



## • Original Article

# Assessment of relationship between the use of household products and atopic dermatitis in Seoul: focused on products with associated risks

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The purpose of this study was to evaluate the relationship between the use of certain household products (HPs) at home and atopic dermatitis (AD) in adults. The study was conducted on 1,500 households in Seoul, South Korea. We obtained information on general characteristics, the use of HPs, and AD through an online panel survey in July 2018. HPs were selected as 23 kinds of products with associated risks that are management targets of the Ministry of Environment. The international study of asthma and allergies in childhood was used for the AD questionnaires. Logistic regression analysis was used to identify AD affected by the use of HPs. Average number of used HPs was 13.44 out of 23, and average usage frequency of HPs was 3.52 times a month at home in Seoul for the last 1 year. Compared with subjects with a low number of HPs used (reference), subjects with a high number of used HPs (4th quartile) were more likely to have lifetime diagnosis of AD (odds ratio (OR) = 1.77, 95% confidence interval (CI); 1.23-2.54), symptoms of AD in the last 12 months (OR = 2.66, 95% CI; 1.92-3.70), and treatment of AD in the last 12 months (OR = 2.37, 95% CI; 1.48-3.80). Compared with subjects with a low HPs usage frequency (reference), subjects with a high HPs usage frequency (4th quartile) were more likely to have lifetime diagnosis of AD (OR = 1.88, 95% CI; 1.31-2.70), symptoms of AD in the last 12 months (OR = 2.14, 95% CI; 1.54-2.96), and treatment of AD in the last 12 months (OR = 2.23, 95% CI; 1.39-3.60). Therefore, the use of HPs was significantly associated with AD. The findings of this study might be useful as basic data for managing allergic diseases and establishing preventive measures.

**Keywords:** Adult, Atopic dermatitis, Household product, Seoul

## INTRODUCTION

Household products (HPs) are constantly being used in daily living, to the extent that a new phrase “*homo chemicus*” has been coined, meaning humans living in a state of dependence on chemical products [1]. Since the humidifier disinfectant accident in 2011, awareness of the risk of HPs has grown, as incidents involving chemicals in HPs continue to occur, such as the inclusion of humidifier disinfectants in some toothpastes, the presence of pesticide in eggs, the discovery of hazardous substances in sanitary napkins, methanol from vehicles in washers, and radon in beds [2]. In fact, according to the

Korea Consumer Agency (KCA), 1,529 cases of the risks of HPs were received through consumer surveillance system in the 3-year period from 2014 to 2016, with 46.5% more cases in 2016 than in 2014 [3].

HPs are continuously produced according to the purpose and use of each manufacturing company, and there are many chemicals in these HPs that are not properly managed [4]. According to the National Institute of Environmental Research (NIER), 682 products, which account for about 50% of the 1,369 HPs in total, were reported as using nanomaterials [5]. In the study of ingredients and hazardous substances contained in detergents and disinfectants, 38 of the 163 ingredients were classified as dangerous substances, and some of them have been shown to be harmful or carcinogenic in oral, transdermal, and inhalation exposure [6]. In an overseas study, 133 kinds of volatile organic compounds were detected among 25 HPs such as laundry products, personal products, cleaning products, and fragrances [7]. In addition, since there are still

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cases in which the labeling of product ingredients is insufficient, consumers may not be properly informed of the harmful chemical substances contained in HPs, as was the case in the humidifier disinfectant incident, and may be exposed to unexpected health effects [8].

A previous study has reported that chemicals in HPs can adversely affect health, resulting in symptoms such as skin rash, allergies, eye irritation, and dyspnea [9]. Of these, atopic dermatitis (AD) with severe itching and dry symptoms is one of the most common skin diseases not only for infants and children but also for adults in Korea [10], and the prevalence of AD continues to grow with the rapid increase of allergic diseases worldwide [11]. According to Statistics Korea (KOSTAT), rates of AD diagnosis in adults aged 19 and over increased from 2.4% in 2007 to 4.1% in 2017 [12]. The cause of AD has not yet been clearly identified, but it is known that various environmental or genetic factors interact with each other and contribute in a complex manner [13]. Significantly, it has been reported that environmental factors are related to the increase of exposure to antigens due to Korea's westernization and changes in the living environment, as well as the presence of allergens such as automobile exhaust, dust, particle matter, etc. [14].

While studies on adult AD continue to be conducted abroad [15], there has been a lack of interest in adult AD in Korea compared to children AD. As such, the purpose of this study is to identify usage status of HPs at home in Seoul, targeting products with associated risks that are management targets of the Korean Ministry of Environment (ME), and to evaluate the relationship between the use of HPs and AD in adults.

## MATERIALS AND METHODS

### Study Population

An online survey was conducted on 1,500 households who lived in Seoul for more than 1 year, using online participants who voluntarily registered with a survey company for 20 days from July 11 to July 30, 2018. To ensure that the survey sample was representative of households in Seoul, we used the statistical data of the Population and Housing Census in 2015, and applied population proportional allocation according to the 5 major areas of Seoul and type of residence. The subjects were limited to adults aged 19 and over. This study was approved by the Institutional Review Board of Seoul Medical Center (IRB no. 2018-05-006).

### Survey

As of early July 2018, 191,850 out of 283,685 participants in

the Seoul registered survey company were randomly extracted and sent e-mail requesting participation through an email program. 25,285 out of 191,850 subjects confirmed via e-mail, and 5,934 of them accessed the online survey. However, 656 subjects were excluded through the screening, 3,424 subjects were excluded due to over-representation of proportional allocation, and 156 subjects were excluded due to abandonment, thus only 1,698 subjects completed the survey. Of these, 198 subjects who repeatedly responded to a certain interval or had a short response time were excluded. Ultimately, 1,500 subjects were included in the analysis. Since the subjects are panel members managed by the survey company, they paid for itself in the form of mileage to the subjects.

### General Characteristics

The general characteristics of survey included the following: gender (male, female), age (20-29 years, 30-39 years, 40-49 years,  $\geq 50$  years), area (downtown, northeast, northwest, southeast, southwest), residence period (1-3 years, 3-5 years,  $\geq 5$  years), residence type (detached house, apartment, multi-plex house, commercial house), marital status (single, married), education ( $\leq$ high school, university,  $\geq$ graduate school), occupation (production, professional, office work, sales/service, self-employed, student, housewife, unemployed), monthly household income (<2 million won, 2-5 million won, 5-7 million won,  $\geq 7$  million won), number of residents (1 person, 2 people, 3 people, 4 people,  $\geq 5$  people), household type (1 generation, 2 generations,  $\geq 3$  generations, non-kin, 1 person), minor child (no, yes), residence scale ( $\leq 60$  m<sup>2</sup>, 60-85 m<sup>2</sup>, 85-135 m<sup>2</sup>, >135 m<sup>2</sup>).

### The use of HPs at home

HPs were selected as 23 kinds of products with associated risks that are management targets of the ME [16]. Products with associated risks are classified as follows in accordance with standard guided by ME: 5 kinds of detergents (cleaner, synthetic detergent, bleaching agent, softening agent, windshield washer fluid), 6 kinds of coatings/adhesives (coating, rust inhibitor, anti-fogging agent, adhesive, ironing auxiliaries, niche filler), 2 kinds of aromatic products (air freshener, deodorant), 3 kinds of dyes (object decolorant and dye, tattoo dye, printing ink and toner) 4 kinds of biocidal products (disinfectant, insect repellent, preservative, algicide), 3 kinds of others (candle, desiccant, antifreeze). In the survey, the use (used, not used) and usage frequency (1-11 times a year, 1-3 times a month, 1-6 times a week, 1-4 times a day) of each product for the last 1 year were examined. If the subject used the product more than 4 times a day, they were asked to fill in

the number directly. Usage frequency of each product was quantitatively converted to a per month figure.

**Status of AD**

The status of AD was assessed using the International Study of Asthma and Allergies in Childhood questionnaires. The survey included the following information related to AD, indoor environmental factors, and family history: lifetime diagnosis of AD (no, yes), symptoms of AD within the last 12 months (no, yes), treatment of AD within the last 12 months (no, yes), current smoking (no, past experience, yes), indoor secondhand smoking (no, 1-2 times a week, 3-4 times a week, 5-6 times a week, everyday), remodeling in the last 12 months (no, yes), use of new furniture in the last 12 months (no, yes), mold stain in current residence (no, yes), pets in current residence (no, yes), parental lifetime diagnosis of allergic diseases (no, yes).

**Statistics**

The number of used HPs was represented by the total number of HPs who answered that they use each product, and usage frequency was expressed as arithmetic mean and standard deviation (SD) using average usage frequency for each product. These were divided into quartiles in the analysis of AD. General characteristics, indoor environmental factors, family history, and number of used HPs and usage frequency were subjected to a Chi-square test. To assess the relationship between the use of HPs and AD, logistic regression analysis was conducted after correcting for general characteristics, indoor environmental factors, and family history of this study. These results were shown by odds ratio (OR) and had a 95% confidence interval (CI). All of the statistics were performed using Statistical Analysis Software (SPSS version 18.0, SPSS Inc.).

**RESULTS**

**Usage Status of HPs**

Average number of used HPs and average usage frequency of HPs of 1,500 households in Seoul were 13.44 out of 23 and 3.52 times a month, respectively (Table 1). Frequency distribution of number of used HPs are presented in Table S1. When

the use of HPs was divided into quartiles, the number of used HPs was ≤10 in the 1st quartile, 11-13 in the 2nd quartile, 14-16 in the 3rd quartile, and ≥17 in the 4th quartile, and the usage frequency was ≤1.32 times a month in the 1st quartile, 1.32-2.52 times a month in the 2nd quartile, 2.52-4.24 times a month in the 3rd quartile, and >4.24 times a month in the 4th quartile.

**Related Factors of AD**

Table 2 showed general characteristics, indoor environmental factors, family history, and the use distribution of HPs of the subjects according to AD. The percentage of adults with the experience of AD diagnosis in their lifetime was significantly higher than those without, as follows: 28.8% for those aged 20-29 years (p<0.05), 48.3% for those who were single (p<0.05), 18.8% for those who had a history of smoking (p<0.05), 22.1% for those with daily indoor secondhand smoke exposure (p<0.01), 32.6% for those who had remodeled in the last 12 months (p<0.001), 61.7% for those with mold stain in the current residence (p<0.001), 23.3% for those with pets in the current residence (p<0.001), 45.7% for those with a parental lifetime diagnosis of allergic diseases (p<0.001), 29.8% for number of used HPs in the 4th quartile (p<0.001), 32.6% for usage frequency of HPs in the 4th quartile (p<0.001). Adults with the experience of symptoms of AD within the last 12 months were significantly higher than those without the experience of AD in the following groups: 52.9% for females (p<0.05), 14.7% for ≤high school graduation (p<0.05), 20.9% for those with a residence size ≤60 m<sup>2</sup> (p<0.05), 24.1% for those with daily indoor secondhand smoke exposure (p<0.001), 31.8% for those who had remodeled in the last 12 months (p<0.001), 38.8% for those with new furniture in the last 12 months (p<0.001), 59.9% for those with a mold stain in their current residence (p<0.001), 20.2% for those with pets in their current residence (p<0.05), 38.8% for those with a parental lifetime diagnosis of allergic diseases (p<0.001), 26.6% for number of used HPs in the 4th quartile (p<0.001), 29.6% for usage frequency of HPs in the 4th quartile (p<0.001). Adults with the experience of treatment of AD within the last 12 months were significantly higher than those without in the following groups: 21.2% for those with graduate school educa-

**Table 1.** Usage distribution of household products (HPs)

Variables	N	Mean	SD*	Percentiles			
				25th	50th	75th	95th
Number of used HPs (number/year)	1,500	13.44	4.82	10.00	13.00	16.00	23.00
Usage frequency of HPs (times/month)	1,500	3.52	4.23	1.32	2.52	4.24	9.75

\*SD = Standard deviation.

**Table 2.** Summary on characteristics of subjects for atopic dermatitis (AD)

	Total	Diagnosis, lifetime					Symptoms, <12 months					Treatment, <12 months				
		No		Yes		p-value	No		Yes		p-value	No		Yes		p-value
		N	%	N	%		N	%	N	%		N	%	N	%	
Total	1,500	1,080	72.0	420	28.0		774	51.6	726	48.4		1,269	84.6	231	15.4	
Gender																
Male	750	538	49.8	212	50.5	0.82	408	52.7	342	47.1	<0.05	637	50.2	113	48.9	0.72
Female	750	542	50.2	208	49.5		366	47.3	384	52.9		632	49.8	118	51.1	
Age (years)																
20-29	350	229	21.2	121	28.8	<0.05	194	25.1	156	21.5	0.27	286	22.5	64	27.7	0.33
30-39	400	296	27.4	104	24.8		205	26.5	195	26.9		343	27.1	57	24.7	
40-49	400	289	26.8	111	26.4		193	24.9	207	28.5		338	26.6	62	26.8	
≥ 50	350	266	24.6	84	20.0		182	23.5	168	23.1		302	23.8	48	20.8	
Area																
Downtown	81	54	5.0	27	6.4	0.40	41	5.3	40	5.5	0.77	65	5.1	16	6.9	0.81
Northeast	466	333	30.9	133	31.7		231	29.8	235	32.4		393	31.0	73	31.6	
Northwest	187	144	13.3	43	10.2		102	13.2	85	11.7		161	12.7	26	11.3	
Southeast	326	238	22.0	88	21.0		167	21.6	159	21.9		277	21.8	49	21.2	
Southwest	440	311	28.8	129	30.7		233	30.1	207	28.5		373	29.4	67	29.0	
Residence period (years)																
1-3	59	37	3.4	22	5.2	0.16	34	4.4	25	3.4	0.53	48	3.8	11	4.8	0.59
3-5	53	35	3.2	18	4.3		25	3.2	28	3.9		43	3.4	10	4.3	
≥ 5	1,388	1,008	93.4	380	90.5		715	92.4	673	92.7		1,178	92.8	210	90.9	
Residence type																
Detached house	180	125	11.6	55	13.1	0.35	86	11.1	94	12.9	0.43	145	11.4	35	15.2	0.16
Apartment	887	654	60.6	233	55.5		473	61.1	414	57.1		748	58.9	139	60.2	
Multiplex house	415	289	26.8	126	30.0		206	26.6	209	28.8		362	28.6	53	22.9	
Commercial house	18	12	1.0	6	1.4		9	1.2	9	1.2		14	1.1	4	1.7	
Marital status																
Single	652	449	41.6	203	48.3	<0.05	342	44.2	310	42.7	0.56	546	43.0	106	45.9	0.42
Married	848	631	58.4	217	51.7		432	55.8	416	57.3		723	57.0	125	54.1	
Education																
≤ High school	182	134	12.4	48	11.4	0.24	75	9.7	107	14.7	<0.05	157	12.4	25	10.8	<0.05
University	1,081	786	72.8	295	70.3		576	74.4	505	69.6		924	72.8	157	68.0	
≥ Graduate school	237	160	14.8	77	18.3		123	15.9	114	15.7		188	14.8	49	21.2	
Occupation																
Production	21	14	1.3	7	1.6	0.76	10	1.2	11	1.5	0.29	16	1.2	5	2.1	0.16
Professional	211	148	13.7	63	15.0		109	14.1	102	14.0		179	14.1	32	13.9	
Office work	701	513	47.5	188	44.8		360	46.5	341	47.0		601	47.4	100	43.3	
Sales/Service	77	57	5.3	20	4.8		42	5.4	35	4.8		68	5.4	9	3.9	
Self-employed	93	66	6.1	27	6.4		45	5.8	48	6.6		73	5.8	20	8.7	
Student	145	96	8.9	49	11.7		88	11.4	57	7.9		119	9.4	26	11.3	
Housewife	185	136	12.6	49	11.7		84	10.9	101	13.9		151	11.9	34	14.7	
Unemployed	67	50	4.6	17	4.0		36	4.7	31	4.3		62	4.8	5	2.1	
Household income (million won/month)																
<2	104	76	7.0	28	6.6	0.84	53	6.8	51	7.0	0.64	93	7.3	11	4.7	<0.05
2-5	743	529	49.0	214	51.0		390	50.4	353	48.7		638	50.3	105	45.5	
5-7	365	269	24.9	96	22.9		192	24.8	173	23.8		310	24.4	55	23.8	
≥ 7	288	206	19.1	82	19.5		139	18.0	149	20.5		228	18.0	60	26.0	
Number of residents																
1	153	109	10.1	44	10.5	0.35	73	9.4	80	11.0	0.52	133	10.5	20	8.7	0.13
2	236	176	16.3	60	14.3		127	16.4	109	15.0		208	16.4	28	12.1	
3	447	331	30.6	116	27.6		242	31.3	205	28.2		383	30.2	64	27.7	
4	544	385	35.7	159	37.9		271	35.0	273	37.7		449	35.4	95	41.1	
≥ 5	120	79	7.3	41	9.7		61	7.9	59	8.1		96	7.5	24	10.4	
Household type																
1 Generation	262	191	17.7	71	16.9	0.92	146	18.9	116	16.0	0.40	228	18.0	34	14.7	0.59
2 Generations	971	702	65.0	269	64.0		495	64.0	476	65.6		812	64.0	159	68.8	
≥ 3 Generations	97	66	6.1	31	7.4		49	6.3	48	6.6		81	6.4	16	6.9	

(Continued to the next page)

**Table 2.** Continued

	Total	Diagnosis, lifetime					Symptoms, <12 months					Treatment, <12 months				
		No		Yes		p-value	No		Yes		p-value	No		Yes		p-value
		N	%	N	%		N	%	N	%		N	%	N	%	
Non-kin	17	12	1.1	5	1.2		11	1.4	6	0.8		15	1.1	2	0.9	
1 Person	153	109	10.1	44	10.5		73	9.4	80	11.0		133	10.5	20	8.7	
Minor child																
No	1,033	746	69.1	287	68.3	0.78	548	70.8	485	66.8	0.10	883	69.6	150	64.9	0.16
Yes	467	334	30.9	133	31.7		226	29.2	241	33.2		386	30.4	81	35.1	
Residence scale (m <sup>2</sup> )																
≤ 60	288	211	19.5	77	18.2	0.56	136	17.6	152	20.9	<0.05	257	20.3	31	13.4	<0.01
60-85	425	308	28.5	117	27.9		240	31.0	185	25.5		368	29.0	57	24.7	
85-135	648	468	43.4	180	42.9		337	43.5	311	42.9		534	42.1	114	49.4	
> 135	139	93	8.6	46	11.0		61	7.9	78	10.7		110	8.6	29	12.5	
Smoking																
No	947	692	64.1	255	60.7	<0.05	502	64.9	445	61.3	0.13	809	63.8	138	59.7	0.28
Past experience	223	144	13.3	79	18.8		118	15.2	105	14.5		181	14.2	42	18.2	
Yes	330	244	22.6	86	20.5		154	19.9	176	24.2		279	22.0	51	22.1	
Secondhand smoke exposure (times/week)																
No	282	229	21.2	53	12.6	<0.01	185	23.9	97	13.4	<0.001	255	20.1	27	11.7	<0.05
1-2	590	427	39.5	163	38.8		308	39.8	282	38.8		502	39.6	88	38.1	
3-4	231	153	14.2	78	18.6		112	14.5	119	16.4		188	14.8	43	18.6	
5-6	106	73	6.8	33	7.9		53	6.8	53	7.3		88	6.9	18	7.8	
Daily	291	198	18.3	93	22.1		116	15.0	175	24.1		236	18.6	55	23.8	
Remodeling																
No	1,112	829	76.8	283	67.4	<0.001	617	79.7	495	68.2	<0.001	968	76.3	144	62.3	<0.001
Yes	388	251	23.2	137	32.6		157	20.3	231	31.8		301	23.7	87	37.7	
New furniture																
No	995	729	67.5	266	63.3	0.13	551	71.2	444	61.2	<0.001	866	68.2	129	55.8	<0.001
Yes	505	351	32.5	154	36.7		223	28.8	282	38.8		403	31.8	102	44.2	
Mold stain																
No	703	542	50.2	161	38.3	<0.001	412	53.2	291	40.1	<0.001	620	48.9	83	35.9	<0.001
Yes	797	538	49.8	259	61.7		362	46.8	435	59.9		649	51.1	148	64.1	
Pets																
No	1,235	913	84.5	322	76.7	<0.001	656	84.8	579	79.8	<0.05	1,068	84.2	167	72.3	<0.001
Yes	265	167	15.5	98	23.3		118	15.2	147	20.2		201	15.8	64	27.7	
Family history																
No	1,066	838	77.6	228	54.3	<0.001	622	80.4	444	61.2	<0.001	964	76.0	102	44.2	<0.001
Yes	434	242	22.4	192	45.7		152	19.6	282	38.8		305	24.0	129	55.8	
Number of used HPs																
1 <sup>st</sup> Quartile	426	336	31.2	90	21.4	<0.001	275	35.6	151	20.8	<0.001	390	30.7	36	15.6	<0.001
2 <sup>nd</sup> Quartile	405	294	27.2	111	26.4		212	27.4	193	26.6		349	27.5	56	24.2	
3 <sup>rd</sup> Quartile	317	223	20.6	94	22.4		128	16.5	189	26.0		264	20.8	53	22.9	
4 <sup>th</sup> Quartile	352	227	21.0	125	29.8		159	20.5	193	26.6		266	21.0	86	37.3	
Usage frequency of HPs																
1 <sup>st</sup> Quartile	375	302	28.0	73	17.4	<0.001	251	32.4	124	17.1	<0.001	343	27.0	32	13.8	<0.001
2 <sup>nd</sup> Quartile	373	259	24.0	114	27.1		186	24.0	187	25.8		318	25.1	55	23.8	
3 <sup>rd</sup> Quartile	377	281	26.0	96	22.9		177	22.9	200	27.5		320	25.2	57	24.7	
4 <sup>th</sup> Quartile	375	238	22.0	137	32.6		160	20.7	215	29.6		288	22.7	87	37.7	

tion or higher ( $p < 0.05$ ), 26.0% for those with a household income of 7 million won per month or more ( $p < 0.05$ ), 12.5% for those with a residence less than 135 m<sup>2</sup> ( $p < 0.01$ ), 23.8% for those with everyday indoor secondhand smoke exposure ( $p < 0.05$ ), 37.7% for those who had remodeled in the last 12 months ( $p < 0.001$ ), 44.2% for those that had used new furniture in the last 12 months ( $p < 0.001$ ), 64.1% for those with a mold

stain in their current residence ( $p < 0.001$ ), 27.7% for those with pets in their current residence ( $p < 0.05$ ), 55.8% for those with a parental lifetime diagnosis of allergic diseases ( $p < 0.001$ ), 37.3% for number of used HPs in the 4th quartile ( $p < 0.001$ ), 37.7% for usage frequency of HPs in the 4th quartile ( $p < 0.001$ ).



**Table 3.** Logistic regression analysis of number of household products (HPs) used and atopic dermatitis (AD)

	Diagnosis, lifetime		Symptoms, <12 months		Treatment, <12 months	
	OR* (95% CI <sup>†</sup> )	p-value	OR* (95% CI <sup>†</sup> )	p-value	OR* (95% CI <sup>†</sup> )	p-value
1 <sup>st</sup> Quartile	1		1		1	
2 <sup>nd</sup> Quartile	1.42 (1.01-2.01)	<0.05	1.65 (1.22-2.23)	<0.01	1.58 (0.98-2.53)	0.06
3 <sup>rd</sup> Quartile	1.46 (1.01-2.10)	<0.05	1.93 (1.39-2.69)	<0.001	1.76 (1.08-2.86)	<0.05
4 <sup>th</sup> Quartile	1.77 (1.23-2.54)	<0.01	2.66 (1.92-3.70)	<0.001	2.37 (1.48-3.80)	<0.001
p for trend	<0.01		<0.001		<0.001	

\*Odds ratio, <sup>†</sup>Confidence interval.

Adjusted variables for gender, age, area, residence period, residence type, marital status, education, occupation, household income, number of residents, household type, minor child, residence scale, smoking, secondhand smoke exposure, remodeling, new furniture, mold stain, pets and family history.

**Table 4.** Logistic regression analysis of usage frequency of household products (HPs) and atopic dermatitis (AD)

	Diagnosis, lifetime		Symptoms, <12 months		Treatment, <12 months	
	OR* (95% CI <sup>†</sup> )	p-value	OR* (95% CI <sup>†</sup> )	p-value	OR* (95% CI <sup>†</sup> )	p-value
1 <sup>st</sup> Quartile	1		1		1	
2 <sup>nd</sup> Quartile	1.19 (0.82-1.72)	0.37	1.84 (1.34-2.53)	<0.001	1.40 (0.85-2.30)	0.19
3 <sup>rd</sup> Quartile	1.64 (1.15-2.35)	<0.01	1.87 (1.36-2.58)	<0.001	1.62 (0.99-2.64)	0.06
4 <sup>th</sup> Quartile	1.88 (1.31-2.70)	<0.01	2.14 (1.54-2.96)	<0.001	2.23 (1.39-3.60)	<0.01
p for trend	<0.01		<0.001		<0.01	

\*Odds ratio, <sup>†</sup>Confidence interval.

Adjusted variables for gender, age, area, residence period, residence type, marital status, education, occupation, household income, number of residents, household type, minor child, residence scale, smoking, secondhand smoke exposure, remodeling, new furniture, mold stain, pets and family history.

### Relationship Between Number of Used HPs and AD

In order to evaluate the relationship between the number of used HPs and AD, a logistic regression analysis was performed by adjusting the confounding variables. The results are shown in Table 3. The risk of lifetime diagnosis of AD compared to the 1st quartile was 1.42 times higher (95% CI; 1.01-2.01) in the 2nd quartile, 1.46 times higher (95% CI; 1.01-2.10) in the 3rd quartile, and 1.77 times higher (95% CI; 1.23-2.54) in the 4th quartile. The risk of symptoms of AD within the last 12 months was 1.65 times higher (95% CI; 1.22-2.23) in the 2nd quartile, 1.93 times higher (95% CI; 1.39-2.69) in the 3rd quartile, and 2.66 times higher (95% CI; 1.92-3.70) in the 4th quartile. The risk of treatment of AD within the last 12 months was 1.76 times (95% CI; 1.08-2.86) higher in the 3rd quartile, and 2.37 times higher (95% CI; 1.48-3.80) in the 4th quartile. As the number of used HPs increased, the risks of lifetime diagnosis ( $p<0.01$ ), symptoms within the last 12 months ( $p<0.001$ ), and treatment of AD within the last 12 months ( $p<0.001$ ) were increased significantly.

### Relationship Between Usage Frequency of HPs and AD

As shown in Table 4, a logistic regression analysis was performed after adjusting for confounding variables to evaluate the relationship between the usage frequency of HPs and AD. Compared to the 1st quartile, the risk of lifetime diagnosis of AD was 1.64 times higher (95% CI; 1.15-2.35) in the 3rd quartile, and 1.88 times higher (95% CI; 1.31-2.70) in the 4th quar-

tile. The risk of symptoms of AD within the last 12 months was 1.84 times higher (95% CI; 1.34-2.53) in the 2nd quartile, 1.87 times (95% CI; 1.36-2.58) higher in the 3rd quartile, and 2.14 times higher (95% CI; 1.54-2.96) in the 4th quartile. The risk of treatment of AD within the last 12 months was 2.23 times higher (95% CI; 1.39-3.60) in the 4th quartile. As usage frequency of HPs increased, the risk of lifetime diagnosis ( $p<0.01$ ), symptoms within the last 12 months ( $p<0.001$ ), and treatment within the last 12 months ( $p<0.01$ ) of AD was increased significantly. These results had a similar trend to the number of used HPs. Relationships between usage of 23 individual HP and AD are presented in Table S2.

## DISCUSSION

This study of average number of used HPs and average usage frequency at home in Seoul for the last 1 year showed that consumers are still highly dependent on HPs. According to risk information trend analysis of household chemical HPs of KCA, accidents such as eye damage, internal dangerous substances, poisoning, burns, and pain at home were the most frequent type when risk was broken down by location [3]. This is thought to be related to the high use rates of HPs at home.

The experience rates of lifetime diagnosis of AD, symptoms of AD within the last 12 months, and treatment of AD within the last 12 months in this study were higher than in a previous study [10]. This is because not only physical factors but also

psychological factors such as stress and depression are reported to be involved in the onset of AD [17]. It is thought that those factors affect the continuous increase of experience rates of AD.

In this study, AD was found to be associated with gender, age, marital status, education, household income, residence scale, smoking, indoor secondhand smoking, remodeling in the last 12 months, the use of new furniture in the last 12 months, mold stain, and parental lifetime diagnosis of allergic diseases. Previous studies on adults have reported the association of AD with gender, age, marital status, education, household income, number of residents, and residential area [17,18], and the direction of relevance was consistent with this study. In particular, AD was significantly associated with parental family history [19], showing similar trend in this study. In addition, AD is also reported to be influenced by obesity, smoking, drinking, pets, stress, and dietary habits [20-23].

The findings of this study, which analyzed the relationship between the use of HPs and AD, shows that the risk of lifetime diagnosis of AD, symptoms of AD within the last 12 months, and treatment of AD within the last 12 months was significantly increased as the number of used HPs and their usage frequency increased. It has been reported that surfactant or antimicrobial components contained in HPs cause allergy from skin contact and increase the risk of developing AD when it exposes continuously [24,25,26], and this study supports this finding. In immunological mechanisms, harmful chemicals contained in HPs are exposed to antigens and the balance between T-helper type 1 (Th1) and T-helper type 2 (Th2) cytokine is broken, resulting in overproduced Th2 cytokines such as interleukin (IL)-4, 5, 9, 13 stimulating B cells and increasing immunoglobulin E (IgE) [27]. Increased IgE binds to receptors on the surface of mast cells and secretes chemicals such as histamine, stimulating blood vessels and skin which leads to AD [28]. In a previous domestic study, the risks of skin eczema were significantly increased according to usage frequency of antibacterial housewares, as follows: by 1.13 times (95% CI; 1.04-1.24) in the 2nd quartile, by 1.15 times (95% CI; 1.05-1.26) in the 3rd quartile, and by 1.13 times (95% CI; 1.03-1.24) in the 4th quartile [29]. In an overseas study conducted through an online survey, 66.8% of the population was exposed to HPs at least 1 time a week due to the use of HPs, and 4.8% of them experienced skin symptoms [30]. A study of the effects of the use of disinfectants at home on allergic diseases found that the risk of AD was significantly higher when disinfectants were used, as follows: 2.6 times higher (95% CI; 1.2-5.6) for lifetime symptoms of skin eczema, 7.0 times higher (95% CI; 1.8-27.1) for symptoms of skin eczema within the last 12 months, and

2.5 times higher (95% CI; 1.1-6.0) for lifetime symptoms of skin rash [31].

This study has a limitation in that it can be interpreted that there is the possibility of underestimation, because it includes subjects who responded that they did not use HPs in their usage frequency of HPs. In addition, the subjects responded to questionnaire relied on his or her memory to answer the online survey, so there is a possibility that the results are affected not only by reliability but also by recall bias. Nevertheless, the subjects of this study were applied population proportional allocation to represent households in Seoul, and this study shows that the risk of AD in adults was significantly increased as the number of used HPs and their usage frequency increased. Therefore, the findings of this study might be useful as basic data for managing allergic diseases and establishing preventive measures.

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## CONFLICT OF INTEREST

The authors have no conflicts of interest to declare in relation to the material presented in this paper.

## REFERENCES

1. Lee S-M. Safety from danger of living chemical products. *J Law Politics* 2018; 18(3): 1-30. (Korean)
2. Lee J-S. New statutory framework for household chemical products in safety of household chemical products and biocidal products act. *Hanyang J Law* 2018; 35(3): 171-200. (Korean)
3. Korea Consumer Agency (KCA). Risk information trend analysis of household chemical products. 2017. (Korean)
4. National Institute of Environmental Research (NIER). Risk assessment for hazardous substances contained in consumer products. 2012. (Korean)
5. National Institute of Environmental Research (NIER). Studies on exposure assessment of nanomaterials in chemical products. 2017. (Korean)
6. Heo D-A, Huh E-H, Park JY, Moon KW, Lee K. An investigation of ingredients and hazardous substances in some consumer products: focusing on cleaners and disinfectants. *J Environ Health Sci* 2015; 41(5): 314-326. (Korean)
7. Steinemann AC, MacGregor IC, Gordon SM, Gallagher LG, Davis AL, Ribeiro DS, et al. Fragranced consumer products: chemicals emitted, ingredients unlisted. *Environ Impact Assess Rev* 2011; 31(3): 328-333.
8. Park DU, Lee S, Lim HK, Bae SY, Ryu SH, Ahn JJ. Review on safety and

- health information on humidifier disinfectant. *J Environ Health Sci* 2017; 43(5): 349-359. (Korean)
9. Wolkoff P, Schneider T, Kildeso J, Degerth R, Jaroszewski M, Schunk H. Risk in cleaning: chemical and physical exposure. *Sci Total Environ* 1998; 215(1-2): 135-156.
  10. Kim MJ, Kang TW, Cho EA, Kim HS, Min JA, Park H, et al. Prevalence of atopic dermatitis among Korean adults visiting health service center of the catholic medical center in Seoul metropolitan area, Korea. *J Korean Med Sci* 2010; 25(12): 1828-1830.
  11. Kim DH. Factors associated with behavioral problems in children with atopic dermatitis. *J Korean Soc Matern Child Health* 2010; 14: 206-214. (Korean)
  12. Statistics Korea (KOSTAT). Korean Statistical Information Service (KOSIS). [cited 2019 March 14]. Available from: [http://kosis.kr/statHtml/statHtml.do?orgId=117&tblId=DT\\_11702\\_N114&vw\\_cd=MT\\_ZTITLE&list\\_id=117\\_11702\\_B01&seqNo=&lang\\_mode=ko&language=kor&obj\\_var\\_id=&itm\\_id=&conn\\_path=MT\\_ZTITLE](http://kosis.kr/statHtml/statHtml.do?orgId=117&tblId=DT_11702_N114&vw_cd=MT_ZTITLE&list_id=117_11702_B01&seqNo=&lang_mode=ko&language=kor&obj_var_id=&itm_id=&conn_path=MT_ZTITLE).
  13. Kim S-H, Park D-J, Byun H-J, Lee H-S, Oh I-B, Sim C-S, et al. House dust mites and associated environmental factors in homes of atopic children: a case-control study. *J Environ Health Sci* 2012; 38(3): 204-212. (Korean)
  14. Benn CS, Melbye M, Wohlfahrt J, Bjorksten B, Aaby P. Cohort study of sibling effect, infectious disease, and risk of atopic dermatitis during first 18 months of life. *BMJ* 2004; 328(7450): 1223-1226.
  15. Katsarou A, Armenaka M. Atopic dermatitis in older patients: particular points. *J Eur Acad Dermatol Venereol* 2011; 25(1): 12-18.
  16. Korea Consumer Agency (KCA). Survey on safety of children's protective packaging for household chemical products. 2017. (Korean)
  17. Kim KH, Park AY, Kim JS. Factors associated with atopic dermatitis in Korean adults: The Korean National Health and Nutrition Survey 2008. *Korean J Rehabil Nurs* 2012; 15(2): 83-90. (Korean)
  18. Kim BJ, Jung JA, Lee JS. Association between social economic status and atopic dermatitis in Korean adult: an analysis of the Fifth Korea National Health and Nutrition Examination Survey (2010-2012). *Allergy Asthma Respir Dis* 2015; 3(2): 128-133. (Korean)
  19. Kim YM, Kim YC, Lee S, Back JH, Chun K. Association between parental history of allergic diseases and atopic dermatitis in school aged children. *Allergy Asthma Respir Dis* 2014; 2(5): 377-382. (Korean)
  20. Lee YM, Hwang SW. Prevalence and risk factors for atopic dermatitis in pre-school and school aged children. *J Korean Acad Child Health Nurs* 2008; 14(3): 285-294. (Korean)
  21. So ES, Yeo JY. Relationship between health status and life styles and atopic dermatitis in adolescents. *J Korean Acad Child Health Nurs* 2012; 18(3): 143-149. (Korean)
  22. Park DH, Bae HS. Lifestyle habits and characteristics of atopic dermatitis occurred in children. *Kor J Aesthet Cosmetol* 2013; 11(1): 17-28. (Korean)
  23. Park J-H. Factors influencing allergy related disease among Korean adolescents. *J Kor Cont Assoc* 2016; 16(3): 596-606. (Korean)
  24. Jeong J, Jeong Y, Jeong S-W. Effects of bowl material and rinsing period on variation in the amount of residual surfactant resided in the bowls after dish-washing. *J Kor Soc Environ Eng* 2013; 35(12): 978-981. (Korean)
  25. Jung KH, Cho DW, Jung JH, Jeong NA, Joo KM, Seung KR, et al. Management directions for dangerous household goods. *Duksung Bull Pharm Sci* 2009; 20: 3-18. (Korean)
  26. Ko JS. Antimicrobial coating agent. *J Korean Oil Chem Soc* 2013; 30(1): 96-115. (Korean)
  27. Agnello D, Lankford CS, Bream J, Morinobu A, Gadina M, O'shea JJ, et al. Cytokines and transcription factors that regulate T helper cell differentiation: new players and new insights. *J Clin Immunol* 2003; 23(3): 147-161.
  28. Lee B-W, Gim S-B, Song H-H, Ji J-G, Bak J-W, Kim D-H. Study on the immune modulatory activity of Seokjahaeki-tang using atopic dermatitis animal models. *Korean J Orient Physiol Pathol* 2012; 26(4): 446-454. (Korean)
  29. Hong S, Kwon H-J, Choi W-J, Lim WR, Kim J, Kim K-S. Association between exposure to antimicrobial household products and allergic symptoms. *Environ Health Toxicol* 2014; 29: e2014017.
  30. Steinemann A. Health and societal effects from exposure to fragranced consumer products. *Prev Med Rep* 2017; 5: 45-47.
  31. Krauss-Etschmann S, Niedermaier S, Beyer J, Campoy C, Escolano V, Decsi T, et al. Current use of room disinfectants and allergic symptoms at the age of 4 years. *J Allergy Clin Immunol* 2009; 123(5): 1176-1178.