
Original Article

An Overview of Cleaning Agents' Health Hazards and Occupational Injuries and Diseases Attributed to Them in Sweden

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Abstract

Using data from the Swedish Products Register, hosted by the Swedish Chemicals Agency (KemI), national occupational injury and disease statistics, and call records from the Swedish Poisons Information Centre (PIC) we characterize health hazards of marketed cleaning products and recorded injuries, disease, and incidents linked to cleaning or disinfection agents. The results show that cleaning agents pose many kinds of health hazards, although corrosion and irritation hazards dominate, in particular for the eyes (54% of all included products). Few products were recognized as inhalation hazards. The nature of the health hazards is reflected in the occupational disease and injury statistics and PIC records for eyes and skin but not for the respiratory tract. Among occupational disease cases attributed to cleaning or disinfection agents, 61% concern skin and 26% the respiratory tract. Among occupational injury cases 64% concern chemical burns. However, only a small part (<0.5%) of all reported diseases and injuries were explicitly attributed to cleaning or disinfection agents. On average, there were 11 cases of disease attributed to cleaning or disinfection agents per million workers and year. For occupational injuries the corresponding number was 8. The data concern a broad range of sectors and occupations, but notable sectors were healthcare, accommodation and food service, and manufacturing. Women were more likely to suffer from disease, men and women equally likely to suffer from injury. PIC cases were evenly distributed between men and women, but the clear risk cases more frequently involved men. Occupational diseases increased many-fold in 2020 while injuries decreased, which could be due to COVID-19 changing use patterns of cleaning and disinfection agents at work. We conclude that cleaning agents pose a variety of risks to a large part of the workforce, although particular attention for preventive efforts may need to be directed to the healthcare, accommodation and food service, and manufacturing sectors.

What's Important About This Paper?

This study demonstrated that corrosion and irritation hazards for the skin and eyes were the predominant health hazards identified among marketed cleaning and disinfection products in Sweden, though few products identified risks for skin sensitization or the respiratory tract. Among reported occupational illnesses, skin diseases and respiratory tract injuries were most commonly attributed to cleaning or disinfection agents, while chemical burns made up most of the occupational injury cases. Cleaning agents pose a variety of risks to a broad range of industry sectors, although particular attention for preventive efforts may need to be directed to the healthcare, accommodation and food service, and manufacturing sectors.

Keywords: cleaning agents; detergents; disinfectants; occupational disease; occupational health and safety; occupational injury; poison control

Introduction

Cleaning agents and disinfectants are used in a broad range of occupational settings. In the 2019 Swedish work environment survey 9% of men and 17% of women reported skin exposure to cleaning agents and/or disinfectants during more than 25% of their working time. Young women (aged 16–29 years) were the most highly exposed group (26%). Domestic cleaners and helpers, healthcare assistants, and nursing professionals are groups where more than 50% experience skin contact with cleaning agents or disinfectants more than 25% of their working hours (SWEA, 2020).

Previous research reviewing the health hazards of cleaning agents have shown that this product group involves multiple health hazards. A survey of 105 products identified as commonly used by Swiss cleaning companies found irritation to be the most frequent hazard, in addition the R-phrases ‘harmful if swallowed’ (R22) and ‘risk of serious damage to eyes’ (R41) each occurred in 6 out of 10 products (Gerster *et al.*, 2014). Fragrances and enzymes in cleaning agents may also pose allergy risks to users (Basketter *et al.*, 2012, 2015). Indeed, established fragrance allergens were found in almost half of 1447 cleaning agents found in 131 German homes (Wieck *et al.*, 2018).

Several chemicals in cleaning agents are known contact allergens, such as fragrances, preservatives, and disinfectants, and these chemicals have a potential to cause allergic contact dermatitis (ACD). In previously sensitized persons re-exposure to the allergen will cause eczema (Lushniak, 2004; Jakasa *et al.*, 2018). Furthermore, frequent exposure to skin irritants such as detergents, alcohol, soap, and water may cause breakdown of the outer layer of the skin barrier leading to the development of irritant contact dermatitis (ICD). Several studies have shown that healthcare personnel and cleaning workers are among professions that are

at risk to develop occupational contact dermatitis (both ICD and ACD) (Mirabelli *et al.*, 2012; Bauer, 2013; Machovcová *et al.*, 2013; Caroe *et al.*, 2014).

Observational studies point towards links between use of cleaning agents and lung disease (Quirce and Barranco, 2010; Van den Borre and Deboosere, 2018; Carder *et al.*, 2019; De Matteis *et al.*, 2020; Dumas and Le Moual, 2020; Archangelidi *et al.*, 2021; Romero Starke *et al.*, 2021). A Belgian registry study found increased mortality in respiratory and cardiovascular diseases among cleaners (Van den Borre and Deboosere, 2018). However, links have in particular been made to asthma (Quirce and Barranco, 2010; De Matteis *et al.*, 2020; Archangelidi *et al.*, 2021) but also to chronic obstructive pulmonary disease (Van den Borre and Deboosere, 2018; Archangelidi *et al.*, 2021). Additionally, a recent study found a correlation between the use of cleaning agents at home and airway obstruction in women (Svanes *et al.*, 2018). This highlights risk of products intended for consumer use as well as the frequent use of these by domestic cleaning staff (Carder *et al.*, 2019). The risks of cleaning agents do not appear to be diminishing; for example, occupational asthma linked to cleaning agents displays an upgoing trend in the UK, while other kinds of occupational asthma are decreasing (Carder *et al.*, 2019).

Efforts to identify specific substances as drivers of the respiratory effects specifically of spray products have named relatively few out of the broad range of ingredients included in cleaning agents. Clausen *et al.* (2020) reviewed the ingredients of 101 frequently used spray products in Denmark and the literature on respiratory effects from spray cleaning and disinfection products. In a follow-up study, QSAR predictions were combined with knowledge on physicochemical properties for 154 ingredients, identifying 28 ingredients for detailed literature review on asthma inducing potential. Of these 28

ingredients, 4 had some indication in humans or animals for asthma induction, 1 had equivocal data while the remaining 23 had insufficient data (Hadrup *et al.*, 2022).

The corrosive and irritative properties of cleaning agents may also cause acute effects or injuries, such as respiratory irritation and chemical burns on skin and eyes. Poison control data have been used to identify or review the health hazards of cleaning agents, in general (Arici *et al.*, 2012; Scazzola *et al.*, 2019) and at work (Schenk and Öberg, 2018; Schenk *et al.*, 2020). A survey of occupational cases handled by the Swedish Poisons Information Centre (PIC) showed that one-fourth of all cases involved cleaning agents or disinfectants, one-third of which were classified as major risk cases, generally due to potential for corrosive eye and skin injuries (Schenk *et al.*, 2020). Follow-up interviews to PIC calls pointed towards limited awareness of safety data sheets and disregard of protective equipment as factors contributing to poor risk management (Schenk *et al.*, 2020). Comparing the PIC records of occupational cases judged as a clear risk incident to the injury statistics of the Swedish Work Environment Authority (SWEA) revealed a substantially higher number, in both absolute and relative terms, of cleaning agent accidents in the PIC data, indicating that there could be an underreporting of occupational injuries (Schenk and Öberg, 2018).

In the present work, we map the health hazards associated with occupational use of cleaning and disinfection agents on the Swedish market through exploring data from the Swedish Products Register, hosted by the Swedish Chemicals Agency, national occupational injury and disease statistics, based on employers' mandatory reporting, and call records from the Swedish Poisons Information Centre (PIC). More specifically the objectives were to characterize and compare health hazards of marketed products, which hazards are realized in the form of disease, injury, or incidents and which kind of workplaces or occupations are involved.

Methods

The present work mainly draws on four sources of data, described below. In addition, supporting information was collected from officially available statistics. Labour market data are available from Statistics Sweden (2021), data on total number of diseases and injuries the current and preceding 5 years are available from SWEA (SWEA, 2021).

The Swedish Chemicals Agency's Products Register

The Swedish Chemicals Agency maintains a Products Register of chemical products containing information

on distribution of products, their ingredients and uses, based on manufacturers' or importers' reporting (Swedish Chemicals Agency, 2021). The notification requirements are based on volume (manufacturing or importing >100 kg year⁻¹) and a list of customs numbers in Annex 1 to the Chemical Products and Biotechnical Organisms Ordinance. In total, data for 8453 unique products were extracted. Data on tonnage, number of products, and each products' health hazards were collected for cleaning agents, selected bleaching agents, and disinfection products for human use in May 2021 (selection based on type of products occurring in cleaning agent-related accidents in a previous study of PIC call records; Schenk *et al.*, 2020). The categorization of product groups is predefined by the Products Register (Swedish Chemicals Agency, 2021). The health hazard information extracted was the reported hazard statements (H-phrases, including the EU specific EUH-phrases) or if no H-phrases were given ($n = 93$ products) the reported risk-phrases (R-phrases). We specifically focussed on acute health hazards and long-term hazards for local health effects.

Swedish Work Environment Authority's statistics

Two sources of data were used from SWEA. First, Information System on occupational Accidents and work-related diseases (ISA). ISA is based on employers', including self-employed's, reporting of occupational injuries and diseases as required by the Swedish Social Insurance Code. Injuries that involve 1 or more days of absence from work and diseases are registered in ISA. Parts of the ISA database are publicly available online (<http://webbstat.av.se/>; last accessed 15 December 2021). Reporting to ISA follows a structured notification form, including variables defined by SWEA and the European Statistics on Accidents at Work (ESAW; Eurostat, 2013).

ISA data were available for the years 2011 through 2020. For ISA diseases, all cases attributed to cleaning or disinfection agents for 2011 through 2020 were extracted ($n = 512$). No further coding or filtering was performed. For ISA injuries, all cases reported Contact with hazardous substances (ESAW codes 15, 16, and 17 for Contact-Mode of injury) were extracted ($n = 2685$). The information reported under the heading of material agent was used to manually identify accidents caused by cleaning and/or disinfection agents. Examples of included material agents are: cleaning agent, drain cleaner, and dish washing machine. Injuries with insufficient detail to ascertain that the material agent was a cleaning or disinfection agent were not included.

In addition to ISA reporting, severe accidents and severe incidents are also to be reported separately to

the SWEA according to section 3a in chapter 3 of the Swedish Work Environment Act (henceforth referred to as 3.3a reporting). Severe accident is not strictly defined, but SWEA exemplifies with injuries to internal organs, burns larger than 5% of the body surface, and accidents where several persons were injured. Near misses that could have caused severe accidents are defined as severe incidents. The unit of these 3.3a reports is the incident or accident, and not like ISA the employee. Although severe accidents should also result in one or several reports to ISA, a previous comparison of reported date of accident indicated overlap between ISA injuries and 3.3a accidents is low (Schenk and Öberg, 2018). In addition, the reporting scheme differs between ISA and 3.3a. In the present study, all cases reported as caused by 'chemicals' were extracted ($n = 3065$), for each case the free-text case description was read and manually coded as cleaning agent related or not. Cleaning agent related was defined as concerning a cleaning and/or surface disinfection task or machinery, such as floor cleaning. We excluded instances of cleaning tasks coinciding with chemical exposures other than cleaning agents, e.g. process chemicals not properly removed before periodical maintenance cleaning of equipment/machinery and manufacturing of cleaning products. Case descriptions that were not informative enough to ascertain whether a cleaning/disinfection agent was involved were coded as not cleaning agent related.

The Swedish Poisons Information Centre call records

The Swedish Poisons Information Centre (PIC) operates a 24-h phone service and is open to medical professionals as well as the general public. Telephone consultations are logged in the PIC database and multiple calls about the same case are connected to the first call allowing identification of individual cases. For this study, we extracted call records for 2015 through 2020 concerning accidental exposures at work, involving cleaning agents or disinfection agents according to the PIC categorization scheme for poisoning agents. Only cases concerning adults were included, which in terms of PIC age categorization means 20 year or older. In total data for 2999 unique cases were extracted, including information on:

- Time of call
- Sex of exposed person (female, male, unknown)
- Poisoning agent (according to predefined categories, see below)
- Route of exposure (eye, ingestion, inhalation, multiple routes, skin; remaining routes regrouped as other)

- Level of risk as per the judgement of PIC expert based on callers' description:
 - Minor risk: no or mild symptoms, possible to manage on site, healthcare recommended if symptoms persist or occur later.
 - Moderate risk: pronounced or prolonged symptoms might occur, immediate healthcare may be recommended.
 - Major risk: risk for severe symptoms, immediate healthcare recommended.
 - Undetermined risk: e.g. due to limited information about symptoms and/or exposures.
 - Confirmed severe outcome: only assigned to patients diagnosed by physician for a severe or life-threatening outcome or in case a lethal outcome was confirmed.
- Advice from PIC expert

The information on poisoning agent for each case is structured in two parts, for instance: "descaler, acid" or disinfection, quaternary ammonium compounds'. That is, a product group category followed by a chemical group or hazard category (referred to hazard category henceforth). The PIC categories for product group were combined to, as far as possible, correspond to the product categorization in the Products Register. Categories containing 29 or less cases were combined with the category 'Other cleaning agents', which also includes cases originally categorized as such by PIC ($n = 414$, 14% of cases). The hazard categories were combined into 'acids', 'alkali', 'hypochlorite', 'alcohols', 'surfactants', 'quaternary ammonium compounds', and 'others'. Under others we grouped cases where PIC categorized the hazard as other/unknown ($n = 547$, 18% of cases) and all categories of hazards that occurred in less than 100 cases.

Analysis

The products' hazard statement codes (H-phrases) were used to identify combinations of co-occurring H-phrases in pairs, which in turn was used to perform a social network analysis. The total number of products having each H-phrase, EU hazard phrase, and R-phrase were represented as weights (size of vertices) in the social network analysis. The Pajek software (version 5.13) was employed to perform the analysis. The network layout was adapted manually using the FishEye Cartesian function of Pajek to remove overlaps after adding information on node size (representing number of products with a H-phrase) and edge thickness (representing number of products with the two H-phrases connected by the edge—i.e. line between circles). Hence, relationships

between nodes (circles with H-phrases) are represented by line thickness and not by distance between nodes. As several products only were reported using R-phrases a separate network analysis was performed for R-phrases ([Supplementary Material](#), available at *Annals of Work Exposures and Health* online).

Data from SWEA and PIC were analysed using descriptive statistics and cross-tabulations. The chi-square test for independence was used to test for differences between men and women, results were considered statistically significant when $P < 0.05$.

Ethical vetting

The handling and treatment of the PIC and SWEA data were approved by the Swedish Ethical Review Authority (Dnr 2020-06172).

Results

In the following section, we will first present findings on health hazards posed by products on the market based on data from the Products Register. This will be followed by findings on hazards realized, where and who, based on data from SWEA and PIC.

As seen in [Table 1](#), there is a large amount of cleaning and disinfecting agents on the Swedish market, both in terms of tonnage and number of products. The largest category, bleaching agent, is not limited to bleach for cleaning purposes. The second largest category based on tonnage is made up of the unspecified group of 'other cleaning/washing agents' and covers the largest number of individual products. A substantial amount of the products in [Table 1](#) are assigned hazard phrases by the suppliers, although the percentage per product group ranges from 6% of textile rinsing agents to 94% of carpet detergents.

An overview of the acute hazards and long-term local effect hazards for cleaning and disinfection products on the Swedish market is shown in [Fig. 1](#). It should be noted a selection of products ($n = 168$) were still reported with solely the older R-phrases, a separate social network diagram is presented for these in [Supplementary Material](#) (available at *Annals of Work Exposures and Health* online). Acute hazards to eyes, i.e. H314, H318, or H319, dominate in terms of number of products and they apply to 7116 products (i.e. 54% of all products in [Table 1](#)). This is followed by acute hazards to skin, H314 or H315, which applies to 4460 products (34%). Respiratory irritation (H335) applies to 643 products (5%). As the properties of being corrosive or irritating are generally not route specific, these hazards are also the most commonly co-occurring (thick lines in [Fig. 1](#)).

We also see phrases indicating a risk for fatality (H300, H304, H310, H330, in total 667 products or 5% of products) among these products. Hazard-phrases indicating a risk for contact allergy (H317) or for respiratory sensitization or asthma (H334) are present as well, but at numbers lower (229 products or 2% and 30 products or 0.2% of products, respectively) than those for potentially fatal hazards (H300, H304, H310, and H330). [Fig. 1](#) clearly shows that cleaning agents are mixtures, and products often pose several types of hazards (see also [Supplementary Fig. A1](#), available at *Annals of Work Exposures and Health* online, encompassing all H- and R-phrases).

[Table 2](#) shows the number of occupational disease cases reported to SWEA as caused by cleaning or disinfection agents for the period of 2011 through 2020. Skin diseases, including eczema is the most frequent type of disease reported (61%), followed by lung and airway diseases (26%). In 2020, the number of reported diseases increased to a level three times higher the average of 2011–2019 (128 cases compared with average 42, [Fig. 2](#)). An increase, was also seen in occupational disease statistics at large, for the years preceding 2020 roughly 10 000 diseases were reported annually, which increased to 19 740 disease cases in 2020 ([SWEA, 2021](#)). On average 76% of the 512 occupational disease cases reported to SWEA as caused by cleaning or disinfection agents (2011 through 2020) concern women ([Table 2](#)).

As with occupational diseases attributed to cleaning agents or disinfectants, numbers are low for occupational injuries caused by cleaning agents reported to SWEA ([Table 2](#)). The most notable time trend is that half as many cleaning agent injuries were reported in 2020, compared with the average previous years ([Fig. 2](#)). No such decline was seen for injuries overall, about 35 000 injuries were recorded annually in ISA in the years 2016 through 2020 ([SWEA, 2021](#)). Among the injuries due to cleaning and/or disinfection agents, chemical burns constitute the majority of injuries (64%), while superficial injuries (10%), other/unspecified kinds of burns (7%), and poisonings (7%) make up smaller parts. Eyes are the most commonly affected part of the body, 62% of the injuries in [Table 2](#) concern eyes. On average, the ISA injuries concern women (48%) about equally as often as men ([Table 2](#)). However, chemical burns and superficial injuries were more likely to be reported for male employees while other burns and poisonings were more likely reported for female employees ($\chi^2_{N=370} = 9.7$, $P = 0.05$).

Numbers of reported severe accidents and severe incidents (3.3a) identifiable as caused by cleaning agents are low ([Table 3](#)), making it difficult to draw any

Table 1. Categories of cleaning agents and their product numbers on the market from 2015 to 2020 based on the Products Register of the Swedish Chemicals Agency.

Type of product	Quantity (tonnes)	Products (n)	Percent w/ H-phrase ^a
Bleaching agents, other ^b	788 957	82	84%
Cleaning/washing agents, other	109 277	4910	65%
Washing agents for textile (detergents)	68 890	1063	67%
Windscreen washing agents	41 376	203	79%
Private area and public health area disinfectants and other biocidal products ^b	32 022	1130	66%
Degreasers (cold degreasing, de-waxing, de-polishing)	25 538	1050	82%
Rinsing agents (textiles)	23 796	261	6%
General cleaning/washing agents (floor wash, basic cleaning) including concentrate	22 300	1116	52%
Cleaning/washing agents for dishwashing machines	19 557	385	85%
Cleaning/washing agents for dish washing	18 126	380	75%
Human hygiene biocidal products	12 563	302	31%
Food and feed area disinfectants	9400	437	86%
Auto Shampoo	5127	327	72%
Optical whiteners	3630	47	26%
Foam cleaning/washing agents	2386	213	86%
Spot (stain) removers	2095	126	59%
Lime deposit (calcium) remover	1989	278	78%
Sanitation agents for toilets	1978	86	65%
Glass and window cleaner (window polish)	1769	199	31%
Rinsing agents (for dish washing machines)	1677	88	61%
High pressure cleaning/washing agents	1190	144	67%
Bleaching agents for textiles ^b	1172	77	86%
Anti-incrustators ^c	801	45	91%
Drain cleaners	701	83	60%
Stove and grill cleaning agents	567	92	71%
Rinsing agents, other	96	34	62%
Carpet detergents	80	33	94%

^aPercent of products that are listed with hazard statement codes and/or risk-phrases.

^bThese product categories are not registered under the category cleaning agents (function code starting with R.10) in the Products Register.

^cUsed for chimney and boiler cleaning.

conclusions on trends, although in absolute numbers reported incidents roughly doubled from 2012 to 2017 and onwards (Fig. 2). The 3.3a records are specific to the accident or incident and contain no data on worker demographics. We expect an overlap between ISA injuries and severe accidents. However, out of the 232 severe accidents 42 matched the reporting dates in ISA injuries, meaning the 3.3a accidents largely hold unique information for our purposes.

Table 3 shows the sectors and occupations involved in the ISA and 3.3a cases. The sector of human health and social work activities had the highest number of disease cases (48%) while the manufacturing sector had the largest number of accidents and incidents (28% of

ISA injuries, 23% of 3.3a accidents, and 20% of 3.3a incidents). On average for the periods of 2011 through 2020, there have been 11 cases of occupational disease attributed to cleaning or disinfection agents per million workers and year in Sweden. The corresponding number for injuries is 8. There is some variation across sectors, occupational disease are three times more common in the healthcare sector (on average 33 cases per million workers and year) than average. Injuries due to cleaning or disinfection agents are 3.5 times more frequently reported within accommodation and food services (on average 27 cases per million workers and year) than average (see Supplementary Table A2, available at *Annals of Work Exposures and Health* online). On

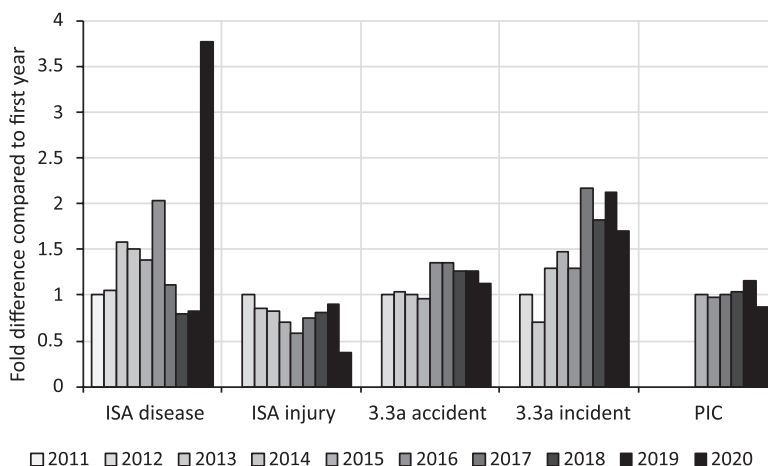


Figure 2. Time trends in number of cases identified as caused by cleaning or disinfection agents in the different databases, each standardized to its first plotted year. ISA disease and injury reports cover 2011 through 2020, 3.3a severe accidents and incidents concern 2012 through 2020 and PIC cases concern 2015 through 2020, years are plotted chronologically from left to right.

PIC cases, 41% were connected to exposures to alkaline products (excluding the category hypochlorite which generally also is alkaline). The number of cases involving exposures to alkali decreased by 25% compared with the average 2015–2019, while the number of cases involving alcohols (mainly ethanol and isopropanol) increased by 50% compared with the average 2015–2019 (Supplementary Fig. A6, available at *Annals of Work Exposures and Health* online). The product groups involved are shown in Table 4. The largest number of cases concerned disinfectants, the specific contribution from 2020 was 128 which was 1.3 times higher than the average for preceding years (97.6). While a substantial part of the total number of cases, the proportion of major risk cases is low for disinfectants. Professional cleaning products, dishwasher detergents, and oven and grill cleaners are the product categories with the largest proportion of major risk cases (39–43%), attributable to these products often having a high pH making them corrosive or severely irritating.

Fig. 3 shows the route of exposure and PIC experts' assessment of risk. Eye exposures dominate both in terms of absolute number of cases (66%) and share of major risk cases (74%), although eye exposures most frequently led to an assessment of moderate risk. Other routes were skin (18% of cases), inhalation (13% of cases), and ingestion (8%), generally risk was judged as moderate or minor when these routes were involved.

Across the 2999 PIC cases, 51% concerned women and 47% men (Table 4), in addition 67 cases did not identify sex of the exposed person (data not shown). Cases where men were exposed were more likely to be assessed as major risk cases, while cases with women

were more likely to be judged as minor risk (excluding cases with unknown sex and indetermined risk, $X^2_{N=2868} = 111, P < 0.001$).

Discussion

This review of register data on cleaning agents on the Swedish market shows that cleaning agents pose many kinds of health hazards, although as also shown by Gerster *et al.* (2014) corrosion and irritation hazards dominate, in particular for the eyes. This is also reflected in the occupational disease and injury statistics and PIC records, as skin disease and eye injuries are most frequent in these databases. Unfortunately, ISA data did not allow a separation of skin and respiratory diseases caused by irritative effects and allergenic effects (few products). Nevertheless, assuming irritation-induced disease, there is some concordance in the nature of hazards posed by products on the market and realized in terms of disease and injury concerning eye and skin. Respiratory diseases (again not specified) constituted 26% of disease cases attributed to cleaning or disinfection agents, while very few products were identified as posing risk to the respiratory tract. It is difficult to evaluate whether there is any relationship between tonnage of products on the market as registered in the Products Register and hazards realized, as SWEA data do not categorize products and the PIC employs a different product categorization than the Products Register (Tables 1 and 4).

Epidemiological research on health effects from cleaning and disinfection agents generally focus on cleaning and nursing occupations (Quirce and Barranco, 2010; Van den Borre and Deboosere, 2018; Carder

Table 3. Overview of sectors and occupations involved in SWEA records attributed to cleaning or disinfection agents.

	ISA diseases <i>n</i> (%)	ISA injuries <i>n</i> (%)	3.3a accidents <i>n</i> (%)	3.3a incidents <i>n</i> (%)
Sector ^a				
Manufacturing	41 (8)	102 (28)	55 (23)	47 (20)
Administrative and support service activities	48 (9)	50 (14)	45 (19)	24 (10)
Accommodation and food service activities	29 (6)	43 (12)	31 (13)	20 (9)
Human health and social work activities	245 (48)	41 (11)	17 (7)	27 (12)
Wholesale and retail trade; repair of motor vehicles and motorcycles	17 (3)	27 (7)	16 (7)	32 (14)
Education	53 (10)	25 (7)	14 (6)	24 (10)
Public administration and defence; compulsory social security	23 (4)	19 (5)	13 (5)	6 (3)
Construction	2 (0)	16 (4)	5 (2)	2 (1)
Transportation and storage	11 (2)	14 (4)	11 (5)	12 (5)
Other service activities	7 (1)	8 (2)	2 (1)	4 (2)
Real estate activities	14 (3)	6 (2)	10 (4)	8 (3)
Arts, entertainment, and recreation	11 (2)	6 (2)	9 (4)	18 (8)
Other sectors (less than 10 ISA cases)	11 (2)	13 (4)	10 (4)	7 (3)
ISCO-08 minor group-level occupation ^a				
Personal Care Workers in Health Services	169 (33)	26 (7)	—	—
Domestic, Hotel and Office Cleaners and Helpers	99 (19)	66 (18)	—	—
Food Preparation Assistants	24 (5)	44 (12)	—	—
Nursing and Midwifery Professionals	45 (9)	4 (1)	—	—
Cooks	29 (6)	18 (5)	—	—
Food and Related Products Machine Operators	3 (1)	28 (8)	—	—
Machinery Mechanics and Repairers	8 (2)	17 (5)	—	—
Shop Salespersons	5 (1)	11 (3)	—	—
Assemblers	9 (2)	5 (1)	—	—
Protective Services Workers	8 (2)	6 (2)	—	—
Building and Housekeeping Supervisors	4 (1)	8 (2)	—	—
Blacksmiths, Toolmakers and Related Trades Workers	5 (1)	6 (2)	—	—
Waiters and Bartenders	1 (0)	10 (3)	—	—
Painters, building structure cleaners and related trades workers	1 (0)	9 (2)	—	—
Chemical and Photographic Products Plant and Machine Operators	3 (1)	7 (2)	—	—
Other occupations (less than 10 ISA cases)	99 (19)	105 (28)	—	—
Total	512	370	238	231

— Not applicable as 3.3a data are specific to accident or incident.

^aISA disease and injuries are available for 2011 through 2020, 3.3a accidents and incidents are available for 2012 through 2020.

et al., 2019; De Matteis *et al.*, 2020; Dumas and Le Moual, 2020; Archangelidi *et al.*, 2021; Romero Starke *et al.*, 2021). To some extent the SWEA data confirm expected patterns regarding in which sectors and occupations diseases and injuries occur, however, the full range of sectors and occupations covered by the ISA data show the wide-spread use of this product group. There are differences between men and women in the reviewed data, women were more likely to suffer from disease, in particular skin diseases, and men more likely to suffer from injuries in particular chemical burns. These patterns are supported by the PIC data, where overall number of cases were almost even between sexes, but men

were more frequently involved in the major risk cases such as chemical burns requiring healthcare treatment. These findings are similar for all PIC cases, and not only limited to cleaning agent accidents (Schenk *et al.*, 2018).

We noted a likely effect from the COVID-19 pandemic in the reviewed data. Reported skin diseases attributed to cleaning or disinfection agents increased during 2020, while injuries clearly decreased during the same year. Skin diseases were most frequently connected to the healthcare sector, which suffered an extreme increase in workload starting spring 2020. These findings are in line with reports on skin damage among healthcare employees due to COVID-19 (Lan *et al.*,

Table 4. Number of PIC cases per type of exposure, product group, and PIC experts' assessment of risk.

	Major risk <i>n</i> (%)	Moderate risk <i>n</i> (%)	Minor risk ^a <i>n</i> (%)	Sum of cases <i>n</i> (%)	% major risk
Total number of cases	780 (100)	1416 (100)	803 (100)	2999 (100)	26%
Of which women	288 (37)	726 (51)	506 (63)	1520 (51)	19%
Of which men	460 (59)	671 (47)	281 (35)	1412 (47)	33%
Of which unknown sex	32 (4)	19 (1)	16 (2)	67 (2)	48%
Type of exposure					
Alkali	517 (66)	582 (41)	145 (18)	1244 (41)	42%
Alcohol	0 (0)	104 (7)	234 (29)	338 (11)	0%
Acids	87 (11)	148 (10)	58 (7)	293 (10)	30%
Hypochlorite	34 (4)	132 (9)	50 (6)	213 (7)	16%
Quats	48 (6)	41 (3)	17 (2)	106 (4)	45%
Surfactant	0 (0)	40 (3)	65 (8)	105 (4)	0%
Other/unknown	97 (12)	369 (26)	234 (29)	700 (23)	14%
Product group					
Disinfectant	67 (9)	247 (17)	302 (38)	616 (21)	11%
Professional cleaning	218 (28)	276 (19)	56 (7)	550 (18)	40%
Dishwasher detergents	181 (23)	177 (13)	54 (7)	412 (14)	44%
Oven and grill cleaners	73 (9)	90 (6)	16(2)	179 (6)	41%
Descaling agents	42 (5)	78 (6)	51 (6)	171 (6)	25%
Bleach	24 (3)	79 (6)	28 (3)	131 (4)	18%
Sewer and drain cleaners	44 (6)	62 (4)	21 (3)	127 (4)	35%
All-purpose cleaner	2 (0)	40 (3)	37 (5)	79 (3)	3%
Pool chemical	3 (0)	35 (2)	22 (3)	60 (2)	5%
Mould and algae remover	15 (2)	26 (2)	8 (1)	49 (2)	31%
Kitchen cleaning	10 (1)	24 (2)	8 (1)	42 (1)	24%
Sanitary cleaners	3 (0)	22 (2)	11 (1)	36 (1)	8%
Laundry detergent	6 (1)	12 (1)	13 (2)	31 (1)	19%
Hand dishwashing agents	0 (0)	11(1)	19 (2)	30 (1)	0%
Other cleaning agents	92 (12)	237 (17)	157 (20)	486 (16)	19%

Quats, quaternary ammonium compounds.

^aThe column minor risk also includes 68 cases for which risk was recorded as undetermined.

2020; Pei *et al.*, 2020; Hamnerius *et al.*, 2021). The number of calls to PIC concerning disinfectants also increased in 2020 compared with previous years. For other sectors, such as manufacturing within which injuries were most common, many workplaces reduced operations due to the pandemic. Also PIC records indicate that the overall number of accidents and incidents decreased in 2020 compared with previous years, although not as markedly as ISA injuries. Severe accidents and incidents (3.3a) were even less affected.

The injury and disease numbers we identified as caused by cleaning and/or disinfection agents in ISA are low, both compared with the size of the Swedish workforce and the total number of reported injuries and diseases. It should be noted that the incident and injury numbers presented herein are not the full picture. We can expect underreporting to SWEA, we know from other

countries that underreporting can be substantial (Leigh *et al.*, 2004; Rosenman *et al.*, 2006; Fagan and Hodgson, 2017) and that underreporting may be proportionally larger for certain sectors, occupations, or groups (Probst *et al.*, 2013; Rappin *et al.*, 2016). As a broad range of occupations of different socioeconomic status are represented in our data, it seems plausible there is some effect from such biases on our findings. In the present study, only cases clearly identifiable as cleaning or disinfection related were included leading to an undercount of the reported cases. We have also previously shown that for injury statistics the reporting does not mandate identification of a chemical agent or product, meaning that in many cases reporting will not allow the identification of, e.g., cleaning agents as the cause of the injury (Schenk and Öberg, 2018). The PIC records hold more information pertaining to the chemical nature of

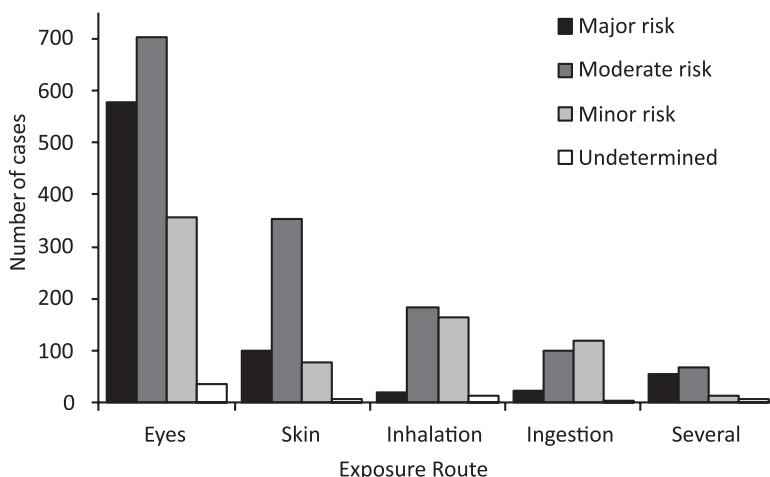


Figure 3. Number of cases reported to the Swedish Poisons Information Centre from 2015 to 2020 based on severity of risk and exposure route. Twelve cases involving other routes are excluded.

substance(s) leading to the hazard as well as the cause of the accident and a brief description of the accident as informed by the caller. Nevertheless, PIC records hold some limitations, as their records are based on callers' reporting of products, extent of exposure and symptoms. Furthermore, not all persons are aware of the PIC service and language may pose a barrier to contacting PIC (the PIC experts provide guidance in Swedish and English). Hence, the persons who do not speak these languages may not be able to report accidents to the PIC, and hence occupations where foreign workers are more frequent may be underrepresented. Severe injuries that lead to immediate hospitalization may not be covered by PIC data, as physicians may not need their assistance for treating the patients. PIC records are also not designed to provide insight on the nature of the workplaces where accidents occurred, or the number of people affected in case of several. It has been previously suggested that adding sector or occupation to the PIC records would majorly increase their value as an occupational surveillance tool (Schenk *et al.*, 2018).

The overview of hazards on the market relies on the producers' self-classification and labelling (H-phrases) of the products, as submitted to the Products Register. We know from the 180 000 self-classified substances in the Classification and Labelling Inventory that there are some inconsistencies across different self-classifications for the same substance and industry compliance is not sufficient (European Chemicals Agency, 2021). Experience from safety data sheets, which also contain the producers' self-classifications, show us there may additionally be issues with the classification of the mixtures in products. In a recent enforcement project in the

EU, 3391 products were inspected across 28 countries. Among 3189 inspected mixture labels, 468 had an error in hazard statements, which in most cases was related to errors in self-classification (European Chemicals Agency, 2019). A recent study on safety data sheets for cleaning and disinfection products used in healthcare, showed that the safety data sheet did not provide complete information for identifying products that contained respiratory sensitizers, but still it was a good available tool for identifying respiratory irritants (Lee *et al.*, 2021). We thus expect Fig. 1 to underestimate some hazards, nevertheless it does provide an overview of the major hazards and complex hazard profiles of cleaning agents as a product group.

Conclusions

In the present study, we have shown that cleaning agents pose a variety of risks to users. Corrosion and irritation hazards dominate, half and one-third of products were labelled for such hazards to eyes and skin, respectively, while 1 in 20 had a respiratory irritation label. The nature of the health hazards is reflected by the type of occupational diseases and injuries attributed to cleaning agents for eyes and skin; 61% of occupational disease cases attributed to cleaning or disinfection agents concern skin disease, 64% of occupational injury cases concern chemical burns. PIC cases most frequently concerned eye exposures (66%). But inhalation hazards seem underrecognized as 26% of occupational disease concerned respiratory tract. Overall, cleaning or disinfection are explicitly attributed as the cause in a relatively small part (<0.5%) of all reported diseases and

injuries. On average, there were 11 cases of disease per million workers and year and 8 cases of occupational disease per million workers and year. Although the numbers were higher for the healthcare, accommodation and food service, and manufacturing sectors, the data show that a broad range of sectors and occupations are afflicted by cleaning agent-related disease and injury. Women were more likely to suffer from disease, men and women about equally likely to suffer from injury. Among PIC data, cases were evenly distributed between men and women, but clear risk cases were more frequently involving men. We conclude that cleaning agents pose a variety of risks to a broad range of workers, although particular attention for preventive efforts may need to be directed to the healthcare, accommodation and food service, and manufacturing sectors. Workers handling cleaning agents should take care to use eye protection when handling potentially irritating or corrosive products. The potential underrecognition of inhalation hazards by self-classification needs further investigation.

Supplementary Data

Supplementary data are available at *Annals of Work Exposures and Health* online.

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Conflict of interest

The authors declare no conflict of interest relating to the material presented in this article. Its contents, including any opinions and/or conclusions expressed, are solely those of the authors.

Data availability

Data underlying this article were provided by the Swedish Chemicals Agency, the Swedish Work Environment Authority and the Swedish Poisons Information Centre. Data will be shared on request to the corresponding author with permission of the respective organizations providing the data.

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