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Safety Management of Textile Products in the European Union and Estimation of its Efficiency. Part 2

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Abstract
This paper presents the second part of an analysis aimed to show the reasons for which textiles are among the consumer products most commonly notified as dangerous on the EU market. In the first part, the authors performed a synthetic review of legal regulations regarding safety requirements for clothing and textile products and carried out an analysis of the RAPEX alert system database in order to identify the origin of textiles representing a serious risk and evaluate the activity of EU countries in reporting dangerous textiles in this system. In the present part, the authors have focused on the main threats posed by textiles and analysed the RAPEX notifications mainly in terms of the nature of risk the textiles pose. It was shown that the main sources of serious risks are cords, drawstrings and small accessories in children's clothes, as well as chemical hazards, attributed mainly to the presence of dangerous aromatic amines and some heavy metals; they are the second most common risk category posed by these products.

Key words: *consumer protection, textiles safety, clothing, dangerous products, RAPEX.*

Introduction

Clothing and textile products can have both a positive and negative influence on human health and well-being. They can protect against adverse external factors but also contribute to the development of various diseases or create a risk of injuries, burns or other harmful effects. On the EU market, there is a quite big number of T&C products that do not fulfil safety requirements. Furthermore, among consumer products they belong to the group of the three non-food products most commonly notified as dangerous. To find out the reasons for this problem, an analysis of RAPEX system data covering the 15 years of its operation was carried out. The analysis presented in the first part of the paper enabled to identify the countries of T&C product origin which represent serious risks. An evaluation of the activity of EU countries was made concerning reporting dangerous textiles in this system. Taking into account that T&C products may cause various kinds of risks, in this part of the paper, the authors have focused on risks notified in the RAPEX alert system in regards to these products and explored them mainly in terms of the risk nature. The aim of this analysis was to identify the most frequently notified risks and the scale of their occurrence during the period under consideration, as well as to indicate the directions of activities that should be undertaken to improve the safety of this product group on the EU market.

Characteristics of the risks posed by textiles and their sources

In the literature of the subject, one can find a number of examples confirming the potentially negative impact of textiles on human health. The majority of them focus on a problem related to chemical substances, which are incorporated into textiles at different stages of manufacturing to make materials stronger and more versatile, and on the development of products that provide comfort, wellness, and freshness. Some of them, due to daily and direct contact with the skin, can pose a health risk to humans, including alterations (i.e. dermatitis, irritation, allergy and skin microflora reduction), or worse cause more serious illnesses such as cancer. The negative impact of chemicals on humans is connected with the fact that some of them are not bound or integrated to the fabrics, being potentially released during their use or perspiration, while others may be dissolved in a sweat, then pass in the form of a solution to the inner layers of the skin into the circulation of blood, and finally into the internal organs [1-7].

Among chemicals that are of particular concern to human health are carcinogenic amines, such as benzidine, 4-aminoazobenzene, bifenylo-4-amina, 4-aminobifenyl, 3,3'-dimethoxybenzidine, etc. (the complete list is defined in Appendix 9 of REACH Regulation) [8]. Their presence in textiles is connected with the use of azo dyes in the finishing process, which under reducing conditions (e.g. under the influence of bacteria present on human skin) are able to split off aromatic amines [5]. Their negative impact on human health has been explored for years and there is no doubt that they can cause allergic, carcinogenic, and even mutagenic activity [1, 7, 9-12]. To protect consumers against their negative influence, limits on their presence in textile products at concentrations higher than 30 mg/kg (0.003% by mass) were introduced [8]. The second group of chemicals creating a huge problem in textiles are heavy metals, which are used for many purposes, such as in metal complex dyes and pigments, and also as a mordant, a catalyst in synthetic fabric manufacture, synergists of flame retardants, antimicrobials, or as water repellents and odour-preventive agents. They are perceived as skin sensitisers (cobalt, copper, chromium), or highly toxic metals (arsenic, cadmium, mercury, lead), being carcinogenic [2-4, 13]. They can penetrate into the human body and affect the nervous, skeletal and genitourinary systems. Thus the presence of these elements in textiles is undesired. The limits for their content in textile products are set out in the REACH Regulation, and for some of them, voluntary requirements e.g. those set out in the OEKO-TEX STANDARD 100 [14] are taken into account in the safety assessment of these products (e.g. in relation to Cr(VI) the limit value is 3 mg/kg). When analysing the negative impact of chemicals on human health, formaldehyde is not to be omitted, as it has been used for many years in the textile industry as

Hazard type								
Strangulation			Choking			Laceration		
a) 			b) 			c) 		
Units Recalled	**Incidents**	**Injuries**	**Units Recalled**	**Incidents**	**Injuries**	**Units Recalled**	**Incidents**	**Injuries**
300 000	1	1 death	666 000	13	0	30 000	6	5

Figure 1. *Types of physical hazards in children's clothing based on the U.S. Consumer Product Safety Commission's recall list from 2004 to 2018.*

a constituent of methylated or propylene urea-formaldehyde resins, e.g. in some finishing processes, such as resist-dyeing and dyeing, where it performs the role of a fixing agent improving the resistance of dyeing, or in the non-iron finishing of woven fabrics made from cellulose fibres as a cross-linking agent. Formaldehyde may be easily extracted from textiles by sweat and may cause skin allergy [15-16]. According to the International Agency for Research on Cancer, formaldehyde is classified as a carcinogen of the first category [15]. It should be underlined that in 2018 formaldehyde was included in the REACH Regulation, classified as carcinogenic – class 1B, and from 1st November 2020 a limit of 75 mg/kg in clothing and textile products that may have contact with human skin, will apply [17]. Apart from the substances mentioned above, textiles may also contain a number of other chemical compounds, although their use in manufacturing processes is banned or limited by law regulation. Analysis of data of the RAPEX system creates an opportunity to identify them and to know the scale of their occurrence, despite the existing restrictions or prohibitions on their use.

In addition to the chemical hazards, textiles can also pose risks of a physical nature. Although in scientific literature it is difficult to find studies on this subject, there is evidence, mostly in the form of recorded consumer accidents, indicating that physical hazards may pose a serious risk to the health and even life of consumers, especially children. ***Figure 1*** shows the most common types of physical hazards in children's clothing, based on dangerous product notifications from the database of the U.S. Consumer Product Safety Commission (CPSC) [18].

The source of such hazards could be cords and drawstrings, located mainly in the upper part of the outfit (marked in ***Figure 1.a***), which can cause serious injuries to a child's body, including strangulation as a result of the tangling of a cord or drawstring around the child's neck. ***Figure 1.a*** presents a hooded drawstring sweatshirt which was the cause of death of a 3-year-old boy, as was reported by CPSC. The boy was strangled when the drawstring on the hooded sweatshirt that he was wearing became stuck on a slide. An equally serious risk type is the presence of small parts in a children's product (***Figure 1.b***) that, due to improper fixing, may become detached and swallowed by a child, thus causing the risk of choking or suffocation. The product shown in **Figure 1.b** has a plastic zipper pull which could be detached from the zipper, posing a choking hazard to young children (the manufacturer has received 13 reports of zipper pulls detaching, including one report of a child mouthing the object). The presence of small parts with sharp edges may cause an additional risk of laceration. In the example shown in ***Figure 1.c***, six reports were noted of the detaching of metal stars placed at the bottom of trouser legs (in five cases detached elements caused lacerations).

A very serious type of risk is also the flammability of textiles, which could be particularly dangerous for children in cases where their clothes contact ignition sources, which then might cause burns and do harm to their health [19]. Besides, analysis of the effects of fires proves that a huge number of deaths are caused by poisoning and the inability to leave burning premises as a result of textile fires, mainly synthetic [20].

Analysis of clothing and textile product safety on the European market

Research subject and methodology

The subject of the research was textile and clothing products notified in Safety Gate: a rapid alert system for dangerous non-food products [21], in the years 2004 – 2018. A description of the subject and methodology of the study was presented in detail in the first part of the paper.

Results

The most frequently indicated risks in textile and clothing products placed on

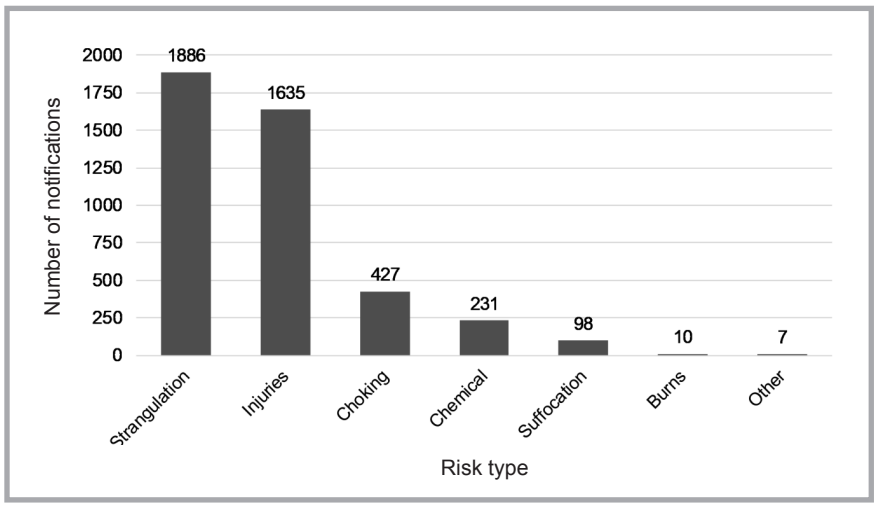

Figure 2. *Number* of most reported risk types; * total number of risks exceeds the sum of notified products because in some notifications several risk types are reported.*

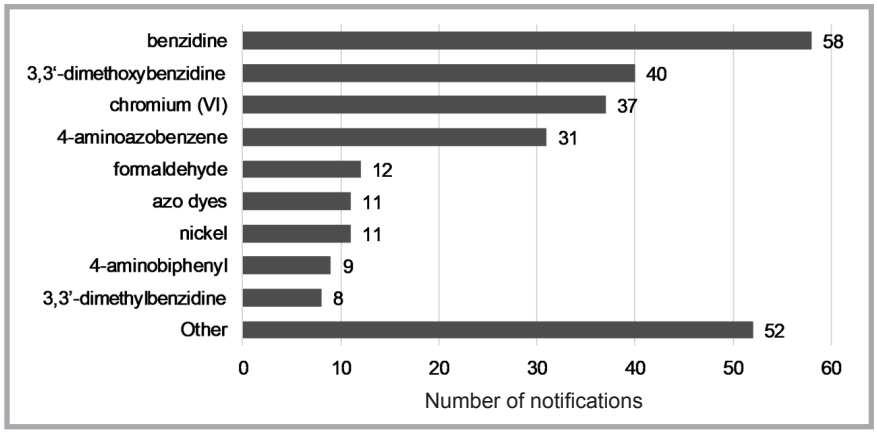

Figure 3. *Types of most frequent chemical hazards in textile products.*

the EU market include strangulation, injuries, choking, chemical, suffocation, burns, environmental, entrapment, drowning, cuts and health risk (***Figure 2***).

In the period under investigation, a total of 3540 notifications of dangerous textile and apparel products were made while indicating 4294 hazards. For an individual dangerous product notification maximally three hazard types were indicated (on average, 1.2 hazards per one notification). The three most numerous risk categories notified are strangulation (44%), injuries (38%) and choking (10%). These risks, along with suffocation (2.3% of all notifications), are physical in nature and comprise a total of 3303 notifications regarding children's products. As follows from the data presented in ***Figure 2***, the third most serious risk type is the presence of small parts in children's products that, due to improper fixing, may become detached and swallowed by a child, thus causing the risk of choking or suffocation (427 notifications). The fourth most common risk in terms of the number of notifications are chemical hazards, comprising on average 5.4% of all notifications recorded in the period under investigation. Among 231 notifications, 108 (47%) apply to women's clothing and accessories, 78 (34%) to children's products, 28 (12%) to men's products, and 17 (7%) to other textile groups. In comparison to physical abnormalities, the share of chemical hazards is very small and most probably results from fewer inspections carried out to detect chemical substances in textile products. It should also be noted that the number of detected chemical hazards varies in different years, which will be presented in the further part of this article.

Thorough analysis allowed 37 elements and chemical compounds to be identified (***Figure 3***). Among them the most numerous group (52% of total) are aromatic amines such as benzidine, 3,3'-dimethoxybenzidine, 4-aminoazobenzene, 4-aminobiphenyl and 3,3'-dimethylbenzidine, which were found in 120 products. The second, less numerous, group of dangerous substances found in textile products are heavy metals such as chromium (VI), nickel, cadmium and lead (54 notifications in total – 23%). Formaldehyde was detected in a total of 12 products. In the group of the remaining 28 compounds, each of them refers to less than five notifications (52 in total). Apart from aromatic amines, which predominate, phthalates are also present, e.g. dibutylphthalate, di-isononylphthalate, bis(2-ethylhexyl) phthalate, as well as biocides, e.g. pentachlorophenol and dimethylfumarate. Among all products creating chemical hazards, most of the notifications (87) were related to ones coming from China. The next 54 notifications applied to products of unknown origin, while 43 referred to ones manufactured in India.

Due to the fact that the presence of chemical substances mentioned above in textile products may pose a serious health hazard to consumers, a detailed analysis of individual notifications in the chemical risk category was carried out. The minimum, average and maximum concentrations of individual chemical substances detected in textile products are presented in ***Table 1*** and compared with applicable regulations. The substances mentioned in ***Table 1*** detected in textile products fall into the category of those classified as carcinogenic, mutagenic or toxic for reproduction (CMR). The substances listed in items 1-5 (***Table 1***) are aromatic amines released from azo colorants by the breaking down of one or more azo groups under reductive conditions. As follows from the data presented in ***Table 1***, the concentrations of individual substances detected in textile products significantly exceed 30 mg/kg. In some cases, for example, in a viscose scarf coming from India, the concentration of benzidine released from an azo dyeing agent used to dye the material was 150 times over the maximum permissible limit (4500 mg/kg).

A numerous group (a total of 48 notifications) were products in which the presence of heavy metals was found, mainly nickel and chromium(VI). The presence of chromium(VI) was found mainly in women's products, which is especially worrisome if such products are used by pregnant women. As scientific research [22] showed, exposure to the influence

of heavy metals during the prenatal period may be hazardous to the unborn child since it may partially penetrate the placental barrier and lead to foetal abnormalities, kidney diseases and infertility. The presence of prohibited nickel in notified textile products applied primarily to clothing equipped with accessories such as buttons, buckles, rivets, zips, etc. coated with this element. According to the REACH regulation for such components that could be in direct or permanent contact with the human skin, the degree of nickel release should not exceed 0.5 μg/cm^2 per week. Exposure to the effect of increased nickel concentrations may cause skin lesions in the form of eczema and an increase in risk of pulmonary and upper airway carcinoma [23]. The maximum release level for this element (42 μg/cm^2 per week) was found in a women's blouse with nickel coated metallic rings joining the straps (***Figure 4***).

Figure 4. *Women's blouse with nickel -plated metal rings.* ***Source:*** *https://ec.europa.eu/consumers/consumers_safety/safety_products/rapex/alerts/?event=viewProduct&reference=0560/08&lng=en.*

While analysing chemical hazards as a basis for the notification of textile and clothing products in the RAPEX system, it is worth paying attention to formaldehyde, which was detected in a total of 12 products, including nine children's products (in one notification the formaldehyde content was as high as 1400 mg/kg). That is a disquieting phenomenon responsible for allergic reactions such as skin and mucosal inflammations, which may occur primarily in children, because of their weak immune system. According to Duan et al. [24], Kang et al. [25], and Leal et al. [26], in mice subjected to formaldehyde treatment, it was found that it may cause increase asthma-like allergic symptoms and contribute to encephalitis. While considering the 15-year period when the data were gathered, the number of notified products containing this compound seems to be small. It should be recalled, however, that since 2012, due to legislation changes, testing for formaldehyde has been excluded from routine inspections performed by market surveillance authorities. At present, there are no EU obligatory requirements specifying a maximum permissible formaldehyde concentration in textile products. However, it should be noted that some countries making such notifications refer to the requirements specified in OEKO-TEX® STANDARD 100, according to which the formaldehyde content in textile products being in direct contact with human skin should not exceed 75 mg/kg, and for children's clothing it should be even below the detectability level, i.e. 16 mg/kg [14]. As mentioned above, this situation will be changed from 1 November 2020 [17].

Among the documents that form a basis for product notification due to chemical hazards, the REACH regulation (119 notifications) has been the most often referred to since 2009. Before this regulation was implemented, the chemical directive 76/769/EEC (20 notifications) was most often referred to. For 35 notifications the basis for product notification were requirements laid down in the criteria of the OEKO-TEX STANDARD 100 voluntary certification, requirements of which related to permissible concentrations of dangerous substances in textile products are more restrictive than those of referred legal requirements. For example, according to the OEKO-TEX STANDARD 100 certificate, the concentration of chromium(VI), should not exceed 0.5 mg/kg, which was the basis of 35 notifications. In addition, national regulations were referred to in 10 cases.

Effectiveness of dangerous product monitoring in particular years

When analysing the safety of textile and apparel products based on notifications submitted to the RAPEX system, it is worth paying attention to its distribution in particular years. The number of risk

Table 1. *Concentrations of chemical substances detected in notified textile products.*

No.	Substances	Acceptable limit, mg/kg (for nickel – μg/cm^2 per week)	Detected concentrations, mg/kg (for nickel – μg/cm^2 per week)		
			Minimum	Average	Maximum
1	benzidine	30.00*	30.00	546.52	4500.00
2	3,3'-dimethoxybenzidine		45.00	264.60	1288.00
3	4-aminoazobenzene		39.00	258.44	1100.00
4	4-aminobiphenyl		36.60	54.58	83.00
5	3,3'-dimethylbenzidine		52.00	290.75	754.00
6	chromium(VI)	3.00*	5.00	14.96	37.30
7	formaldehyde	75.00**	23.50	273.12	1400.00
8	nickel	0.50*	0.94	7.72	42.00

* *based on Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals – REACH (Annex XVII).*

** *based on OEKO-TEX® STANDARD 100 requirements and Commission Regulation (EU) 2018/1513 of 10 October 2018 amending Annex XVII to Regulation (EC) No 1907/2006 (REACH).*

Table 2. *Number and types of risk notified in the following years.*

Risk types	Years														
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Strangulation	1	1	1	2	27	158	327	251	374	235	220	118	71	61	39
Injuries	0	0	4	12	14	82	176	176	303	254	248	125	70	89	82
Choking	0	0	3	17	18	27	60	34	15	49	18	40	30	58	58
Chemical	6	4	19	2	13	29	72	36	8	7	8	10	7	5	5
Suffocation	3	2	1	15	72	2	1	1	1	0	0	0	0	0	0
Burns	1	2	0	0	0	1	0	1	2	0	0	0	1	0	2
Other	0	0	2	1	0	0	0	0	0	0	0	0	1	1	2
Total number of risks reported (n = 4294)	11	9	30	49	144	299	636	499	703	545	494	293	180	214	188
% change	–	-18	233	63	194	108	113	-22	41	-22	-9	-41	-39	19	-12

types reported in the years 2004-2018 is presented in ***Table 2***.

Based on data presented in ***Table 2***, one can observe that the total number of risk notifications increased every year, reaching a particularly high value in 2010, and a significant increase compared to the previous year. In that year the largest number of notifications in the chemical risk category was noted as well. In 2011 a significant decrease in the share of chemical hazards of up to 100% compared to 2010 was recorded. The small share of this hazard category has been maintained until now. It could be assumed that this is a positive trend, indicating a product safety improvement. However, while considering the fact that since 2012 the regulations associated with the safety assessment of textile products have been changed and hitherto more unambiguous national regulations related to safety assessment have been repealed, the causes of such a trend should be rather assigned to the reduced inspection scope. For example, in Poland after the year 2012 the number of product safety inspections represented only 6.8% of all controls carried out by the Trade Inspection, while in 2008 the share of such inspections was more than doubled, representing 15.7% [27]. For other types of risk, the data presented in ***Table 2*** shows a particularly high number of notifications regarding threats included in the categories "injuries" and "strangulation" up to 2012, but with a slight decrease observed in 2011. Since 2013, the number of notifications related to these threats has decreased again, reaching quite a small number of reports in 2015 and subsequent years. As was noted in the first part of this paper, this decrease can be assigned to the implementation of standards in China containing safety requirements for textile products designed for children and infants.

Conclusions

The analysis of data from the RAPEX system provided important information about the nature and scale of the risks that T&C products placed on the EU market pose. Based on the analysis carried out, it should be stated that among the notifications submitted, those pertaining to children's products clearly prevail (above 95%), which include related hazards such as strangulation, injuries, choking and suffocation. The main sources of these hazards are cords, drawstrings and small accessories. Among the physical risks, the lowest number of notifications was recorded in the case of burns. The contribution of chemical hazards to all notifications submitted in the period under consideration is rather low (5.4% on average), and has not exceeded 1% since 2012. These risks are attributed mainly to the presence of carcinogenic aromatic amines and some heavy metals (mainly chromium(VI) and nickel). The small share of chemical hazards in comparison to physical ones most probably results from the less numerous inspections carried out in regards to this category of risk, especially in Eastern European countries, as mentioned in the first part of the paper.

On the basis of the analysis conducted, it can also be stated that changes in the law have a significant impact on the level of product safety. This can be confirmed by the example of introducing new guidelines for the management of the RAPEX system, contributing to a visible increase in submitted notifications in 2010, which was the first year of their application. In turn, when analysing the distribution of various hazard types notified in particular years of the period under investigation, a significant relationship between their number and legislation changes that establish the requirements for minimising hazards was found, which is noticeable both for physical and chemical hazards. In fact, the number of notifications of the "strangulation" and "injuries" type significantly dropped after China implemented mandatory standard regulating requirements for children's clothing, as an effect of enhancing the safety of these products. In turn, with regard to chemical hazards, the declining number of notifications in 2012 and persisting low level of notifications in the next years should not be assigned to the improved safety of T&C products but rather to the decreasing number of relevant inspections carried out due to the lack of clear requirements. This was probably a result of the introduction of Regulation (EU) No 1007/2011, related to the labelling and marking of textiles products, which repealed national regulations containing clearly specified requirements for textile product safety assessment. Since 2012 the main basis for non-food product safety assessment in respect of chemical hazards is the REACH regulation, which, until its amendment made in October 2018 (most of the requirements implemented will start to apply from 2020), had not specified detailed requirements for many dangerous substances used in the textile industry.

While considering the conclusions derived from the analysis, a number of remarks arose indicating directions to be taken by the European Commission as well by non-governmental organisations to increase the level of consumer protection against dangerous textile and clothing products. These actions should be oriented towards:

- improving the safety of textiles and clothing by organising training courses addressed to designers and manufacturers in the scope of requirements that these products should meet;
- organising social and media campaigns for consumer education, in order to

raise awareness of potential threats posed by T&C products and encourage them to be more aware while shopping to make choices of certified products and in cases of any accidents caused by T&C products towards higher activity in reporting such events;

- modifying laws and regulations to define clear criteria of textile product safety assessment, in particular with respect to chemical hazards and country of origin marking on goods;
- entering into agreements with leading manufacturers and exporters of textile and clothing products to harmonise requirements comprising the highest standards of product safety assurance. This is of paramount importance due to the steadily increasing online trading of these products;
- increasing spending on market surveillance to extend the scope of inspections, in particular with respect to extremely dangerous and unidentifiable chemical hazards, and supporting research on new methods of identification of these risks.

In summary, it should be concluded that the methods of safety management for textile and clothing products are quite relevant in the European market but require continuous monitoring and improvement, in the light of the changes in today's world. This is the only approach that will enable a significant reduction in the number of products that are hazardous to the health and life of consumers.

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