

Significant variations of dangerous exposures during COVID-19 pandemic in Italy: a possible association with the containment measures implemented to reduce the virus transmission

Felice Giordano (✉ felice.giordano@iss.it)

National Center for Chemicals, Cosmetics and Consumer Protection, Istituto Superiore di Sanità, Viale Regina Elena 299, 00100 Roma

Valeria Margherita Petrolini

Toxicology Unit, Poison Centre and National Toxicology Information Centre, Istituti Clinici Scientifici Maugeri, IRCCS, Pavia

Domenico Spagnolo

National Center for Chemicals, Cosmetics and Consumer Protection, Istituto Superiore di Sanità, Viale Regina Elena 299, 00100 Roma

Rosanna Maria Fidente

National Center for Chemicals, Cosmetics and Consumer Protection, Istituto Superiore di Sanità, Viale Regina Elena 299, 00100 Roma

Lucrezia Lanciotti

National Center for Chemicals, Cosmetics and Consumer Protection, Istituto Superiore di Sanità, Viale Regina Elena 299, 00100 Roma

Lucilla Baldassarri

National Center for Chemicals, Cosmetics and Consumer Protection, Istituto Superiore di Sanità, Viale Regina Elena 299, 00100 Roma

Francesco Luca Moretti

National Center for Chemicals, Cosmetics and Consumer Protection, Istituto Superiore di Sanità, Viale Regina Elena 299, 00100 Roma

Elena Brambilla

Toxicology Unit, Poison Centre and National Toxicology Information Centre, Istituti Clinici Scientifici Maugeri, IRCCS, Pavia

Davide Lonati

Toxicology Unit, Poison Centre and National Toxicology Information Centre, Istituti Clinici Scientifici Maugeri, IRCCS, Pavia

Azzurra Schicchi

Toxicology Unit, Poison Centre and National Toxicology Information Centre, Istituti Clinici Scientifici Maugeri, IRCCS, Pavia

Carlo Alessandro Locatelli

Toxicology Unit, Poison Centre and National Toxicology Information Centre, Istituti Clinici Scientifici Maugeri, IRCCS, Pavia

Rosa Draisci

National Center for Chemicals, Cosmetics and Consumer Protection, Istituto Superiore di Sanità, Viale Regina Elena 299, 00100 Roma

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Abstract

Background: In response to the COVID-19 health emergency, mass media widely spread guidelines to stop the virus transmission, leading to an excessive and unaware use of detergents and disinfectants. In Italy and in other countries this tendency caused a significant increase of exposures to these products in 2020. Evaluating data collected by the Italian Pavia Poison Centre (PPC), this study intends to examine the relationship between the COVID-19 lockdown and the variations of exposures to specific product categories possibly associated to the containment measures implemented.

Simultaneously, this work shows the effectiveness of the European Products Categorisation System (EuPCS) in surveillance activities of dangerous chemicals.

Methods: Exposure cases managed by the PPC during March-May 2020 (lockdown) and during the same months of 2017-2018-2019 were compared. Differences in categorical variables were tested with the Chi-square test. The level of significance was set at Alpha = 0.05. The study included all EuPCS groups but specifically focused on cleaners, detergents, biocides and cosmetics.

Results: During the lockdown calls from private citizens significantly increased (+11.5%, $p < 0.001$) and occupational exposures decreased (-11.7%, $p < 0.05$). Among Cleaners, exposures to *Bleaches* slightly increased while *Drain cleaning products* went through a significant reduction (-13.9%, $p < 0.05$). An increase of exposures to *Disinfectants* was observed (+7.7%, $p < 0.01$), particularly to those for surfaces (+6.8%, $p < 0.05$). Regarding Cosmetics, both *handwashing soaps* and *gel products* significantly increased (respectively: +25.0 and +9.7%, $p < 0.05$).

Among children 1-5 years, the statistical significance is reached with exposures to *Dishwashing detergents* (+13.1%), *handwashing soaps* (+28.6%, $p < 0.05$) and *handwashing gel products* (+16.8%, $p = 0.01$). Contrarily, *Liquid Laundry Detergent Capsules* significantly decreased (-25%; $p = 0.001$).

The general severity of exposures decreased (Moderate: -10.1%, $p < 0.001$).

Conclusions: This study investigated the relationship between the COVID-19 lockdown and the variations of exposures to some product categories related to the containment measures. The results obtained support any action to be taken by Competent Authorities to implement measures for a safer use of cleaners/disinfectants. This paper shows the benefit in applying the EuPCS to categorize products according to their intended use, though an extension of this system to products not covered by CLP Regulation may be a further advantage.

Background

Due to COVID-19 worldwide pandemic events, in the first months of 2020 there was a dramatic increase in the use of detergents/cleaners and disinfectants, both in health care and domestic settings. Starting on February 23rd 2020, the Italian government issued a series of guidelines intended to contain COVID-19

dissemination among the population [1]. The decree of March 4th 2020 specifically mentioned several actions, amongst all the frequent handwashing with hydro-alcoholic solutions and the disinfection of surfaces with chlorine or alcohol based products [2].

The National Decrees also used as sources the available information provided by CDC (Centers for Disease Control and Prevention), ECDC (European Centre for Disease Control and Prevention) and WHO (World Health Organization) about the use of substances active on viruses [3]. These warnings were advertised in the main *mass media* channels/newspapers/web, mixing both true and false information about use and application of detergents and disinfectants, leading to an increase in accidental exposures to these products [4, 5]. This finding is particularly relevant in domestic settings (i.e. use of not-appropriate products in relation to the intended target or field of application), while in professional ones a decrease was observed [4, 5]. On March-April 2020, Poison Centers (PCs) all over the world launched several alerts concerning the increasing trend of poisonings due to disinfectants. One of these alerts was spread by an Italian PC and mentioned the inhalation as the main route of exposure: children under 5 years were mainly exposed to disinfectants held in not-labelled bottles and left within reach of children, while adults underwent poisonings caused by the use of disinfectants to improperly treat face masks or by poisonous aerosols released by mixing different household products [6]. A first study based on data coming from the National Poison Data System of United States was published by Chang et al. [7], highlighting a sharp increase in alert calls for exposures to both cleaners and disinfectants at the beginning of March 2020. The study compared exposure information of the first quarter of 2020 with the same period of 2018 and 2019. Bleach-based products and non-alcohol and hand sanitizer products were the most common cause of such alerts. It was possible to observe an increase in the percentage of exposures through the inhalation route also in this case.

Subsequently, during 2020 and early 2021, many other scientific reports documented this occurrence [8–9].

In Italy, the National Center for Chemicals, Cosmetics and Consumer Protection (CNSC-ISS) collects the exposure cases to dangerous chemical substances according to the EuPCS - European Product Categorization System [10, 11]. Referring to data coming from an Italian PC, the aim of this study was to evaluate the temporal association between the lockdown period due to COVID-19 pandemic and the variation of exposures to specific product categories (i.e. cleaning products, detergents, biocidal products and cosmetics) possibly associated to the containment measures implemented in Italy. This study also intends to show the effectiveness of applying the EuPCS categorization for surveillance activities carried out by PCs.

Methods

Data sources

In Italy, The Agreement of the Permanent Conference “Italian State- Regions”, 28th February 2008, defined rules and activities of PCs [12].

Currently, the Italian network involves ten PCs [13]. One of them is the Pavia Poison Centre (PPC) – National Toxicology Information Centre - a hospital based unit (24/7) where clinical toxicologists give precious advice and assist both physicians from the hospital emergency departments in diagnosing and managing poisonings and citizens requiring specialist consultations all over Italy. All consultations are recorded and significant cases are followed up to the outcome.

The occurrence of clinical cases due to non-pharmaceutical chemical agents is more than 25,000 per year (about the 40% of cases referred to all the Italian PCs) [14]. The PPC database records agents of exposure, demographic characteristics, route of exposure, reason for exposure, signs and symptoms, treatment and outcome variables.

According to the activity of toxicosurveillance for exposures to hazardous substances, the PPC transmits its data to the Italian Appointed body (CNSC-ISS).

Study design

A retrospective analysis on PPC data was conducted. All cases of exposure to EuPCS product groups were included.

A case series study was designed to compare the exposure cases managed by the PPC during the lockdown period (pinpointed in March-May 2020 trimester) *versus* the same period of the previous three years (2017–2019). Percentages on the total of exposures managed in the first 5 months of each year were performed.

Variables

Descriptive analysis included patients’ demographic characteristics (gender and age), source of the call (hospital, non-hospital), exposure characteristics (intentional/ inadvertent), place of exposure, period_year (2017–2019 / 2020), period_month (January-February / March-May), route of exposure, symptoms, Poison Severity Score [15] and product categories involved. The latter variable is based on the EuPCS developed by ECHA (European Chemicals Agency). This system intends to facilitate the transmission of information on the intended use of a mixture for which a submission must be made according to Article 45 and Annex VIII of the Regulation (CE) 1272/2008 (CLP) and to support the statistical analysis of poisonings.

In Italy, products for hand hygiene not registered as disinfectants under the transitional period (i.e. containing active substances under revision according to the Reg (UE) 1062/2014 [16]) can be placed on the market as cosmetics. Being out of the scope of CLP Regulation, their categorization is based on the Regulation (CE) 1223/2009 [17].

To assign the correct product category some rules were fixed:

- Searching the web (also through the images) to obtain label information
- For biocidal product, confirm it by searching the trade name or the active substance in ECHA website (ECHA > Information on Chemicals > Biocidal Products)
- If technical information on the label was not available, the product category was assigned using the label claim.

Case selection criteria

For the first 5 months of the years 2017, 2018, 2019 and 2020 all human exposure cases were extracted from the PPC database.

The analysis considered all the EuPCS third-level product categories.

Focusing on *Cleaning, care and maintenance products* (PC-CLN), *Detergents and auxiliaries for laundry and dishwashing* (PC-DET) and *Biocidal products* (PP-BIO), the following subcategories were specifically considered:

PC-CLN-3: *Bleaching products for cleaning or laundry use (excludes biocidal products)*

PC-CLN-5: *Drain cleaning products*

PC-DET-1: *Laundry detergents*

PC-DET-3: *Dishwashing detergents*

PP-BIO-1: *Biocidal products for human hygiene*

PP-BIO-2: *Disinfectants and algacides not intended for direct application to humans or animals.*

The last two categories are included in the group of *Disinfectants* (Table 2), according to the Regulation (EU) No 528/2012 on biocides [18].

Among PC-DET-1 we also considered the subgroup of *Liquid Laundry Detergent Capsules* (LLDC). The analysis also concerned *Cosmetics*, which are not included in the EuPCS. Among them, the following subgroups were considered:

Handwashing soaps (excludes biocidal products)

Handwashing gel products (excludes biocidal products)

Statistical analysis

Data were analysed using descriptive statistical methods. Differences in categorical variables were tested with the Chi-square test. The level of significance was set at Alpha = 0.05. For each EuPCS category, the observed cases (obs) and the expected ones (exp) in March-May 2020 were reported. Expected cases were calculated by applying the percentages of observed cases in March-May 2017–2020 on the total of

cases occurred in the first five months of the same years. The percentage difference (% of increase) between observed and expected values was reported. The statistical analysis was performed using IBM SPSS® Statistics Ver. 26 software.

Results

In applying the selecting criteria, 15,534 patients were identified by adding up the exposure cases of the first 5 months of 2017–2019 and 2020: 2017–2019 n. 11,574; 74.5% and 2020 n. 3,960; 25.5% (Fig. 1). The distribution by months in 2020 [January–February: n. 1,434 (36.2%); March–May: n. 2,526 (63.8%)] does not show a statistically significant difference in comparison with 2017–2019 period [January–February: n. 4,117 (35.6%); March–May: n. 7,457 (64.4%)] ($p = 0.467$).

Table 1 shows the number of observed and expected biological and poisoning characteristics of patients exposed during the lockdown period (March–May 2020). Distribution by gender is comparable, even if there is a slight not significant decrease in observed male patients compared to the expected ones (-2.5%; $p = 0.077$). Among age classes, a statistically significant percentage difference highlights a reduction of exposures in patients aged 11–19 years (-17.9%; $p < 0.001$). The age class 1–5 years is the only one showing an increase in the lockdown period, although in a not statistically significant way (+ 2.8%; $p = 0.099$). The percentage difference among main circumstance categories is not statistically significant but the Occupational subcategory shows a significant decrease in comparison with the expected value (obs: n. 118; exp: n. 134; -11.7%; $p = 0.011$). While the hospital calls show a decrease in March–May 2020 (-10.8%; $p < 0.001$), the non-hospital ones increase (+ 10.5%; $p < 0.001$). This finding is mainly driven by private citizens (+ 11.5%; $p < 0.001$). The ocular route of exposure highlights a 6.8% increase in comparison with the expected frequency (obs: n. 166; exp: n. 156; $p = 0.083$), being statistically significant with the age class 1–5 years (obs: n. 72; exp: n. 64; +12.5%; $p = 0.039$) (data not shown). During the lockdown period symptomatic cases significantly decreased (-2.7%; $p = 0.047$), especially among those with PSS = Moderate (-10.1%; $p < 0.001$).

Table 1
 Biological and poisoning characteristics of patients exposed: observed and expected values in the lockdown period (March-May 2020).

Variables	March-May 2020 (Lockdown period)		% of increase	p-value (χ^2)
	Observed	Expected		
	N.	N.		
Gender	1,293	1,325.9	-2.5	0.077
Male	1,233	1,223.5	+ 0.8	0.599
Female	-	0.5	-100	1
Unknown				
Age class (years)	65	70.4	-7.7	0.208
< 1	959	933.2	+ 2.8	0.099
1-5	80	82.8	-3.4	0.544
6-10	96	117.0	-17.9	<0.001
11-19	1,020	1,027.3	-0.7	0.659
20-65	247	258.4	-4.4	0.156
66+	59	54.8	+ 7.7	0.291
Unknown				
Circumstance	2,181	2,187.5	-0.3	0.786
Inadvertent	118	133.6	-11.7	0.011
Occupational	328	339.6	-3.4	0.242
Intentional	17	17.4	-2.3	0.839
Unknown				
Caller	1,279	1,433.5	-10.8	<0.001
Hospital	1,247	1,128.3	+ 10.5	<0.001
Non-hospital	1,083	971.1	+ 11.5	<0.001
Citizen				

Variables	March-May 2020 (Lockdown period)		% of increase	p-value (χ^2)
	Observed	Expected		
	N.	N.		
Route of exposure				
Ingestion	1,701	1,709.5	-0.5	0.693
Inhalation	393	409.1	-3.9	0.114
Dermal	197	208.5	-5.5	0.103
Ocular	166	155.5	+ 6.8	0.083
Injection	8	8.7	-8.0	*0.745
Symptoms				
Yes	1,413	1,451.9	-2.7	0.047
Minor	1,102	1,105.1	-0.3	0.856
Moderate	288	320.4	-10.1	<0.001
Severe-Fatal	23	27.0	-14.8	0.139
Total	2,526	2,544.9	-0.7	0.467
*Fisher Exact Test				

Table 2 shows the observed and the expected number of commercial products categorized by using the EuPCS and involved in inadvertent exposures occurred during the lockdown.

The percentage difference of *Art materials* undergoes an unexpected 10.8% increase, notwithstanding the lack of statistical significance ($p = 0.244$). Among *Cleaning, care and maintenance products*, the number of observed *Bleaching products* (PC-CLN-3) is higher than the expected one (obs: 322; exp: 309; +4.3%; $p = 0.132$). This result becomes statistically significant among male patients aged 20–65 years (obs: 56; exp: 47; +19.1%; $p = 0.008$) (data not shown). On the contrary, a statistically significant decrease is observed for *Drain cleaning products* (-13.9%; $p = 0.035$). Here too, this difference becomes greater among male subjects belonging to the age class 20–65 years (obs: 20; exp: 30; -33.3%; $p < 0.001$) (data not shown). In March-May 2020 *Laundry detergents* prove to be less involved in inadvertent exposures than expected (obs: 66; exp: 77; -14.0%; $p = 0.024$). This finding seems to be associated with the decrease of *LLDC* (obs: 35; exp: 46; -24.1%; $p = 0.002$), mainly driven by the age class 1–5 years (obs: 33; exp: 44; -25%; $p = 0.001$) (data not shown). In contrast with other PC-DET subcategories, *Dishwashing detergents* highlight a 6.6% increase compared to the expected values ($p = 0.138$), becoming statistically significant in the age class 1–5 years (obs: 70; exp: 62; +13.1%; $p = 0.032$) (data not shown). For products belonging to the *Inks, toners and related printing materials* (PC-INK), there is a statistically significant decrease ($p =$

0.031) in observed exposures (n. 12) compared to the expected value (n. 17). An increased number of *Biocidal products* is observed (obs: 382; exp: 364; +4.9%; $p = 0.032$), probably due to *Disinfectants* (obs: 265; exp: 246; +7.7%; $p = 0.007$) and in particular to *Disinfectants and algaecides not intended for direct application to humans or animals* (obs: 182; exp: 170; +6.8%; $p = 0.039$). During the lockdown period, the proportion of *Cosmetics* used for personal hygiene increased too: *Handwashing soaps* showed a 25.0% increase ($p = 0.016$) while *Handwashing gel products* registered a 9.7% increase ($p = 0.028$). The statistical significance is also reached with children aged 1–5 years (*handwashing soaps*: obs: 18; exp: 14; +28.6%, $p = 0.014$; *handwashing gel products*: obs: 32; exp: 27; +16.8%, $p = 0.010$) (data not shown).

Table 2

Product categories (EuPCS) involved in patients' inadvertent exposures: observed and expected values in the lockdown period (March-May 2020).

Variables	March-May 2020 (Lockdown period)		Increase (%)	p- value (χ^2)
	Observed	Expected		
	N.	N.		
<i>Adhesives and sealants</i> (PC-ADH)	26	27.5	-5.5	0.557
<i>Air care products</i> (PC-AIR)	35	36.4	-3.8	0.698
<i>Products for animals</i> (PC-ANI)	2	1.5	+ 33.3	*1.000
<i>Art materials</i> (PC-ART)	44	39.7	+ 10.8	0.244
<i>Cleaning, care and maintenance products (excludes biocidal products)</i> (PC-CLN)	840	848.3	-1.0	0.582
<i>Bleaching products for cleaning or laundry use</i> (PC-CLN-3)	322	308.8	+ 4.3	0.132
<i>Drain cleaning products</i> (PC-CLN-5)	59	68.5	-13.9	0.035
<i>Colourants</i> (PC-COL)	1	1.4	-28.6	*1.000
<i>Construction products</i> (PC-CON)	10	8.5	+ 17.6	*0.465
<i>Detergents and auxiliaries for laundry and dishwashing (excludes biocidal products)</i> (PC-DET)	278	281.1	-1.1	0.720
<i>Laundry detergents</i> (PC-DET-1)	66	76.7	-14.0	0.024
<i>- LLDC</i>	35	46.1	-24.1	0.002
<i>Dishwashing detergents</i> (PC-DET-3)	127	119.1	+ 6.6	0.138
<i>E-liquids and mixtures for electronic cigarettes</i> (PC-ELQ)	13	14.0	-7.1	0.632
<i>Fertilisers and fertilising products</i> (PC-FER)	45	46.4	-3.0	0.653
<i>Fuels (and fuel additives)</i> (PC-FUE)	70	78.6	-10.9	0.081
<i>Inks, toners and related printing materials</i> (PC-INK)	12	16.8	-28.6	0.031
<i>Paints and coatings (and related auxiliaries)</i> (PC-PNT)	36	37.4	-3.7	0.683
<i>Pyrotechnic products</i> (PC-PYR)	-	-	-	-
<i>Products for chemical or technical processes</i> (PC-TEC)	121	124.2	-2.6	0.618
<i>Biocidal products</i> (PP-BIO)	382	364.3	+ 4.9	0.032

Variables	March-May 2020 (Lockdown period)		Increase (%)	p- value (χ^2)
	Observed	Expected		
	N.	N.		
<i>-Disinfectants</i> (PP-BIO-1 to PP-BIO-5)	265	246.0	+7.7	0.007
<i>Biocidal products for human hygiene</i> (PP-BIO-1)	79	72.6	+ 8.8	0.108
<i>Disinfectants and algaecides not intended for direct application to humans or animals</i> (PP-BIO-2)	182	170.4	+6.8	0.039
<i>Plant protection products (excludes biocidal products)</i> (PP-PRD)	76	80.7	-5.8	0.161
<i>Cosmetics</i>	289	276.5	+ 4.5	0.145
<i>Handwashing soaps (excludes biocidal products)</i>	23	18.4	+25.0	0.016
<i>Handwashing gel products (excludes biocidal products)</i>	52	47.4	+9.7	0.028
*Fisher Exact Test				

Discussion

This research based on PC data aimed at verifying whether during COVID-19 pandemic lockdown there were variations of exposure frequencies to specific product categories possibly associated to the containment measures and to the recommendations disclosed by the health authorities.

Italy has been the first Western country to adopt the most restrictive lockdown measures in the first months of 2020. Since PPC provides consultancies for the whole national territory, covering about 40% of those referring to all ten Italian PCs [13], the results obtained are representative of the entire Italian situation.

This is the first study using all EuPCS third-level categories and some of their sub-categories. Among all EuPCS categories, the attention was specifically focused on those involved in disinfecting and cleaning activities.

Considering the biological characteristics, the observed number of male patients slightly decreased during the lockdown period (March-May 2020) in comparison with the expected value. This finding may be attributed to women taking greater responsibilities to manage the disinfection of different settings, particularly the domestic ones. On the other hand, exposures in workplaces significantly decreased. This evidence is in line with the reduction of occupational injuries during COVID-19 lockdown reported by the National Institute for Insurance against Accidents at Work (INAIL) [19]. Soave et al. [5] showed a 200% increase of occupational exposures during January-May 2020 but the small population involved does not allow making a comparison with the present study.

Among age groups, the class 1–5 years shows a not statistically significant increase during the lockdown period. Children's exposures to disinfectants are a matter of great concern for Li et al. [20] (2020), who highlight that, due to their more frequent mouthing activities, children have consistent higher exposures to disinfectants than other age classes. The percentage difference calculated for the age class 11–19 years shows a statistically significant reduction of exposures during the lockdown. In fact, it seems that young people have significantly changed their lifestyle habits in this period, spending more time at home and mainly preferring sedentary activities [21]. These unhealthy behaviours might have avoided other physical activities involving accidental exposures to dangerous chemicals.

While normally PPC mainly receives hospital calls (about 82% of consultancies come from emergency departments), a significant decrease was observed during the lockdown period. On the other hand, the number of non-hospital calls increased, particularly because of calls from private citizens. This evidence could highlight a tendency of the population not to access hospitals or general practitioners if not strictly necessary, a fact in line with the recommendations given during COVID-19 pandemic. Other European PCs also reported this trend [4, 5].

The ocular route of exposure shows an increased percentage in comparison with the expected frequency, reaching the statistical significance with children aged 1–5 years. A statistically significant increase of paediatric ocular exposures to alcohol-based hand sanitizers (ABHS) from April to August 2020 are reported by Martin et al. [22], though considering subjects younger than 18 years.

In March-May 2020 symptomatic cases significantly decreased, especially among those with a Moderate PSS. This finding is mainly driven by a decrease of occupational exposures; in fact, high severities are significantly linked to this kind of exposures ($p < 0.001$) (data not shown). Also Le Roux et al. [4] detected a significant decrease of exposures at work (-45.5%; $p < 0.001$) in March-April 2020 in comparison with the same period of the previous two years, and at the same time they observed a decrease in severity (moderate/severe - 17.2%). On the contrary, data from US PCs, where containment measures were less restrictive in that period, did not report the same decrease [8].

Moreover, fewer intentional exposures and the increased percentage of 1–5 years' children's exposures may have also contributed to a lower severity of the clinical picture: in many cases the effectiveness of children's exposures is uncertain so most of them have little clinical relevance.

To categorize the products included in this study, the EuPCS developed by ECHA was used [11]. The advantage of this tool is that the intended use is easier to assign in comparison with other categorizations based on chemical structures. Nevertheless, ambiguous categorizations are still possible. Another limitation, in considering the purpose of a PC, is that this categorization system covers only product categories needing CLP classification, excluding other potentially toxic agents like cosmetics, animals, plants, food, drugs, tobacco (only E-liquid for E-cig is mentioned in the EuPCS). A certain advantage is that some product categories driven by specific regulations (Regulation (EU) No 528/2012 for Biocidal products, Regulation (EC) No 1107/2009 for Plant protection products [23]) maintain their original categorization in the EuPCS.

In this research, EuPCS allowed the categorization of products not only for consumer use, but also for professional and industrial use.

Among *Cleaning, care and maintenance products* (PC-CLN), *Bleaching products for cleaning or laundry use* (PC-CLN-3) and *Drain cleaning products* (PC-CLN-5) are the subcategories of most interest. Regarding the first, a 4.3% increase in exposures during the lockdown period was detected and the difference becomes statistically significant with male subjects belonging to the adult class 20–65 years. Since this evidence cannot be observed neither among female subjects nor among other age classes, it could be related to mistakes in handling these products made by non-professional and non-skilled/habitual users. Other authors commented the increase in household product exposures observed in many developed countries arguing that the probable reason for the high incidence detected could be ascribed to careless storage, ignorance, non-compliance with prescribed instructions for use and negligible parental supervision in case of children [24]. In the European Union a survey highlighted that the 70% of European citizens use the label to obtain information about the potential danger of a chemical, although chemical hazard pictograms are usually not very understood [25]. A more recent U.S. survey verified an important knowledge gap in the safe use of cleaners and disinfectants among the adult population [26]. Inadvertent exposures indicated that the general public/non-professionals pay little or no attention to the instructions for use of cleaners and disinfectant products. Also Chang et al [7], in evaluating data from American PCs, found that, among cleaner categories, bleaches accounted for the largest percentage of the increase (n. 1,949; 62.1%). Increased exposures to bleaches seem to be temporally subsequent to advises reported in all the main Italian mass media including guidelines issued to prevent COVID-19 circulation, recommending to disinfect surfaces with chlorine and alcohol based products. Fortunately, bleach intoxication from inhalation or ingestion of small amounts due to accidental reasons is not normally of clinical significance [27]. This evidence may further explain the low percentage of moderate/severe cases registered in March-May 2020. Considering the subgroup of *Drain cleaning products* (PC-CLN-5), a significant decrease in comparison with the expected value was observed. Moreover, among gender and age classes, the statistically significant difference becomes greater with male subjects of the adult class 20–65 years. Since these products are often referred to work contexts, this finding proves to be in line with the decrease of occupational exposures.

Among *Detergents and auxiliaries for laundry and dishwashing (excludes biocidal products)* (PC-DET), two different trends could be observed: on the one hand, there was a statistically significant decrease of *Laundry detergents* (PC-DET-1) probably caused by *LLDC* exposures of children aged 1–5 years; on the other, a significant increase in exposures of the same age class was detected for *Dishwashing detergents* (PC-DET-3). Differently, during COVID-19 crisis, Gulamhusein and Sabri [28] saw an increase in ocular exposures to *LLDC* among Canadian children. When investigating American NDPS data among children aged < 6 years, Gaw et al [29] saw a declined trend by 55.5% from 2015 to 2017.

A possible explanation to the opposite tendencies observed could be as follows: with regard to *Laundry detergents*, the confinement reduced the possibility to go out and so the frequent need to wash clothes. On the other side, confinement doubtlessly led to an increase in the number of meals consumed at home,

with a consequent increase in dishwashing activities. This high percentage in the age class 1–5 years underlines the need of a greater parental supervision when using products not suitable for children.

Regarding *Biocidal products*, a statistically significant increase during the lockdown period was observed. This result is probably due to *Disinfectants*. Chang et al. [7] observed a similar trend, although the statistical significance was not evaluated. Increased calls regarding household disinfectants were registered by several PCs around the world [5, 8, 9, 30]. In the present study, the statistical significance was specifically reached for *Disinfectants and algaecides not intended for direct application to humans or animals*, while *Biocidal products for human hygiene (PP-BIO-1)* only show a not statistically significant increased percentage. In the recent past, Wieck et al. [31] performed a study to investigate the knowledge about the appropriate use of biocidal products through a standardised questionnaire fed to German consumers. The research highlighted how only the 21% of consumers provided the exact definition of biocide. Nevertheless, the majority of the interviewees seemed not to be aware when and where they were actually using specific biocidal products. As a matter of fact, the product types mentioned in the interview often did not correspond to those the researchers actually found in interviewees' houses. The highest percentage of the interviewees failed to mention disinfectants used for surfaces (17%). This type of biocides (PP-BIO-2) are often perceived as simply cleaners with a lower risk associated compared, for example, to *Insecticides* (PP-BIO-18). A survey of the Joint Research Centre of the European Commission [32] highlighted that more than a half of EU citizens always read the instructions before using pesticides and insecticides, but the reliance on the instructions is less common for other categories of chemical products. This underestimation of the risk could have led to dangerous exposures especially regarding disinfectants for surfaces frequently used in COVID-19 period.

Considering *Cosmetics*, both *handwashing soaps* and *handwashing gel products* show a statistically significant increase in March-May 2020 with respect to the expected value. In both cases, children aged 1–5 years mainly drive this increase. This evidence is consistent with the findings of Hakimi and Armstrong [33], who pointed out a significant increase in daily calls to US PCs regarding paediatric hand sanitizer exposures in March 2020 compared to March 2018–2019 and to January-February 2020, yet referring to children aged 12 years and younger.

Conclusions

The present study highlighted the variations of dangerous exposures to specific product categories during COVID-19 lockdown, by investigating the possible connection with the containment measures implemented in Italy. Both increase and decrease of exposures to certain product categories (i.e. cleaning products, detergents, biocidal products and cosmetics) were observed.

These findings are meant to be an encouragement for the Competent Authorities involved in public health matters to implement preventative measures for the general population, with awareness raising campaigns about the safe use of cleaners and disinfectants, as Italy carried out through the National Institute for Health website [34]. Even though already present in well prepared labels, further visibility

should be provided to fundamental, although basic, warnings, such as: *read the label carefully, use the indicated dilution of the product, do not mix different products if not specifically mentioned in the label, use products in well-ventilated areas, keep out of the reach of children.*

This work is also an interesting example of the practical application of the EuPCS in an epidemiological study, used to categorize commercial products causing exposures/intoxications. EuPCS proved to be very useful when categorizing products according to the intended use is necessary. Nevertheless, an extension of the EuPCS to include those categories not covered by CLP Regulation may represent a further advantage for PCs.

Abbreviations

PPC:Pavia Poison Centre; EuPCS:European Product Categorisation System; CDC:Centers for Disease Control and Prevention; ECDC:European Centre for Disease Control and Prevention; WHO:World Health Organization; PC(s):Poison Center(s); CNSC-ISS:National Center for Chemicals, Cosmetics and Consumer Protection-Istituto Superiore di Sanità; ECHA:European Chemicals Agency; PC-CLN:Cleaning, care and maintenance products; PC-DET:Detergents and auxiliaries for laundry and dishwashing; PP-BIO:Biocidal Products; PC-CLN-3:Bleaching products for cleaning or laundry use; PC-CLN-5:Drain cleaning products; PC-DET-1:Laundry detergents; PC-DET-3:Dishwashing detergents; PP-BIO-1:Biocidal products for human hygiene; PP-BIO-2:Disinfectants and algacides not intended for direct application to humans; PC-INK:Inks, toners and related printing materials; LLDC:Liquid Laundry Detergent Capsules; ABHS:Alcohol-based hand sanitizers; PP-BIO-18:Insecticides, acaricides and products to control other arthropodes.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

RD and CAL were the project managers. DL, AS, VMP managed the exposure cases and organized the dataset. EB organized the dataset and assigned the first product categorization. FG, LL, DS, RMF, FLM performed the quality control of the dataset. FG, LL worked on the study design, the results and on the initial and final analysis. FG, LL, RMF, LB wrote the initial draft of the paper. All authors made edits and contributions to the final draft. The authors read and approved the final manuscript.

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Figures

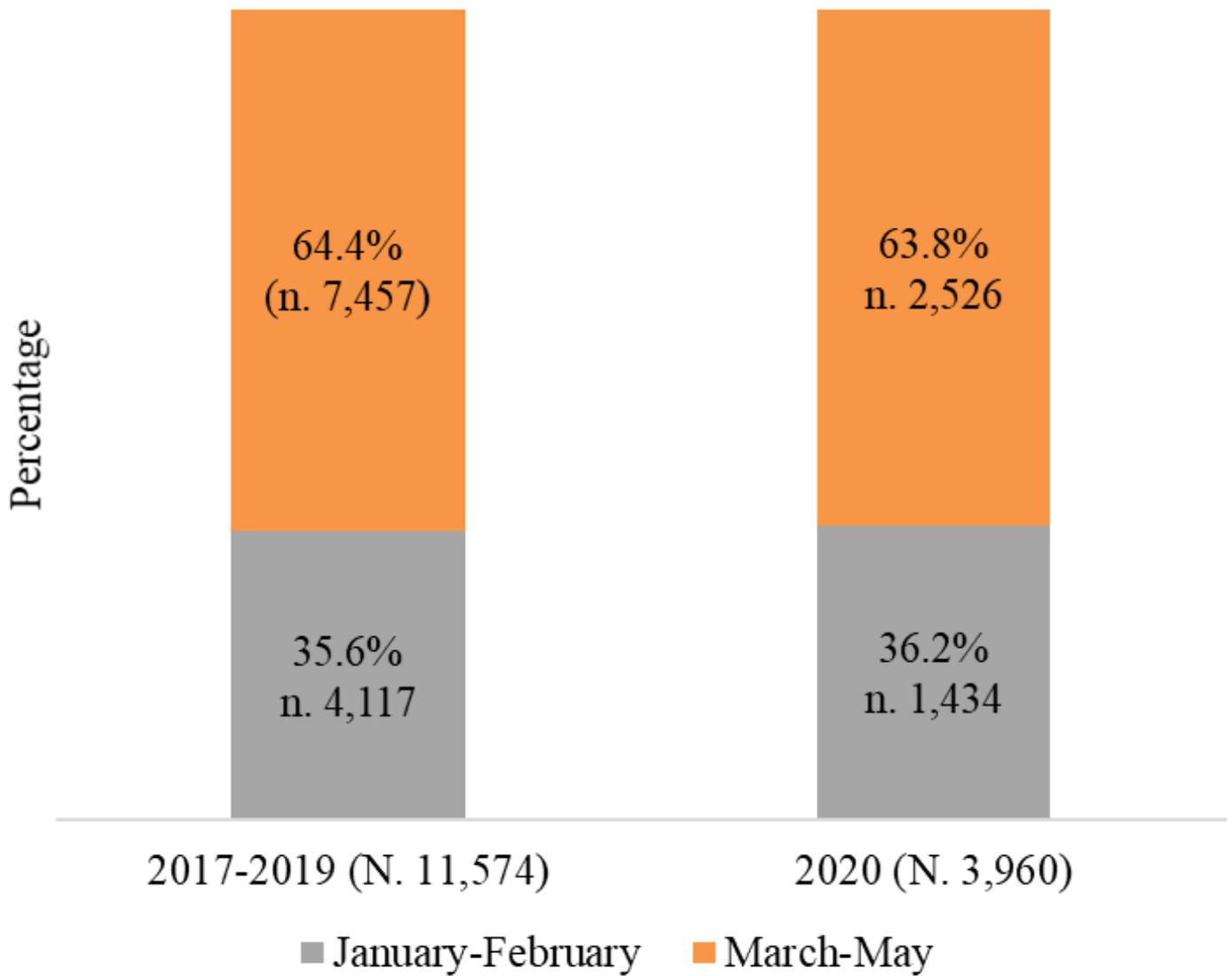


Figure 1

Exposure cases managed by the PPC: comparison between January-February and March-May of 2017-2019 and 2020.