **Table 3**.The survey yielded information associated with the general demographics of the respondents and was completed by 5001 respondents. Among respondents, female respondents participated more in survey than male respondents. There were more respondents in their 30s and 40s than those in other ages (**Table 4**).

Table 3 Questionnaire for survey

Categories	Questions
Demographic information	Living city or region, respondents' age (birth year) and gender, number of people living in the household and their age, number of children living in the household and their age, occupation, respondents' education level, type of dwelling and number of rooms in the house, total size of house, average staying duration of family members in the house.
Products examples (application types)	Trigger spray type / Trigger foam type / Aerosol spray type / Aerosol spray foam type / Fumigation type / Liquid type / Powder type / Gel type / Foam-making powder type / Tissue type / Solid type
	
Frequency of use	How often did you use studied products?
	Period
	①1 day②1 week③1 month ④6months ⑤1 year
Duration of use	Time from the beginning to end of the products use including task time
	Application types / T
	~ type / (
Amount of use	Non-spraying type: - Amount of use per product application
	application types / factors

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

	(single use), if it was measured using a 50 ml glass cup - How many pieces were used per product application (tissue type) Spraying type: - Number of triggering/squeezing (trigger type) ->Amount of spent use during the number of triggering/squeezing (laboratory evaluation) - The time of pressing button on the aerosol spray products (aerosol spray type) ->Amount of spent use during the time of pressing button on the aerosol spray products (laboratory evaluation)	①aerosol spray type ②trigger spray type	mean ( ) spray per second mean ( ) times

Table 4 Demographics of the surveyed population

Distribution of respondents	No. of respondents		
	Total	Male (M)	Female (F)
Total respondents	5001	2403	2598
19 – 29 y	972	283	689
30s of age	1899	795	1104
40s of age	1411	843	568
50s + of age	719	482	237

3.4.Household non-human hygiene disinfectants use frequency

Table 5 summaries the mean, standard deviation (s.d.) and 50percentile–95percentile product use frequency values for each of the application type products considered. The use frequency of disinfectant products was defined as the numbers of use by users who reported using the disinfectant products in the last two years. Disinfectant products for children's good and companion animal were used more than once a week by respondents and disinfectant products for kitchen, bathroom, fungi in bathroom, toilet, and multi-purpose were used more than once a month. Among disinfectants for kitchen, liquid type products had the higher use frequency than the other application type products. The use frequency of aerosol spray foam type products for bathroom was comparatively higher than the other application type products. For multi-purpose disinfectants, tissue type products were used more than twelve a month, with a mean use frequency of 12.8 times per month.

Table 5 Household use frequency of disinfectants

Disinfectants and application types		Frequency of use (use/week [a], use/month[b], use/year [c])					
		Mean	S.D.	50th	75th	85th	95th
Disinfectants for kitchen	Trigger spray/ Trigger foam	6.6 [b]	16.0 [b]	4.0 [b]	8.0 [b]	12.0 [b]	20.0 [b]
	Liquid	9.4 [b]	17.4 [b]	4.0 [b]	10.0 [b]	20.0 [b]	30.4 [b]
	Powder	5.6 [b]	11.0 [b]	3.3 [b]	8.0 [b]	12.0 [b]	20.0 [b]
Disinfectants for bathroom	Trigger spray	3.8 [b]	14.2 [b]	2.0 [b]	4.0 [b]	4.0 [b]	12.0 [b]
	Trigger foam	3.4 [b]	6.1 [b]	2.0 [b]	4.0 [b]	4.0 [b]	10.0 [b]
	Aerosol spray foam	6.4 [b]	29.1 [b]	2.0 [b]	4.0 [b]	8.0 [b]	12.0 [b]
	Liquid	3.8 [b]	14.2 [b]	2.0 [b]	4.0 [b]	4.0 [b]	12.0 [b]
	Powder	3.4 [b]	5.9 [b]	1.6 [b]	4.0 [b]	4.0 [b]	12.0 [b]
Disinfectants & removers for fungi in bathroom	Trigger spray	2.8 [b]	5.4 [b]	1.0 [b]	4.0 [b]	4.0 [b]	10.0 [b]
	Trigger foam	2.6 [b]	4.2 [b]	1.0 [b]	4.0 [b]	4.0 [b]	8.0 [b]
	Aerosol spray foam	3.2 [b]	4.7 [b]	2.0 [b]	4.0 [b]	5.0 [b]	12.0 [b]
	Liquid	2.9 [b]	4.1 [b]	1.0 [b]	4.0 [b]	4.0 [b]	12.0 [b]
	Gel	1.9 [b]	4.4 [b]	1.0 [b]	2.0 [b]	4.0 [b]	7.0 [b]
Disinfectants for drainage at home	Trigger spray/ Trigger foam	36.0 [c]	55.9 [c]	24.0 [c]	48.0 [c]	60.0 [c]	120.0 [c]
	Liquid	22.1 [c]	109.5 [c]	12.0 [c]	24.0 [c]	36.0 [c]	60.0 [c]

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

		Foam making powder	20.6 [c]	36.3 [c]	12.0 [c]	24.0 [c]	36.0 [c]	72.0 [c]
Disinfectant for toilet & toilet seat		Trigger spray/ Trigger foam	4.0 [b]	7.4 [b]	2.5 [b]	4.0 [b]	8.0 [b]	12.0 [b]
		Liquid	3.5 [b]	5.7 [b]	2.0 [b]	4.0 [b]	4.1 [b]	12.0 [b]
		Gel	7.2 [b]	69.2 [b]	2.0 [b]	4.0 [b]	5.0 [b]	12.0 [b]
		Foam making powder	3.6 [b]	10.6 [b]	1.0 [b]	3.0 [b]	4.0 [b]	12.0 [b]
Disinfectants for air-conditioner	Use in home	Trigger spray	31.4 [c]	82.2 [c]	12.0 [c]	25.0 [c]	50.0 [c]	120.0 [c]
		Aerosol spray	20.0 [c]	57.3 [c]	6.0 [c]	24.0 [c]	36.0 [c]	60.0 [c]
	Use in vehicle	Trigger spray	24.0 [c]	45.1 [c]	12.0 [c]	24.0 [c]	48.0 [c]	120.0 [c]
		Aerosol spray	19.5 [c]	41.5 [c]	4.0 [c]	24.0 [c]	36.0 [c]	72.0 [c]
		Fumigation	9.2 [c]	31.7 [c]	2.0 [c]	5.0 [c]	12.0 [c]	26.0 [c]
Disinfectants for children's goods		Trigger spray	4.7 [a]	7.1 [a]	2.0 [a]	5.0 [a]	8.0 [a]	20.0 [a]
		Tissue	12.9 [a]	38.6 [a]	5.0 [a]	12.0 [a]	20.0 [a]	40.0 [a]
Disinfectants for companion animals		Trigger spray	8.0 [a]	21.6 [a]	3.0 [a]	7.0 [a]	14.0 [a]	30.0 [a]
		Aerosol spray	5.4 [a]	7.6 [a]	2.0 [a]	7.0 [a]	14.0 [a]	21.0 [a]
		Liquid	7.2 [a]	19.9 [a]	2.0 [a]	7.0 [a]	7.0 [a]	35.0 [a]
		Tissue	10.7 [a]	17.9 [a]	5.0 [a]	14.0 [a]	21.0 [a]	35.0 [a]
Other multi-purpose disinfectants		Trigger spray	6.1 [b]	9.7 [b]	4.0 [b]	8.0 [b]	12.0 [b]	20.0 [b]
		Trigger foam	6.1 [b]	9.7 [b]	4.0 [b]	8.0 [b]	12.0 [b]	20.0 [b]
		Liquid	4.2 [b]	8.2 [b]	2.0 [b]	4.0 [b]	8.0 [b]	12.0 [b]
		Tissue	12.8 [b]	38.9 [b]	4.0 [b]	12.0 [b]	20.0 [b]	32.0 [b]

[a]No. of use per week; [b] No. of use per month; [c] No. of use per year

3.5. Household non-human hygiene disinfectants use duration

In order to investigate the time spent applying the disinfectant products, respondents were asked how long they took to use the product, from the beginning to end, in one application. We estimated that the total exposure time for which users are exposed to disinfectant products is the duration in the place where the product was used, once it had been applied. The time spent to use disinfectant products was estimated as the time taken for a series of tasks involving the use of each product. In case of disinfectants for kitchen, the mean spraying time taken per use for trigger spray types was 11.2 min and for liquid type was 16.6 min. For trigger spray type of disinfectants/removers for fungi in bathroom, the mean time taken per use was 58.0 min. **Table 6** shows the exposure durations for the disinfectant products based on application per single use.

Table 6 Indoor use duration (including task time) of disinfectants

Disinfectants and application types		Duration of indoor use (min/use)					
		Mean	S.D.	50th	75th	85th	95th
Disinfectants for kitchen	Trigger spray/Trigger foam	11.2	21.1	5.0	10.1	20.2	30.0
	Liquid	16.6	33.5	10.0	20.0	30.0	60.0
	Powder	17.8	36.9	10.0	25.0	30.0	60.0
Disinfectants for bathroom	Trigger spray	15.4	21.8	10.0	20.0	30.0	60.0
	Trigger foam	21.6	51.4	10.0	30.0	30.0	60.0
	Aerosol spray foam	13.5	18.6	8.7	20.0	30.0	50.0
	Liquid	21.9	32.0	10.0	30.0	30.0	60.0
	Powder	23.9	32.4	15.0	30.0	30.0	60.0
Disinfectants & removers for fungi in bathroom	Trigger spray	58.0	124.0	30.0	60.0	90.0	240.0
	Trigger foam	63.6	144.8	30.0	60.0	90.0	190.1
	Aerosol spray foam	45.8	125.6	15.0	50.0	60.0	150.5
	Liquid	91.4	210.4	30.0	60.0	120.0	360.0
	Gel	128.2	231.1	60.0	120.0	240.0	600.0
Disinfectants for drainage at home	Trigger spray/Trigger foam	57.8	136.5	20.0	60.0	61.0	180.0
	Liquid	111.9	199.6	30.0	120.0	240.0	480.0
	Foam making powder	89.9	148.1	30.3	100.0	180.0	360.0
Disinfectant for toilet & toilet seat	Trigger spray/Trigger foam	40.4	90.9	20.0	40.0	60.0	120.0
	Liquid	53.1	123.6	20.0	60.0	61.0	190.0
	Gel	88.3	233.7	20.0	60.0	120.0	366.1

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

		Foam making powder	137.1	324.6	20.0	60.0	180.0	1200
Disinfectants for air-conditioner	Use in home	Trigger spray	63.8	126.4	30.0	60.0	120.0	180.0
		Aerosol spray	62.4	133.9	30.0	60.0	100.0	180.0
	Use in vehicle	Trigger spray	55.5	85.5	25.0	60.0	120.0	210.3
		Aerosol spray	53.8	130.9	15.0	60.0	61.0	183.0
		Fumigation	90.1	202.7	30.0	60.0	120.0	360.0
Disinfectants for children's goods		Trigger spray	45.0	84.4	20.0	60.0	70.0	180.0
		Tissue	30.7	94.7	5.0	30.0	60.0	120.0
Disinfectants for companion animals		Trigger spray	50.6	163.8	5.0	60.0	61.0	180.0
		Aerosol spray	63.4	173.7	10.0	60.0	90.0	295.0
		Liquid	74.7	161.7	44.9	62.0	120.0	300.0
		Tissue	42.3	135.4	5.0	20.0	60.0	150.0
Other multi-purpose disinfectants		Trigger spray	43.2	108.6	12.7	60.0	60.0	150.0
		Trigger foam	43.2	108.6	12.7	60.0	60.0	150.0
		Liquid	60.6	137.2	30.0	60.0	90.0	230.7
		Tissue	26.9	85.4	10.0	20.0	30.0	70.0

3.6. Household non-human hygiene disinfectants respiratory exposure time

Table 7summarizesthe exposure time of inhalable application type disinfectant products. Inhalation exposure is generally derived from airborne concentrations in breathing zone [12]. Trigger spray type, trigger foam type, aerosol spray type, and aerosol spray foam type were defined as the inhalable application types. The exposure time were calculated as the number of triggering actions, the total time of trigger spray type products during triggering action and the time of pressing button of aerosol spray type products reported by respondents. The exact exposure amount could be derived (calculated) from the exact exposure time of products.

Table 7 Exposure time of inhalable spraying types of disinfectants

Disinfectants and application types				Exposure time of spraying type disinfectants (No. of triggering action/use [a], sec/use [b, c], g/sec [d])					
				Mean	S.D.	50th	75th	85th	95th
Disinfectants for kitchen		Trigger spray/ Trigger foam	Triggering [a]	7.1	8.2	5.00	10.0	10.0	20.0
			Spraying [b]	2.9	3.4	2.0	4.1	4.1	8.3
Disinfectants for bathroom		Trigger spray	Triggering [a]	10.2	11.9	5.0	10.0	20.0	30.0
			Spraying [b]	4.3	5.0	2.1	4.2	8.4	12.6
		Trigger foam	Triggering [a]	10.3	11.9	5.0	10.0	20.0	30.0
			Spraying [b]	4.5	5.2	2.1	4.3	8.7	13.1
		Aerosol spray foam	Pressing [c]	19.8	52.7	5.0	20.0	30.0	60.0
			Mass [d]	3.5	0.8	3.0	4.5	4.5	4.7
Disinfectants & removers for fungi in bathroom		Trigger spray	Triggering [a]	10.9	14.5	5.0	10.0	20.0	30.0
			Spraying [b]	4.6	6.2	2.1	4.2	8.5	12.8
		Trigger foam	Triggering [a]	11.9	15.6	7.0	15.0	20.0	30.0
			Spraying [b]	5.0	6.6	2.9	6.3	8.4	12.7
		Aerosol spray foam	Pressing [c]	20.1	43.4	10.0	20.0	30.0	60.0
			Mass [d]	3.1	0.1	3.1	3.3	3.3	3.3
Disinfectants for drainage at home		Trigger spray/ Trigger foam	Triggering [a]	7.6	8.6	5.0	10.0	10.0	20.0
			Spraying [b]	3.0	3.4	1.9	3.9	3.9	7.9
Disinfectant for toilet & toilet seat		Trigger spray/ Trigger foam	Triggering [a]	7.5	8.0	5.0	10.0	10.0	20.0
			Spraying [b]	3.5	3.7	2.3	4.7	4.7	9.4
Disinfectants for air-conditioner	Use in home	Trigger spray	Triggering [a]	6.6	8.3	5.0	8.0	10.0	20.0
			Spraying [b]	2.5	3.1	1.8	3.0	3.7	7.5
		Aerosol spray	Pressing [c]	24.7	50.3	10.0	30.0	30.0	60.0
			Mass [d]	4.4	1.8	4.3	5.7	6.0	6.5
	Use in	Trigger spray	Triggering [a]	8.0	14.2	5.0	7.0	10.0	30.0

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

	vehicle		Spraying [b]	3.4	6.0	2.1	2.9	4.2	12.7
		Aerosol spray	Pressing [c]	21.3	40.3	10.0	30.0	30.0	60.0
			Mass [d]	2.4	1.7	1.5	2.6	5.0	5.5
Disinfectants for children's goods		Trigger spray	Triggering [a]	5.9	10.8	3.0	5.0	10.0	20.0
			Spraying [b]	3.0	5.5	1.5	2.5	5.0	10.1
Disinfectants for companion animals		Trigger spray	Triggering [a]	4.0	3.2	3.0	5.0	5.0	10.0
			Spraying [b]	2.1	1.7	1.6	2.6	2.6	5.3
		Aerosol spray	Pressing [c]	11.3	13.8	5.0	15.0	25.0	30.0
			Mass [d]	0.7	0.6	0.3	1.2	1.5	1.7
Other multi-purpose disinfectants		Trigger spray/ Trigger foam	Triggering [a]	8.0	9.6	5.0	10.0	10.0	30.0
			Spraying [b]	3.5	4.2	2.2	4.4	4.4	13.2

[a]number of triggering action (triggers/use); [b] total time of spraying during triggering action (sec/use); [c] time of pressing button of aerosol spray type disinfectants (sec/use); [d] generated mass (g/sec).

3.7. Household non-human hygiene disinfectants use and exposure amounts

As a final task in the present study, we evaluated the exposure amounts of household disinfect products. **Table 8** shows used (exposed) amounts of disinfectant products divided by application (g/use). The used amounts per application differed among disinfectants products and their application types. Among application types of various disinfectants products, relatively high amounts of liquid type products were used by user. In case of disinfectants for air-conditioner, used amount of aerosol spray type products was relatively high. In this study, we could not measure these amounts and concentrations in indoor air. The mean used amount of trigger spray type of disinfectants for kitchen was determined to be 6.5 g/use (7.6 g/use–trigger foam type, 92.0 g/use–liquid type, 7.0g/use–powder type). The used amounts data of disinfectant products by respondents were investigated to the mean, standard deviation, and the percentile ranges of use frequency (50percentile–95percentile). The exposure amount information used by respondents might be helpful in carrying out the approach for exposure assessment to human risk by disinfectant products exposure.

Table 8 Used and exposed amount of disinfectants

Disinfectants and application types		Amount of exposure (g/use)					
		Mean	S.D.	50th	75th	85th	95th
Disinfectants for kitchen	Trigger spray (0.9 g/triggering)	6.5	7.5	4.5	9.1	9.1	18.2
	Trigger foam (1.1 g/triggering)	7.6	8.8	5.3	10.6	10.6	21.2
	Liquid	92.0	131.8	75.1	112.7	150.3	187.9
	Powder	7.0	11.2	3.6	9.0	9.0	18.1
Disinfectants for bathroom	Trigger spray (1.2 g/triggering)	11.9	13.8	5.7	11.5	23.1	34.7
	Trigger foam (0.9 g/triggering)	8.8	10.2	4.2	8.5	17.0	25.5
	Aerosol spray foam	71.4	189.4	17.9	71.8	107.8	215.6
	Liquid	110.9	105.9	71.2	142.5	142.5	356.3
	Powder	8.15	11.0	4.8	8.0	16.0	24.0
Disinfectants & removers for fungi in bathroom	Trigger spray (0.8 g/triggering)	8.8	11.7	4.0	8.0	16.1	24.2
	Trigger foam (1.0 g/triggering)	11.5	15.1	6.7	14.4	19.3	28.9
	Aerosol spray foam	64.2	138.4	31.8	63.7	95.6	191.2
	Liquid	181.6	1639	67.2	134.5	134.5	201.8
	Gel	21.8	50.7	21.8	43.7	87.4	153.0
Disinfectants for drainage at home	Trigger spray (0.9 g/triggering)	6.5	7.3	4.2	8.5	8.5	17.1
	Trigger foam (0.9 g/triggering)	7.1	7.9	4.6	9.2	9.2	18.5
	Liquid	237.0	361.3	135.6	271.3	407.0	678.4
	Foam making powder	89.9	148.1	30.3	100.0	180.0	360.0
Disinfectant for toilet & toilet seat	Trigger spray/Trigger foam (0.8 g/triggering)	6.4	6.9	4.3	8.6	8.6	17.2
	Liquid	141.5	1115	63.2	126.4	126.4	189.7
	Gel	15.7	151.2	31.5	63.0	78.7	189.0
	Foam making powder	50.5	10.8	50.7	60.4	60.4	60.5

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

Disinfectants for air-conditioner	Use in home	Trigger spray (0.6 g/triggering)	3.8	4.7	2.8	4.5	5.7	11.4
		Aerosol spray	110.8	225.6	44.8	134.5	134.5	269.0
	Use in vehicle	Trigger spray (1.3 g/triggering)	8.1	14.4	5.0	7.1	10.1	30.4
		Aerosol spray	52.3	98.8	24.4	73.4	73.4	146.9
		Fumigation	14.5	21.8	9.8	9.8	19.7	29.6
Disinfectants for children's goods		Trigger spray (1.2 g/triggering)	7.2	13.1	3.6	6.0	12.1	24.2
		Trigger foam (1.3 g/triggering)	7.8	14.2	3.9	6.5	13.0	26.1
		Tissue	10.4	14.7	6.1	9.2	15.3	30.6
Disinfectants for companion animals		Trigger spray (0.9 g/triggering)	3.6	3.0	2.7	4.5	4.5	9.1
		Aerosol spray	7.0	8.5	3.1	9.3	15.2	18.6
		Liquid	61.1	31.0	59.8	67.3	89.7	119.6
		Tissue	10.3	8.3	7.8	11.7	15.6	19.6
Other multi-purpose disinfectants		Trigger spray (0.3 g/triggering)	2.2	2.7	1.4	2.8	2.8	8.4
		Trigger foam (0.8 g/triggering)	6.7	8.0	4.2	8.4	8.4	25.2
		Liquid	93.5	102.5	65.9	131.8	131.8	164.8
		Tissue	10.5	11.0	9.2	12.2	15.3	30.6

4. DISCUSSION

In 2019, the Korean government (KMOE) adopted regulations to promote the safe use of a range of non-human hygiene disinfectant products, as these contained chemicals that could adverse health effects in humans [4].The present general population-based study demonstrated the household usage and exposure pattern of non-human hygiene disinfectant products that had a high potential for risk if exposed. Our present findings were based on a questionnaire survey and experimental measurement for an estimation of the exposure information of disinfectant products including biocidal active ingredients in an actual location. To understand the pattern of household product use by Korean consumers, this study investigated the frequency and exposure amount per use, including time exposed to products. Additionally, we accurately evaluated the exposure time and amount of product consumers were exposed to, considering the characteristics of each products and these application types in our analysis. The lack of reliable exposure database to disinfectant products was a major limitation of the risk assessment study [13]. Estimating human exposure to disinfectant products is a fundamental element of the risk assessment process that requires quantifying the levels to which users are exposed to disinfectant products. To quantify the user exposure, information of use pattern should be investigated. The essential information of use pattern required to derive exposure scenarios, which are then evaluated to derive quantitative exposure estimates. The pattern of use is not universe and thus likely to show considerable variability within countries based on regional and climatic differences. The specific pattern of use data requirements for different biocidal products are purpose of product (physical properties, where used, description of tasks), use environment (pattern of control, use pattern), loading phase (task, frequency per task, duration of task, quantity used per task), application phase, post-application phase, and others. The frequency and the duration of a task are major determinants influencing levels of exposure. The scenario consists of a series of tasks and actual exposure duration at home involved in the application of the product. Methods for data collection using web surveys have been well established. Online questionnaires have been demonstrated to be an inexpensive, convenient, and quick data collection method [14]. Considering these advantages, several researchers have used web surveys to collect data on exposure factors for consumer products [9,15-17]. In this study, we evaluated the exposure time and the amount for inhalable disinfectant products in terms of indoor air by considering the characteristics of the application type such as aerosol sprays and trigger sprays. The essential information of use pattern required to derive exposure scenarios, which are then evaluated to derive quantitative exposure estimates. The specific pattern of use data requirements for different biocidal products are purpose of product (physical properties, where used, description of tasks), use environment (pattern of control, use pattern), loading phase (task, frequency per task, duration of task, quantity used per task), application phase, post-application phase, and others. The frequency and the duration of a task are major determinants influencing levels of exposure[12].The actual concentrations of active biocidal ingredients in indoors air that come from disinfectant products should be analyzed according to the amount of ingredients emitted from the products [18]. An understanding of the actual amount of such ingredients present in indoor air, based on emission from the products studied, is needed to further evaluate and refine estimations of consumer exposure to disinfectant products.

ISSN: 2394-7659
IMPACT FACTOR- 3.775

IJERMS

International Journal of Engineering Researches and Management Studies

5. CONCLUSION

This study investigated a fundamental approach to assess human exposure to non-human hygiene disinfectant products used in daily life. The process of assessing exposure to household disinfectant products requires determining the patterns of use (exposure factors), identifying the exposure population (non-professional users), establishing exposure pathways (inhalation and dermal exposure), and quantifying potential product (or chemical) intake. This study determined the recent exposure factors using a web survey of over 5001 consumers in Korea. The result showed that the same product has different exposure factors depending on the method of application. Therefore, the type of application should be considered when exposure assessments are conducted. This comprehensive study suggests for how to conduct exposure assessments of disinfectant products in the Korean market. Additionally, advances in emission analysis of substances from household products will certainly improve the quality of exposure estimates in health risk assessments. Biocidal products such as non-human hygiene disinfectant products may be valuable part of biocidal regulation in Korea. This approach might be useful in establishing guidelines of exposure assessment for public users.

References

[1] National Institute of Public Health and the Environment (RIVM). Disinfectant products fact sheet to assess the risks for the consumer. 2006, RIVM report 320005003.
[2] Garner JS, Favero MS. Guideline for handwashing and hospital environmental control, 1985 supersedes guideline for hospital environmental control published in 1981. American J Infection Control 1986;14(3);110−126.
[3] Park DU, Leem JH, Lee KM, Lim HK, Choi YY, Ahn J-J, Lim SY, Park JI, Choi KH, Lee NR, Jung HJ, Ha JS, Paek DY. Exposure characteristics of familial cases of lung injury associated with the use of humidifier disinfectants. Environ HealthPerspect 2014;13;70−2.
[4] Lee JH, Kim YH, Kwon JH. Fetal misuse of humidifier disinfectants in Korea: importance of screening risk assessment and implications for management of chemicals in consumer products. Environ SciTechnol 2012;46;2498–2500.
[5] Sundell J. On the history of indoor air quality and health. Indoor air 2004;15;51−8.
[6] United States Environmental Protection Agency (EPA). Guidelines for Exposure assessment 1992;FedReg 57;22888−22938.
[7] United States Environmental Protection Agency (EPA). Framework for aggregate risk assessment 2003. Available at http://www.EPA.gov/risk/framwork-cumulative-risk-assessment [verified 22 January 2020].
[8] Van Engelen J, Heinemeyer G, Rodriguez C. Consumer exposure scenarios: development, challenges and possible solutions. J Expo Sc. Environ Epidemiol 2007;17;S26−S33.
[9] Park JY, Lee KY, Hwang Y, KimJH. Determining the exposure factors of personal and home care products for exposure assessment. Food ChemToxicol 2015;77;105−10.
[10] Delmaar J, Bremmer H. The ConsExpo spray model-Modelling and experimental validation of the inhalation exposure of consumers to aerosols from spray cans and trigger sprays 2010, RIVM report 320104005.
[11] World Health Organization (WHO). Safe and effective use of household insecticide products. Guide for the production of educational and training materials. World Health Organization Communicable Disease Prevention and Control WHO Pesticide Evaluation Scheme (WHOPES) 1999.
[12] European Chemicals Agency (ECHA). Guidance for human health risk assessment, 2013, In: volume III, part B, Chapter 3: Exposure assessment(Version 1.0).
[13] Chensheng L, Dianne EK, Jennifer FA, Richard AF. Biological monitoring survey of organophosphorus pesticide exposure among preschool children in the Seattle Metropolitan area. Environ Health Perspect 2001;109;299–303.
[14] Walker D-M. The internet as a medium for health services research. Part 2. Nurse researcher 2013;20;33−7.
[15] Ficheux A, Wesolek N, Chevillotte G, Roudot A. Consumption of cosmetic products by the French po pulation. First part: frequency data. Food ChemToxicol 2015;78;159−169.
[16] Ficheux A, Chevillotte G, Wesolek N, Morisset T, Dornic N, Bernard A, Bertho A, Romanet A, Leroy L, Mercat A. Consumption of cosmetic products by the French population second part: amount data. Food Chem Toxico 2016;90;130−141.

ISSN: 2394-7659
IMPACT FACTOR- 3.775

International Journal of Engineering Researches and Management Studies

[17] Park JY, Lim M, Yang W, LeeK. Exposure factors for cleaning, automotive care, and surface protection products for exposure assessments. Food ChemToxicol 20174;99;128−134.
[18] Wolkoff P, Nielsen GD. Effects by inhalation of abundant fragrances in indoor air-an overview. Environ Int 2017;101;96–107.