



Education on Exposure and Health Risks of Forever Chemicals (PFAS) for Housewives and Adolescent Girls

Cimi Ilmiawati^{1,3*}, Roza Silvia^{2,3}, Dessy Arisanty³, Elly Usman³, Masrul³, Arni Amir³, Hasmiwati³, Mohamad Reza³, Didan Ariadapa Rahadi³, Rezky Fauzan³, Abi Siregar³, Ivonne Olivia³, Yuli Dwiaryani³, Muhammad Ilham³

¹Division of Environmental Toxicology, Department of Pharmacology and Therapeutics, Faculty of Medicine, Universitas Andalas, Padang, Indonesia

²Department of Histology, Department of Pharmacology and Therapeutics, Faculty of Medicine, Universitas Andalas, Padang, Indonesia

³Master's Program in Biomedical Sciences, Faculty of Medicine, Universitas Andalas, Padang, Indonesia

*Corresponding author: ilmiawati@med.unand.ac.id

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ABSTRACT

Our community service activity aimed to increase knowledge and awareness about the dangers of per- and polyfluoroalkyl substances (PFAS), known as “forever chemicals,” which are commonly found in household products, food packaging, and cosmetics. Long-term exposure to PFAS has been associated with numerous serious health effects, including an increased risk of several cancers, disruption of hormone homeostasis, liver toxicity, impaired immune function, and adverse reproductive and developmental outcomes. The participants included housewives and adolescent girls ($n = 20$) who attended Padang Pasir Community Health Center, East Padang, Padang on 6 September 2025. An interactive educational session was conducted using a pre-test-post-test design to evaluate changes in knowledge and awareness. Analysis of participants who completed both assessments showed an improvement in knowledge following the intervention, with the greatest increases observed in understanding of healthy cooking utensils (50%) and the presence of persistent chemicals in cosmetics (50%). However, evaluation of awareness levels revealed only a minimal increase in median scores (from 57 to 60), which was not statistically significant ($p = 0.221$). We conclude that a focused educational session is effective in improving participants' cognitive knowledge, but a more comprehensive and sustained approach is needed to promote meaningful behavioral change and deeper awareness, particularly since practicality and convenience remain major considerations when choosing household products, food packaging, and cosmetics.

Keywords: household equipment, awareness, cosmetics, knowledge, PFAS

INTRODUCTION

The rapid advancement of modern technology and industry has introduced numerous innovations that simplify daily life; however, it has also brought new chemical substances into the environment and the human body. One group of chemicals that has gained global attention is per- and polyfluoroalkyl substances (PFAS), widely referred to as “forever chemicals.” This term reflects their exceptionally strong carbon-fluorine bonds, which make them highly stable and resistant to degradation, requiring hundreds to thousands of

years to break down in the natural environment (Evich et al., 2022). As a result, these substances can persist in the environment, contaminate water, soil, and air, and accumulate in the bodies of humans and animals through bioaccumulation processes (Li et al., 2022).

PFAS have been extensively used since the 1940s in various industrial applications and consumer products due to their water-repellent, oil-resistant, stain-resistant, and heat-resistant properties. Exposure to PFAS can occur through several pathways, including consumption of contaminated drinking water or food, use of PFAS-containing products, and inhalation of polluted air. Among the most common and relevant sources of exposure in daily life are household items, food packaging, and cosmetics (Dewapriya et al., 2023). Non-stick cookware, such as Teflon-coated pans, is known to contain PFAS. Likewise, food packaging—including microwave popcorn bags, pizza boxes, and ready-to-eat containers—is often coated with PFAS to prevent grease and oil leakage (Ramírez Carnero et al., 2021). The cosmetics industry also utilizes PFAS, particularly in waterproof and long-lasting products such as foundations, mascaras, and lipsticks, to enhance consistency and water resistance (Keawmanee et al., 2024). Our previous research demonstrated that various personal care products contain toxic substances that may pose health risks, particularly among adolescent girls (Putra et al., 2023).

Long-term exposure to PFAS has been associated with numerous serious health problems. Studies have reported links between PFAS levels in the body and an increased risk of specific cancers, including testicular, kidney, and thyroid cancers (Messmer et al., 2022). Additionally, PFAS may disrupt thyroid hormones, damage the liver, impair immune function, and exert adverse effects on reproductive and developmental health, such as delayed puberty in adolescent girls and reduced bone mineral density (Fenton et al., 2020). Our recent research also indicated a potential positive association between postnatal PFAS exposure and obesity risk in children older than three years (Brataatmaja et al., 2025). These findings raise significant concern, particularly for vulnerable populations such as pregnant women and adolescent girls.

In Indonesia, a study conducted by the Nexus3 Foundation and IPEN reported high levels of PFAS in consumer products, including food packaging and synthetic clothing sold in local markets (Nexus for Environmental, Health and Development Foundation, 2023). These findings are particularly relevant given the absence of specific regulations on PFAS in food packaging by Indonesia's National Agency of Drug and Food Control (BPOM), underscoring the need for public education to protect consumers. Our previous community engagement program, which provided online educational webinars on PFAS in waterproof cosmetics, successfully improved participants' knowledge and attitudes regarding the presence and hazards of these toxicants (Ilmiawati et al., 2023). The widespread presence of PFAS highlights the urgent need for educational interventions. This community service activity was designed to address existing gaps in public knowledge and awareness. The primary objectives of this program were to: (1) provide education on PFAS hazards and common exposure sources in daily life; (2) assess improvements in participants' knowledge following the educational session; and (3) evaluate changes in participants' awareness of PFAS-related risks.

METHOD

This community service activity was conducted on 6 September 2025 at the Padang Pasir Community Health Center in Padang and involved participants consisting of housewives and adolescent girls who visited the health center. The location was selected based on its accessibility and its suitability for reaching the target population relevant to

the topic. The duration of the activity included the pre-intervention, intervention, and post-intervention phases. Figure 1 illustrates the flow of the community service activity.



Figure 1. Flow of the community education program on PFAS exposure from household products, food packaging, and cosmetics among housewives and adolescent girls at the Padang Pasir Community Health Center, East Padang, Padang

The first stage involved collecting baseline data (pre-test) using a structured questionnaire (Figure 2). The questionnaire was designed to assess two main components: (1) respondents' demographic characteristics and habits related to the use of cooking utensils, food packaging, and cosmetics; and (2) their baseline knowledge and awareness regarding the hazards of PFAS. The pre-intervention questionnaire included items on the types of cooking utensils used, frequency of use, reasons for product selection, and key questions addressing the dangers and health impacts of these chemicals.



Figure 2. Baseline data collection (pre-test) (A) and post-intervention assessment (post-test) (B) were conducted with the assistance of graduate students from the Master's Program in Biomedical Sciences, Faculty of Medicine, Universitas Andalas, Padang.

The main intervention consisted of a health education session delivered through an interactive presentation and open discussion. The educational material covered an introduction to PFAS as highly persistent chemicals, the primary sources of exposure in

everyday products (such as non-stick cookware, styrofoam, and paper-based food packaging, and waterproof cosmetics), and scientifically documented health effects. In addition, the session provided practical tips for reducing exposure, including choosing alternatives such as stainless steel or ceramic cookware, using personal reusable food containers, and reading cosmetic ingredient labels to avoid components containing “fluoro” or “PTFE.” The illustrations of health education session activity were seen in Figure 3.



Figure 3. Health education session on PFAS delivered by Prof. dr. Ilmiawati, Ph.D (A and B), and reproductive health education delivered by Dr. dr. Roza Silvia, MClInEmbryol (C and D)

After the educational session was completed, a post-intervention questionnaire (post-test) was distributed to all participants (Figure 2). This questionnaire contained the same items as the pre-test to assess changes in knowledge and awareness following the educational intervention. The comparison of pre-test and post-test scores served as an indicator of the program’s effectiveness.

The collected data were analyzed using descriptive statistical methods to summarize participant characteristics and habits (frequency and percentage). To compare knowledge and awareness scores before and after the intervention, a non-parametric statistical test—the Wilcoxon Signed Rank Test was used for paired data, with the level of significance set at $p < 0.05$.

RESULTS AND DISCUSSION

A total of 20 respondents participated in this activity. The demographic characteristics showed that most participants (55%) were older than 25 years, while the remaining 45% were ≤ 25 years. The characteristics of participant data are presented in Table 1. Epidemiological studies indicate that PFAS exposure occurs across all age groups and genders (Szilagyi et al., 2020). In terms of occupation, students made up the largest proportion (50%), followed by housewives (25%), traders (15%), and adolescent girls (10%).

Table 1. Characteristics of housewives and adolescent girls (n=20) participating in the health education session at Padang Pasir Community Health Center, East Padang, Padang

Characteristic	Category	Frequency	Percentage (%)
Age	≤ 25 years	9	45
	> 25 years	11	55
Job	Student	10	50
	Housewife	5	25
	Trader	3	15
	Adolescent girls	2	10
Pregnancy history	Ever/currently pregnant	14	70
	Never pregnant	6	35
Household income (per month)	< Rp. 1.500.000	8	40
	Rp. 1.500.000-2.500.000	7	35
	Rp. 2.500.000-3.500.000	1	5
	>Rp. 3.500.000	4	30

The analysis of daily product-use habits showed that respondents had a high level of exposure to products potentially containing PFAS. A total of 70% of respondents reported using non-stick cookware, with most using it on a daily basis. Regarding reasons for use, 50% chose such cookware because it is “easy to clean,” and 45% because “food does not stick.” Only 10% selected “healthier” as their reason, indicating that practicality and convenience were the primary factors influencing purchasing decisions, rather than health considerations.

These findings indicate that although products potentially containing PFAS are widely used, health considerations have not yet become a dominant factor in household consumption behavior. A strong preference for practicality and convenience may increase the risk of long-term exposure, particularly when such products are used routinely on a daily basis. This situation provides an important rationale for the implementation of the educational session, in which the approach was designed not only to emphasize the health risks associated with PFAS, but also to contextualize these risks within the practical needs of the community. Therefore, educational interventions should highlight that safer cookware alternatives can still offer functional benefits and ease of use, thereby increasing the likelihood that health messages are accepted and translated into potential behavioral change.

The use of packaged food and beverages was also high, with 65% of respondents reporting consumption. The primary reason for choosing these products was “more practical” (45%), followed by “healthier” (30%) and “more hygienic” (10%). The most commonly used types of packaging were plastic containers, styrofoam, and glass, each accounting for 30.0%. The majority of respondents (85.0%) consumed 1–5 packaged products per day.

These findings were directly addressed during the educational intervention by clarifying that certain types of food packaging, especially plastic- and paper-based materials, may contain persistent chemicals that can migrate into food. Consequently, the education session emphasized practical risk-reduction strategies, such as minimizing the use of single-use packaging and adopting personal reusable containers, to align health messages with participants’ daily routines and practical needs.

In the area of cosmetics, 89.5% of respondents reported using cosmetic products, with 65.5% using them 1-3 times per day. Although 65.5% did not use waterproof cosmetics, 50% preferred long-lasting products, with the main reason being “long-lasting”

(35.5%). These behavioral patterns highlight a common dilemma in consumer behavior: the tension between convenience and potential health risks. Most respondents, regardless of age or occupation, seemed to prioritize practicality in their daily routines, a preference that may limit the acceptance of new information regarding health risks. This understanding is crucial when interpreting the outcomes of the educational intervention.

Complete data on cookware, food packaging, and cosmetic-use habits are presented in Table 2. Special attention should be given to eye and lip products such as lipsticks, eye shadows, eyeliners, and mascaras because the risk of absorption through the skin and ingestion through the mouth is significantly higher in these areas compared to other parts of the body (Mesko et al., 2020).

Table 2. Summary of cooking utensil, food packaging, and cosmetic use habits among housewives and adolescent girls (n=20) who participated in the health education session at Padang Pasir Community Health Center, East Padang, Padang

Category	Questions	Answer Choices	Frequency	Percentage (%)
Cooking utensil	Cooking utensils you use (Q1) (Multiple answers allowed)	Teflon	9	45
		Stainless-steel	2	10
		Iron	1	5
		Ceramic	2	10
		Aluminum	2	10
		Don't know	5	25
	Do you use non-stick cookware? (Q2)	Yes	14	70
		No	6	30
	Frequency of non-stick cookware use? (Q3)	Every day	9	45
		Often	1	5
		Sometimes	4	20
		Seldom	3	15
		Never	3	15
	Prefer non-stick cookware over regular cookware (Q4)	Yes	14	70
		No	6	30
	Reasons for choosing the option above (Q5)	Food does not stick	9	45
		Easy to clean	10	50
		Healthier	2	10
	Number of non-stick cookware items used (Q6)	1-3 per day	18	90
		>5 per day	2	10
Food packaging	Do you consume packaged food/drinks? (Q7)	Yes	13	65
		No	7	35
	Type of packaging (Q8) (You can choose more than one option)	Paper	1	5
		Mica plastic	6	30
		Styrofoam	6	30
		Aluminum	2	10
		Glass	6	30
		Don't know	2	10

Frequency of consumption? (Q9)	Every day	6	30	
	Often	4	20	
	Sometimes	1	5	
	Seldom	2	10	
	Never	7	35	
Do you prefer to consume packaged food or drinks rather than those that come in their own packaging? (Q10)	Yes	7	35	
	No	13	65	
Reasons for your choice? (Q11)	Healthier	6	30	
	More practical	9	45	
	More hygienic	2	10	
	Other	4	20	
How many packaged foods and drinks do you consume per day? (Q12)	>5 times a day	3	15	
	1-5 times a day	17	85	
Cosmetics	How often do you use cosmetics on a daily basis? (Q13)	> 5 times a day	3	15
		4-5 times a day	2	10
		1-3 times a day	13	65.5
		No cosmetics	2	10
	Do you use waterproof cosmetics? (Q14)	Yes	6	30
		No	13	65.5
		Don't know	1	5
	Frequency of use? (Q15)	Always	3	15
		Often	3	15
		Sometimes	4	20
		Rarely	6	30
		Never	4	20
	What types of cosmetics do you use that are waterproof, non-sticky, and long-lasting? (Q16)	Make up base	9	45
		Face powder	2	10
		Lip cosmetics	5	25
		Other	4	20
	Do you prefer waterproof, non-sticky, and long-lasting cosmetics over regular products? (Q17)	Yes	10	50
		No	10	50
	Why did you choose the options above? (Q18) (You can choose more than one option)	Long-lasting	7	35.5
		Non-transfer	4	20
		Doesn't fade when exposed to water	1	5
		Cheaper	2	10
		Other	6	30

Knowledge Levels Before and After the Educational Intervention

The comparison of pre-test and post-test scores demonstrated that the educational intervention effectively improved participants' knowledge levels (Table 3). In nearly all categories, there was an increase in the percentage of respondents who reported "know" about PFAS-related hazards following the intervention. The most notable improvement was observed in the question regarding the healthiest types of cookware, where the percentage of respondents who answered correctly increased by 50%. Other questions that

also showed substantial improvement included the health impacts of non-stick cookware (45%) and the presence of persistent chemicals in cosmetics (50%).

Before the intervention, knowledge level about these topics was relatively low; for example, only 15.0% of respondents were aware of the potential health impacts associated with non-stick cookware. The ability of the educational session to bridge these knowledge gaps indicates that the material presented was both relevant and easily understood by the target audience.

These findings also highlight the important role of healthcare workers and local institutions, such as community health centers, as agents of change in improving public health literacy. By leveraging institutional proximity and community trust, messages regarding the hazards of PFAS and strategies to reduce exposure can be delivered in a more consistent and persuasive manner. Overall, the knowledge gained through this activity provides a strong foundation for the development of more comprehensive follow-up interventions oriented toward sustainable behavior change.

Table 3. Level of knowledge of housewives and adolescent girls (n=20) who attended educational session regarding PFAS exposure and health risks at Padang Pasir Community Health Center, Padang

Key Questions	Percentage of Subjects Answering 'Know'	
	Pre-test	Post-test
Cooking utensil		
Q19: Do non-stick coatings stick to food?	25%	65%
Q20: Are non-stick coatings made from chemicals that are difficult to break down?	35%	65%
Q21: Are non-stick cookware good for your health?	15%	60%
Q22: Are cookware good for your health?	35%	85%
Food packaging		
Q25: Are chemicals difficult to decompose in packaging?	35%	60%
Q26: Do chemicals from packaging contaminate food?	60%	65%
Q27: Are there health impacts of food packaging?	30%	65%
Cosmetics		
Q29: Are the chemicals in cosmetics difficult to break down?	15%	65%
Q30: Can cosmetics accumulate in the body?	30%	70%
Q31: Can cosmetics be absorbed by the body?	45%	75%
Q32: Health effects of cosmetics?	50%	70%

Awareness Levels Before and After the Educational Intervention

The gap between improved knowledge and stagnant awareness represents an important finding (Table 4). Knowledge refers to cognitive understanding of facts (e.g., "PFAS are harmful"), whereas awareness reflects a heightened sense of vigilance that motivates intention or action (e.g., "I should avoid products containing PFAS"). While the brief educational session was effective in conveying factual information, it had a relatively limited impact on shifting the underlying values that drive daily behavior.

As noted earlier, most respondents prioritized practicality and convenience when choosing products. Although awareness of potential health risks may have increased, it was not strong enough to overcome entrenched habits rooted in convenience.

Table 4. Level of awareness score before and after educational session regarding PFAS exposure and health risks among housewives and adolescent girls (n=20)

Variabel	Median (IQR) Pre-test	Median (IQR) Post-test	Δ Median (Post-Pre)	p-value
Awareness	57 (13.8)	60 (13.8)	3.0	0.221*

*Wilcoxon Signed Rank Test

These findings align with the broader behavioral science and public health literature, which consistently shows that meaningful behavior change requires more than the transfer of information. Sustainable message reinforcement, approaches that are culturally and socially relevant, and the availability of accessible and appealing alternatives are all essential. For example, challenging preferences for “more practical” or “easy to clean” products require demonstrations or hands-on experiences that show healthier alternatives can also be practical and efficient.

Therefore, although this program successfully improved participants’ knowledge, increasing awareness will require more intensive and longer-term efforts. These findings provide a foundation for strengthening future community outreach programs that address not only what the community knows, but also how that knowledge influences attitudes and behaviors.

This activity had several limitations, including a small and relatively homogeneous participant group, the absence of follow-up monitoring to evaluate behavioral change, and the implementation of only a single educational session.

Despite these limitations, the intervention demonstrated a positive short-term impact by enhancing knowledge of PFAS exposure and associated health risks, particularly related to safer cookware and cosmetic products. The minimal change in awareness highlights the need for sustainable strategies, such as repeated educational sessions, practical demonstrations, and the integration of PFAS education into routine health promotion activities at local health centers.

CONCLUSION

Overall, this community outreach activity demonstrated that a single educational intervention can effectively improve the knowledge of housewives and adolescent girls regarding the risks associated with PFAS in household items, food packaging, and cosmetics. The significant increase in knowledge—particularly concerning health effects and the persistence of these chemicals highlights the relevance and effectiveness of the educational content delivered.

However, the findings also reveal a broader challenge. Although knowledge improved, the increase in awareness was not significant. This indicates a gap between cognitive understanding and the level of awareness that drives behavior. Daily product choices driven by practicality, convenience, and long-established habits appear to outweigh newly acquired information about health risks. Based on these findings, several recommendations can be made for future community engagement programs.

First, future community engagement programs should move beyond single-session activities by incorporating sustained and repeated interventions to reinforce key messages, allow sufficient time for internalization, and support the gradual adoption of healthier behavior. Second, these programs should also include practical, hands-on activities, such as demonstrations on identifying PFAS-containing ingredients on cosmetic labels or cooking workshops using safer cookware, to help overcome real-world barriers. Third,

collaboration with relevant government agencies, including Pusat Kesehatan Masyarakat (Puskesmas) and Badan Pengawasan Obat dan Makanan (BPOM), is essential to support policy advocacy, promote stricter regulation of PFAS use, and improve the availability of safer consumer products. Finally, further longitudinal research is needed to evaluate the long-term effectiveness of educational interventions and to identify key barriers to behavior change, such as cost, social norms, and product accessibility.

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