

# Nursing students' knowledge and attitudes regarding brominated flame retardants from three Croatian universities

Brominated  
flame  
retardants

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Krešimir Jakšić

*Department of Psychology, University of Zadar, Zadar, Croatia*

Marijana Matek Sarić

*Department of Health Studies, University of Zadar, Zadar, Croatia, and*

Jelena Čulin

*Maritime Department, University of Zadar, Zadar, Croatia*

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## Abstract

**Purpose** – This study explored Croatian nursing students' knowledge and attitudes regarding brominated flame retardants (BFRs) as indicators of their predisposition to educate future patients. The purpose of the study was to identify knowledge gaps and barriers and to propose possible remedies.

**Design/methodology/approach** – The cross-sectional survey was conducted on a convenience sample of 114 nursing students at undergraduate and graduate levels from three Croatian universities during the winter semester in the academic year 2018–2019. Descriptive and inferential statistical analyses were performed using STATISTICA 13 software.

**Findings** – Slightly over half of the students (58.49%) were knowledgeable of BFR health effects and 45.28% showed knowledge about its presence in the environment. Only 33.02% of students identified prenatal exposure effects and 24.53% answered correctly about legislative actions. Participants expressed modest interest in the topic ( $M = 3.15$ ,  $SD = 1.35$ ). Although informing the public on the health consequences of BFRs was important to them ( $M = 4.18$ ,  $SD = 1.03$ ), they did not perceive health-care providers as primarily responsible for communicating that information.

**Originality/value** – There is a need to enhance related content in the curriculum to improve students' knowledge. Raising students' awareness regarding the role of nurses in clinical and policy arenas is proposed to facilitate active participation in improving environmental health.

**Keywords** Brominated flame retardants, Environmental health, Environmental health advocacy, Nursing students, Stockholm Convention

**Paper type** Research paper

## Introduction

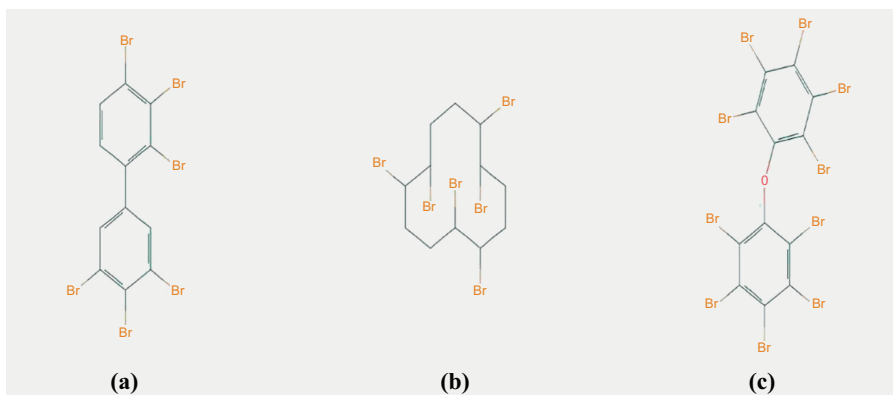
The Stockholm Convention on Persistent Organic Pollutants (Stockholm Convention) was adopted in 2001 and aimed to protect human health and the environment from synthetic substances characterized by the resistance to environmental degradation, the ability to accumulate in living tissues, the ability for long-range environmental transport and toxicity [1]. Initially, it regulated 12 persistent organic pollutants (POPs). Currently, it focuses on eliminating or reducing production and usage of 28 intentionally produced chemicals.

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Several brominated flame retardants (BFRs), chemicals which delay ignition and slow subsequent fire growth, were shown to fulfill inclusion criteria and belong to so-called new POPs because they have been added after 2001. Hexabromobiphenyl, commercial octabromodiphenyl and commercial pentabromodiphenyl ethers in 2009, hexabromocyclododecane in 2013 and commercial mixture, c-Deca BDE in 2017, are listed in Annex A, meaning that their production is no longer allowed, used, imported or exported except following provisions of the Stockholm Convention. The chemical structures of some listed BFRs are given in Figure 1.



**Figure 1.** Chemical structures of some brominated flame retardants listed in the Stockholm Convention

**Note(s):** a) 2,3,3',4,4',5'-hexabromobiphenyl [2], b) 1,2,5,6,9,10-hexabromocyclododecane [3], c) decabromodiphenyl ether [4]

However, they were widely used in products with long usage times, such as furniture and upholstery in homes and vehicles and building materials. Moreover, recycling exemptions enable the contamination of new products [5]. Therefore, they may pose a risk to human health in the future [6].

Under the Stockholm Convention, signatory countries are obliged to promote and facilitate public information, awareness and education regarding the issue of POPs. Educational and public awareness programs for women, children and the least educated are recognized as particularly important because they are the most vulnerable groups. Epidemiological and experimental evidence links BFRs with endocrine disruption and neurological, reproductive, metabolic, developmental and immune adverse health effects such as alterations in thyroid hormone levels, type 2 diabetes, insulin resistance, reduced fecundability, changes in the timing of menarche and pubarche, male genitourinary conditions, lower birth length, weight, lower chest and head circumference, reduced intelligence quotient (IQ), impaired attention, poorer fine motor coordination [7], including widespread health problems such as cancer [8] or obesity [9]. Therefore, governmental bodies (the United States Environmental Protection Agency) [10] and professional organizations (American Academy of Pediatrics, American College of Nurse-Midwives, American College of Obstetricians and Gynecologists, American Society for Reproductive Medicine, Association of Women's Health, Obstetric and Neonatal Nurses and International Federation of Gynecology and Obstetrics) [6, 11] serve as science-based sources of information and suggest actions to reduce individual exposure.

The successful implementation of the Stockholm Convention also depends on bridging the gap between scientists and decision makers. *Health providers, as an important stakeholder, and highly trusted*, can inform policymakers, demand regulatory changes and take other actions in policy settings [12]. However, there is a need to build their knowledge and capacity.

An inclusion of POPs issues within university curricula has been recognized as a tool for the empowerment of relevant stakeholders to acknowledge the health risks related to POPs and advocate for policies, strategies and programs that decrease exposure [13]. As nurses

constitute the greatest professional segment of Croatian health providers [14] and work in various areas in the health system, they are in a unique position to provide information and enable individuals to make informed environmental health choices. Contents of the Croatian undergraduate university programs of nursing are in accordance with the Directive 2005/36/EC of the European Parliament and of the Council of 7 September 2005 on the recognition of professional qualifications [15] and Directive 2013/55/EU of the European Parliament and of the Council of 20 November 2013 [16]. There are no obligatory courses completely dedicated to environmental health but related topics have been addressed in three obligatory courses at the undergraduate level: hygiene and epidemiology, public health and dietetics. An overview of syllabi showed that some chemicals regulated under the Stockholm Convention have been covered but BFRs have not been among them. However, there is a possibility that some lecturers have broadened the range of topics beyond those listed in the curriculum.

This study aimed to explore Croatian predisposition to contribute to the implementation of the Stockholm Convention related to BFRs. Therefore, nursing students' knowledge about toxicity and exposure to BFRs and three dimensions of attitudes toward BFRs were assessed in this study: personal interest for the topic, perceived importance of informing the general public on BFRs' health consequences and perceived responsibility of specific sources (government, media, medical associations, health-care practitioners and self-informing) to inform the general public on BFRs' health consequences.

## Methodology

### *Participants*

Participants from three Croatian universities (University of Zadar, University of Split and University of Dubrovnik) were included in the sample using a convenience sampling technique [17]. A questionnaire was group administered during the winter semester of the academic year 2018–2019. Since the study was exploratory, the sample size could not be specified *a priori*. All students who agreed with the terms of the study were included in the sample.

### *The questionnaire*

Participants were asked to answer four multiple choice questions which briefly assessed their knowledge of different aspects of BFRs (Table 1). After a systematic literature review, item development was based on special communication issued by the International Federation of Gynecology and Obstetrics [18]. Our goal was to create items that would assess participants' basic knowledge of those facts about BFRs that are essential for future nurses' actions to reduce the most vulnerable population exposure. Knowledge on the BFRs' presence in the environment (question 1), BFRs' health effects (question 2), legislative actions on BFRs (question 3) and effects of BFRs prenatal exposure (question 4) was investigated. A group of three experts read questions and agreed on their content. Participants' attitudes regarding BFRs were assessed in three ways: they expressed their interest in the topic of BFRs using a Likert-type scale ranging from 1 (not interesting at all) to 5 (totally interesting), rated how important it is in their opinion to inform the general public about BFRs (1: not important at all, 5: totally important) and finally rated five specific sources (government, media, medical associations, health care practitioners, individuals) in terms of their responsibility to inform the general public of BFRs and their possible related health consequences. Each source was rated on the scale from 1 (most important) to 5 (least important).

### *The data analysis*

*The analysis related to knowledge assessment.* Answers to each question were coded as either correct (1) or incorrect (0). In the case when the participant did not answer all the questions (which was the case for one participant), missing responses were coded as incorrect answers. Because the results of the exploratory factor analysis did not confirm the one-dimensional model (Table 1), a summation of the scores was not justified and the analysis was done on the

Question	Answers	Factor loading
1. BFRs can be present in (circle one or more of the following)	(1) Food (2) Dust (3) Mother's milk (4) All answers are correct (5) No answer is correct	0.24
2. Exposure to BFRs is related to (circle one or more of the following)	(1) Reproductive problems in adults (2) Neurological problems in adults (3) Psychomotor and cognitive impairment in children (4) All answers are correct (5) No answer is correct	0.14
3. Please circle the correct statement	(1) No BFRs have been forbidden in any country (2) In some countries, certain BFRs have been forbidden and replaced by BFRs with known levels of toxicity (3) In some countries, certain BFRs have been forbidden and replaced by BFRs with unknown levels of toxicity	-0.52
4. Please circle the correct statement	(1) BFRs pass through the placenta and their concentration in umbilical serum is significantly higher than that in the mother's serum (2) BFRs do not pass through the placenta and their concentration in umbilical serum is significantly lower than that in the mother's serum (3) BFRs pass through the placenta and their concentration in umbilical serum is significantly lower than that in the mother's serum	0.44

**Table 1.**

The factor analysis of the knowledge test

**Note(s):** \*analysis was conducted in R 3.6.1. in package "Psych" on the polychoric correlation matrix. If items were unidimensional, all would have positive loading equal to or higher than 0.3

item level. To test if there was any statistically significant difference in the number of correct and incorrect responses on particular questions, the difference between two proportions was calculated. The critical  $p$ -value was set at  $p = 0.0125$  applying the Bonferroni correction (0.05/4 comparisons) to keep a family-wise error rate at 5%.

*The analysis related to attitudes assessment.* Descriptive statistics (mean and standard deviation) were used to present data on participants' interest in the topic of BFRs and their opinion on how important it was to inform the general public about BFRs. To assess if there are differences in the evaluation of participants' perceived responsibility of different sources to inform the general public about BFRs health consequences, Friedman's test was applied. The critical  $p$ -value for Friedman's test was  $p < 0.05$ . *Post hoc* analyses were performed using Wilcoxon's matched pairs test. To keep the probability of type 1 error at 5%, the Bonferroni correction was applied. The critical  $p$ -value was set at 0.005 (0.05/10 comparisons).

#### *Ethics consideration*

Approval of the Ethical Committee of the University of Zadar (class: 114-06/1701/13, reg. no. 2198-1-79-37/1802) was obtained before commencing the study.

## **Results**

### *Sample characteristics*

In total, 114 nursing students at the undergraduate and graduate levels participated in the survey. In the final sample, students were included based on a few specific criteria. To be

included in the final sample, participants had to answer at least one question in the BFRs knowledge test (which was seen as participants' willingness to participate in the test) to completely follow BFR test instructions (e.g. some participants circled that both one specific answer was correct and that all possible answers were correct, which was contradictory) and to fill in most of the other questionnaire parts (especially demographic data and the part on attitudes toward BFRs). Based on these criteria, the final sample consisted of 106 students ( $M = 29.00$ ,  $SD = 8.71$ ). Most students were in the third year of their studies ( $n = 48$ ) and were dominantly women ( $n = 100$ ) because commonly, women are prevalent in this profession.

### *Knowledge*

The frequency of correct and incorrect answers per question on the knowledge test is given in [Table 2](#). Nursing students did not differ in the proportions of correct and incorrect answers on question 1 and question 2, but they did differ in the proportion of correct and incorrect answers to question 3 and question 4. The proportion of incorrect answers to both questions was higher than the proportion of correct answers.

### *Attitudes*

*Interest in the topic of brominated flame retardants.* It could be expected that participation of nurses in accessing and providing information to patients and communities, promoting more environment-friendly health care and engagement in political and economic decisions related to BFRs would depend on their interest in an issue. Participants of this study expressed modest interest in the topic of BFRs ( $M = 3.15$ ,  $SD = 1.35$ ).

*Informing the general public on brominated flame retardants.* Participants of the study found that informing the public on the health consequences of BFRs was very important ( $M = 4.18$ ,  $SD = 1.03$ ). However, they did not perceive all sources of information as equally important ( $X^2 = 80.15$ ,  $df = 4$ ,  $p = 0.000$ ) ([Table 3](#)). Specifically, nursing students found self-informing as the least important way of gathering information about BFRs' health consequences on human health in comparison to other sources (all  $p = 0.000$ ), which could be expected because of the complexity of the issue. Furthermore, students found the media to be a more important information source than medical associations ( $p = 0.000$ ). However, all other sources were recognized as moderately important, without a clear distinction between different sources ( $p > 0.005$ ), indicating that there is a possibility that the role of the health practitioners in the provision of information related to environmental health may not be recognized by students. That is potentially worrying due to the unique position of nurses as a trusted source of information [19] and translators of scientific health literature.

## **Discussion**

The difference in the proportion of correct and incorrect answers on questions 1 and 2 and questions 3 and 4 is not particularly surprising given the questions' content. Questions 3 and 4 required knowledge of highly specific details about BFRs which participants probably did not have an opportunity to acquire during their studies. Contents of questions 1 (presence of BFRs in the environment) and 2 (BFRs' health consequences) allowed for educated guessing and that could be a reason why they seemed to be easier for participants to respond correctly. That is particularly valid for question 2 because it could be expected that nursing students would be able to answer it correctly since their general knowledge helped them to make an educated guess.

In summary, this study shows that participants possess low to relatively moderate knowledge regarding BFRs. As discussed above, BFRs most likely were not included in the curricula. Other possible information sources such as the Internet and mass media and

Question	Choices	Answers		P	Total (N)
		Correct (N) (%)	Incorrect (N) (%)		
1. BFRs can be present in (circle one or more of the following)	(1) Food (2) Dust (3) Mother's milk (4) All answers are correct (5) No answer is correct	48 (45.28%)	58 (54.72%)	0.31	106
2. Exposure to BFRs is related to (circle one or more of the following)	(1) Reproductive problems in adults (2) Neurological problems in adults (3) Psychomotor and cognitive impairment in children (4) All answers are correct (5) No answer is correct	62 (58.49%)	44 (41.51%)	0.10	106
3. Please circle the correct statement	(1) No BFRs have been forbidden in any country (2) In some countries, certain BFRs have been forbidden and replaced by BFRs with known levels of toxicity (3) In some countries, certain BFRs have been forbidden and replaced by BFRs with unknown levels of toxicity	26 (24.53%)	80 (75.47%)	0.000**	106
4. Please circle the correct statement	(1) BFRs pass through the placenta and their concentration in umbilical serum is significantly higher than that in the mother's serum (2) BFRs do not pass through the placenta and their concentration in umbilical serum is significantly lower than that in the mother's serum (3) BFRs pass through the placenta and their concentration in umbilical serum is significantly lower than that in the mother's serum	35 (33.02%)	71 (66.98%)	0.001**	106

**Table 2.**  
Frequency of correct and incorrect answers per question on the knowledge test

**Note(s):** \*correct answers: 4, 4, 3 and 1  
\*\*Difference between proportions of correct and incorrect answers is statistically significant ( $p < 0.0125$ )

**Table 3.**  
Medians of participants' perceived responsibility of different sources to inform the general public about brominated flame retardants' health consequences

Median	Government	Media	Medical associations	Health-care practitioners	Self-informing
	3	2	3	3	5

**Note(s):** \*from 1 (most important) to 5 (least important)  
\*\*Students find self-informing as the least important way of gathering information about BFRs' health consequences on human health in comparison to other sources (Wilcoxon's matched pairs test; all  $p < 0.005$ )

preferred media for the access of environmental information by young people [20] do not or rarely address the issue of POPs in Croatia [21]. Education, public information and awareness raising are defined as a priority in the Second National Implementation Plan for the Stockholm Convention on Persistent Organic Pollutants in the Republic of Croatia [21]. To the best of our knowledge, there are no published studies addressing nursing students' knowledge related to BFRs. Also, there are no published studies investigating knowledge related to the environmental risks of nursing students in Croatia. However, recent international literature suggests that there is a need to improve basic knowledge of environmental health among nursing students [22–24]. For example, the Alliance of Nurses for Healthy Environments to facilitate environmental nursing education offers curricular recommendations, teaching tips and published e-textbook, Environmental Health in Nursing [25].

Including topics related to BFRs in the curriculum could facilitate the implementation of the Stockholm Convention. Namely, nurses' familiarity regarding BFRs can play an important role in reducing exposures of vulnerable groups. Providing preconception care, including information on environmental health by nurses and midwives has been recommended as a measure to improve the chances of conception and to optimize pregnancy outcomes [26]. Because BFRs have been associated with an increased risk of infertility [27] and spontaneous abortion [28], nurses can advise future parents about sources of emission and ways to reduce exposures. Similarly, nurses are involved and frequently asked for advice regarding the health and well-being of children [29] and they can help to diminish childhood exposure by counseling parents to purchase furniture, toys and baby products that do not contain BFRs, avoid mouthing electronic devices, keep dust levels down or wash hands regularly [25].

One of the requirements of the Stockholm Convention is to monitor the presence, levels and trends of POPs in humans. Breast milk has been recognized as a convenient and noninvasive sample matrix and was used to monitor POPs (organochlorine pesticides and polychlorinated biphenyls) [21]. However, because there is a possibility that information on contaminants discourages breastfeeding, educational programs showing the advantages of breastfeeding, particularly in case of higher chemical body burdens should be provided concurrently [30]. Research indicates that nurses can encourage breastfeeding by providing informational support to mothers [31]. Additionally, studies have shown that fathers' positive attitudes related to knowledge regarding breastfeeding positively influenced overall breastfeeding success. Again, the role of the nurses has been emphasized [32]. Therefore, this paper proposes introducing teaching that hazards posed by infant exposure to BFRs in human milk are outweighed by benefits of breastfeeding to enable future nurses to counsel parents to avoid possible anxiety and confusion about breastfeeding. Moreover, nurses can be involved in developing educational material for potential participants in breast milk biomonitoring studies to avoid communication gaps [33].

Knowledge and expertise, analytics, leadership and communication skills are vital for ensuring that nurses are well qualified for advocacy work [34]. However, although nurses' social and ethical roles and responsibilities regarding participation in shaping more health-protective policies have been widely recognized and emphasized, studies indicate that even when many educational opportunities, learning tools and advocacy strategies exist, the level of their involvement remains low [35, 36]. Studies performed in different countries identified numerous barriers and challenges preventing engagement in policy advocacy [37]. On the other hand, perceived effectiveness, control beliefs and personal interest in a topic facilitate participation.

Lectures on BFRs may address this significant aspect of nurses' professional role that is not emphasized enough in nursing programs, although it is important to educate students about it. For example, the issue of flame retardants regulation in the USA may be presented as

an example of successful advocacy because the coalition of groups and activists achieved a wide range of policy advances [38]. Namely, the Washington State Nurses Association, as a member of the Toxic-Free Legacy Coalition helped pass laws banning polybrominated diphenyl ethers (PBDEs) [39]. Moreover, biomonitoring research performed in Sweden revealed that body burdens of BFRs have decreased following regulation [30].

Furthermore, health care and nursing practices significantly contribute to the emissions of toxic materials and it is important to equip nurses to practice health care in a way that would reduce compromising public health, to be involved in greening medical facilities and to influence environmental health policy [40, 41]. Therefore, environmental impacts of nursing practice and relevance for nurses, as one of the most exposed professions, need to be included in educational curricula [42]. For example, the results of the biomonitoring study of health-care professionals showed that PBDEs were found in all participants (nurses and doctors) [43].

Participants expressed modest interest in the topic, which is not surprising given that this topic is probably not covered in the study program and is not present in media, as discussed earlier. Moreover, there are no published biomonitoring results for Croatia yet, although it could be expected that they are present both in humans and the environment [21] and Croatia should have performed monitoring on the presence of BFRs in food according to the European Commission's Recommendation 2014/118/EU [44]. However, further research is needed to establish whether nursing students find more interesting topics related to other contaminants or reasons for their level of interest in environmental health.

#### *The study's limitations*

The conducted study is not without limitations. The sample was convenient and may not entirely represent the population of nursing students in Croatia and results possibly would have been different on another sample. Also, there is a possibility that students with more knowledge or interest completed the survey, so this could lead to an overestimation in the results. Moreover, we assessed participants' knowledge of limited aspects of BFRs and for each aspect, only a single question was used. Because of this, the reliability of the estimation of participants' knowledge on each dimension (item) could not be computed. In future research, more questions should be included for each facet of knowledge, which will allow for a more reliable estimate of participants' knowledge and calculation of reliability coefficient (e.g. Kuder-Richardson) for each dimension. Also, items' face validity could have been assessed by more experts and more rigorously (e.g. by calculating the index of experts' agreement on the appropriateness of each item). However, our goal was to get an initial assessment of students' knowledge to spur the development of relevant measures and we believe that item selection was appropriate in that regard. When it comes to specific items, questions 1 and 2 due to their content and construction allowed for educated guessing, while questions 3 and 4 did not. It is possible that proportions of correct answers on these questions are overestimated and that lower proportions of correct answers would have been seen if the questions were constructed differently (e.g. if we asked participants to write down three items where BFRs are present).

Also, it is possible that participants gave socially desirable responses when it came to their interest in the topic and the importance of informing the public on BFRs' consequences.

#### **Conclusions**

This is the first study to examine Croatian nursing students' knowledge and attitudes regarding BFRs. Despite its limitations, it provides information that can help to increase their competence to contribute to achieving the aim of the Stockholm Convention. Results of the study indicate that Croatian nursing students have low or moderate knowledge about BFRs



and that they do not perceive health practitioners as the most important information source when it comes to informing the general public on BFRs' health consequences. Therefore, it seems there is a need for interventions to improve their capacity for educating future patients on strategies to reduce risks related to BFRs. We propose including or enhancing related content in the nursing curriculum, particularly facts important for the protection of the most vulnerable groups (woman and children). For that purpose, learning tools may be translated or prepared. Population educational tools developed by health-care providers may be presented and discussed to raise awareness about the important role of nurses as educators.

Results indicate that Croatian nursing students have a modest interest in the topic. We suggest providing information on the results of the biomonitoring studies on BFR levels to increase interest and stimulate students to consider promoting eco-friendly practices and to influence environmental health policy.

Considering the importance of promoting environmental health by educating nurses, further research is needed on facilitators and barriers to learning about other environmental health issues. As future nurses with a clear understanding of various roles of their profession may benefit patients and advocate for interventions that can protect the most vulnerable groups, there is a need for further research to establish how nursing students in Croatia see their professional roles in society and there is a need to enable them to empower individuals and patients toward reducing environmental risks.

Conflict of Interest: None

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### Corresponding author

Marijana Matek Sarić can be contacted at: [marsaric@unizd.hr](mailto:marsaric@unizd.hr)

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