

Hazardous substances in frequently used professional cleaning products

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Background: A growing number of studies have identified cleaners as a group at risk for adverse health effects of the skin and the respiratory tract. Chemical substances present in cleaning products could be responsible for these effects. Currently, only limited information is available about irritant and health hazardous chemical substances found in cleaning products. We hypothesized that chemical substances present in cleaning products are known health hazardous substances that might be involved in adverse health effects of the skin and the respiratory tract.

Methods: We performed a systematic review of cleaning products used in the Swiss cleaning sector. We surveyed Swiss professional cleaning companies ($n=1476$) to identify the most used products ($n=105$) for inclusion. Safety data sheets (SDSs) were reviewed and hazardous substances present in cleaning products were tabulated with current European and global harmonized system hazard labels.

Results: Professional cleaning products are mixtures of substances (arithmetic mean 3.5 ± 2.8), and more than 132 different chemical substances were identified in 105 products. The main groups of chemicals were fragrances, glycol ethers, surfactants, solvents; and to a lesser extent, phosphates, salts, detergents, pH-stabilizers, acids, and bases. Up to 75% of products contained irritant (Xi), 64% harmful (Xn) and 28% corrosive (C) labeled substances. Hazards for eyes (59%) and skin (50%), and hazards by ingestion (60%) were the most reported.

Conclusions: Cleaning products potentially give rise to simultaneous exposures to different chemical substances. As professional cleaners represent a large workforce, and cleaning products are widely used, it is a major public health issue to better understand these exposures. The list of substances provided in this study contains important information for future occupational exposure assessment studies.

Keywords: Health risk, Irritant, Harmful, Corrosive, Cleaning products, Occupational exposure

Introduction

Professional cleaning is a basic service occupation worldwide, and cleaning products are used daily in different environments, both indoors and outdoors.^{1,2} In recent years, a growing number of scientific studies have shown an association of cleaning work with respiratory adverse effects including asthma.^{3–5} In addition, skin diseases such as dermatitis of the hand have also been reported.^{6–8} One explanation for the observed respiratory adverse health effects among cleaning workers is chemical exposures deriving from cleaning products.^{2,9–11}

Several studies have investigated the relationship between adverse health effects, cleaning activity, and cleaning products.^{12–19} Several risk factors were

identified including exposure to chemical substances via application of cleaning products and other cleaning activities. Researchers have called for objective and more accurate estimates of occupational exposure to cleaning products in order to better understand their adverse effects.¹² One major difficulty in this context is the multitude of cleaning products used, and the large number of chemical substances present in these products. Moreover, cleaning products are constantly changing because of ecological, economic, and consumer demands.

Safety data sheets (SDSs) for professional cleaning products are made available to provide workers with health hazard information regarding substances or mixtures. The current EU classification system (Directives 1999/45/EC and 67/548/EEC) defines substances and preparations as dangerous if they are explosive (E), oxidizing (O), extremely or highly flammable (F+, F), very toxic (T+), toxic (T),

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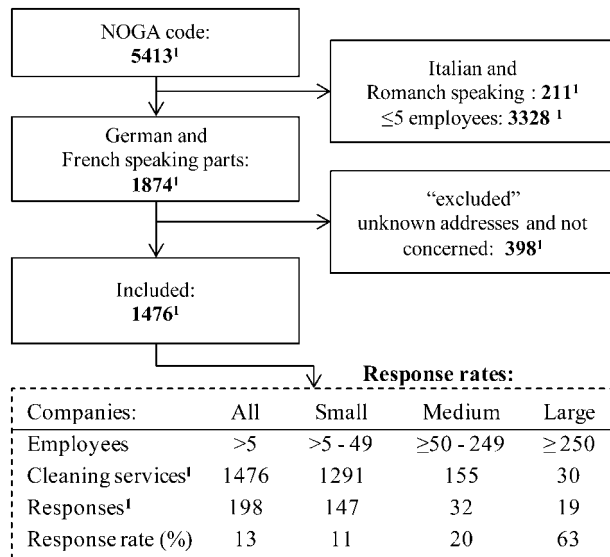


Figure 1 Flow-chart of the decision process for including and excluding (non-French- and non-German-speaking cantons, unknown addresses, or uncommon types of cleaning) cleaning companies in the study. ¹ Number of cleaning services selected for the study. The table shows response rates by company size.

harmful (Xn), corrosive (C), irritant (Xi), sensitizing (Xn or Xi), carcinogenic (T, Xn), mutagenic (T, Xn), toxic for reproduction (T, Xn), or dangerous for the environment (N). These labels are accompanied by risk phrases (R-phrases), and typical R-phrases used for cleaning products are listed in the Methods section.

We identified frequently used professional cleaning products in Switzerland and through a systematic SDS analysis of these products, hazardous (C, Xn, Xi) substances were identified and listed. We plan to use these results in a future exposure study to better characterize exposures to substances presenting a health hazard among professional cleaning workers.

Methods

Selection of cleaning products

To select a representative group of frequently used cleaning products, we mailed a letter to cleaning companies located in the French- and German-speaking cantons of Switzerland ($n=1476$, Fig. 1). The letter mailed to cleaning services was not available in Romansh and Italian languages, thereby excluding cleaning companies in the Romansh and Italian cantons of Switzerland. Cleaning companies were asked to specify cleaning activity, company size, and cleaning products used. Cleaning companies were identified from the Federal Office of Statistics using the code for cleaning companies ('Nomenclature Générale des Activités économiques' (NOGA code) (2008)). The NOGA data contained estimates about company size by number of employees. Companies were grouped into small (5–49 employees), medium (50–250 employees), and large (≥ 250 employees). Technical terms (both French and German) used in

the cleaning sector were retrieved from the training manual used for professional cleaners in Switzerland.²⁰ To process the large number of responses, we used the TeleForm software (Cardiff TeleForm, Version 10.5.2, San Diego, USA).

The letter included a list of cleaning products ($n=488$) from four major companies that manufactured, produced, and/or supplied products in Switzerland. This list of cleaning products by brand names was finalized after discussions with a professional cleaning association, a medium-sized cleaning company, and a training center for professional cleaners. The cleaning companies were asked to mark the cleaning products they used from the provided list, and in the case where the cleaning products they used were not listed, the company was asked to write down these names before mailing the responses back. An Excel spreadsheet was generated from TeleForm and imported to Stata (Stata 12, Stata Corp Lp, Lakeway Drive, USA). Response rates by company size were calculated. Cleaning products marked as being used by at least 10 cleaning companies were included in the systematic SDS analysis.

Safety data sheet analysis

Safety data sheets for cleaning products were obtained from the companies' web sites. If SDSs were not available, products were excluded from the SDS analysis. Selected products were grouped into 10 product categories: floor cleaners (FCs), general purpose cleaners (GPCs), polishing products (PPs), carpet cleaners (CCs), scale removing products (SRPs), bathroom cleaners (BCs), glass cleaners (GCs), disinfection products (DPs), kitchen cleaners (KCs), and other surfaces cleaners (OSCs).

A comprehensive table was created listing all substances mentioned in the SDSs under section 3. Section 3 in the SDS lists all the ingredients in a mixture (chemical name, CAS number, and concentrations) that are classified as health hazards and are present above their cut-off/concentration limits. The frequency of a chemical substance's occurrence in selected products was recorded. Section 3 of SDSs is titled 'Composition/information on ingredients' and provides details about hazardous substances in the mixtures. Names, substance identifier (CAS number), concentration or concentration ranges, and classifications according to current danger letters and R-phrases (Directives 1999/45/EC and 67/548/EEC) as well as new hazard classes and statements (Regulation (EC) No. 1272/2008) are presented in the table.^{21–23} This was possible because Switzerland has from 1 December 2010 to 1 June 2017 to replace the current classification system (Directives 1999/45/EC and 67/548/EEC) with the new (Regulation (EC) No. 1272/2008), meeting the requirements of the Globally

Harmonized System of Classification and Labeling of Chemicals (GHS).²⁴ Therefore, both the current classification and the new GHS labeling were available for this study. The regulations (Directive 67/548/EEC, Directive 1999/45/EC, EC No. 1272/2008) define substance concentration restrictions regarding the listing of substances in this section.^{21–23} Table 1 includes also the types(s) of cleaning products (FC, GPC, PP, CC, SRP, BC, GC, DP, KC, OSC) where the chemical substances were present. A literature search was performed in PubMed (<http://www.ncbi.nlm.nih.gov/pubmed/>, 15 October 2013) by searching for ‘substance name’+‘exposure’ and ‘CAS number’+‘exposure’. If available, up to three studies were chosen for each chemical substance that was present in at least two selected cleaning products. Further criteria for the selection of references were ‘publishing date’, ‘health aspects’, ‘dermal and respiratory exposure studies’, ‘occupational exposure studies’, ‘exposure assessment methods’, ‘cleaning’, and ‘cleaning products’.

Fragrances sometimes do not meet the criteria to be listed in section 3 ‘Composition/information on ingredients’ of the SDSs (e.g. low concentration). However fragrances, preservatives, and others are mentioned in section 15 ‘Regulatory Information’ if they are subjected to other regulations such as substances depleting the ozone layer ((EC) No. 2037/2000, persistent organic pollutants (EC) No. 850/2004, and export/import of dangerous substances (EC) No. 689/2008).^{25–27} Names of fragrances, preservatives, and other chemical substances listed under section 15 of SDSs are reported in the Results section.

Cleaning products containing at least one substance listed with corrosive, irritant, and harmful symbols under the current EU classification system were counted and expressed in percentage for each of the 10 product categories. Similar results were presented for the R-phrases. R-phrases relevant in this study are harmful by inhalation (R20), are harmful in contact with skin (R21), are harmful if swallowed (R22), causes burns (R34), causes severe burns (R35), is irritating to eyes (R36), is irritating to respiratory system (R37), is irritating to skin (R38), has risk of serious damage to eyes (R41), may cause sensitization by skin contact (R43), has danger of serious damage to health by prolonged exposure (R48), has possible risk of impaired fertility (R62), has possible risk of harm to the unborn child (R63), is harmful: may cause lung damage if swallowed (R65), repeated exposure may cause skin dryness or cracking (R66), and vapors may cause drowsiness and dizziness (R67). The fractions of cleaning products, with at least one substance listed with the R-phrases R20, R21, R22, R34, R35, R36, R37, R38, R41, R43, R48, R62, R63, R65, R66, and R67, were expressed in percentage.

Results

The response rate to the letter sent to cleaning companies was the highest (50%) for large companies (≥ 250 employees), and lower for medium (24%) and small (11%) companies (Fig. 1). Based on company responses, respondent companies employed $>40\,000$ employees. A total of 116 products were selected for SDS analysis and 11 products were excluded because of missing SDSs. In the 105 remaining selected products, 132 different chemical substances were listed in the SDSs reviewed. In average, one cleaning product contained $3.5 (\pm 2.8)$ chemical substances listed in section 3 of the SDSs. The composition of the cleaning products varied depending on their intended use. The substances we identified are listed in Table 1. Although the type of glycol ethers varied greatly across cleaning products, they were often (20% of the products) present in both small and large amounts (0.1–50% in the products). Most glycol ethers were found in PPs (48%), SRPs (42%), GPCs (37%), and FCs (36%); some (20%) were found in DPs and KCs, and few (10–11%) were found in GCs, BCs, and CCs. The choice of surfactants was diverse but were present in 19% of the products and their concentration ranges varied greatly (0.1–30% in the products). We particularly focused on ethanolamines, known for their sensitizing properties.²⁸ Three ethanolamines were identified: monoethanolamine, triethanolamine, and 2-diethylaminoethanol. The most frequently used was monoethanolamine, which was present in eight products ($n=8$): five FCs, two GPCs, and one KC. In all, 16% of the products contained organic solvents and the concentration ranges varied enormously (0.1–75%) making up 75% of one of the products (PP). Other typical ingredients, although in lower concentrations, accounted for 18% of our substance list (Table 1): phosphates, salts, detergents, pH-stabilizers, acids, and bases. Quaternary ammonium compounds or ‘quats’, a substance class known for sensitizing and allergic responses among cleaners, were found in two products in 3–10% concentrations.^{2,29}

Fragrances were commonly (27% of identified substances) found in low concentrations (0.01–5%), except when they also acted as a solvent (30%). Interestingly, up to 91% of the selected cleaning products contained at least one substance that was subject to other regulations and are listed under section 15 of SDSs. In total, 26 substances were found under section 15 of the SDS (Table 2).

In all, 11 substances listed in section 3 of SDSs were neither classified with danger symbol letters and R-phrases nor with hazard classes and categories. The remaining 117 substances were classified with danger symbol letters and R-phrases as well as with hazard classes and categories. Of these, 82 substances

Table 1 List of substances identified in section 3 of safety data sheets (SDSs) for 105 selected cleaning products, listed in decreasing order of occurrence in products

Substance	EU ¹					GHS ²			Product ³			Reference ⁴
	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹	N ¹⁰	Product type				
Isopropyl alcohol	67-63-0	F	R11	Flam.Liq2	H225	1-75	16	FC, GPC, CC, BC, PP	34-36			
		Xi	R20/21/22	Eyelrrit.2	H319							
		Xn	R36 R36/38 R67	STOTSE3	H336							
Diethylene glycol monoethyl ether	111-90-0	Xi	R36	SkinCorr.1B EyeDam1	H314 H318	0.1-10	15	PP, GPC, FC	37-39			
				AcuteTox4 AquaticAcute1	H302 H400							
Poly(oxy-1,2-ethanediyl), alpha-tridecyl- omega-hydroxy-, branched	69011-36-5	Xn	R22	EyeDam1	H318	1-20	14	FC, GPC, DP, CC, SRP, BC	na			
			R41	AcuteTox4	H302							
Dipropylene glycol monomethyl ether	34590-94-8	na	na	na	na	1-20	12	PP, FC, GPC, CC, BC	40-42			
		Xi	R36	Eyelrrit.2	H319	1-30	9	SRP, BC, FC				
Citric acid	77-92-9	Xi	R22	na	na	1-15	9	SRP, KC, FC, BC, GPC	na			
		Xi	R22	na	na							
Deceth-4	26183-52-8	Xn	R41	na	na				na			
Ethanol	64-17-5	F	R11	Flam.Liq.2	H225	1-20	9	GPC, PP, FC, BC, OSC	44-46			
		Xi	R38	EyeDam1	H318	1-15	8	GPC, FC				
Sulfonic acids, C13-17- sec-alkane, sodium salts	85711-69-9	Xi	R41	SkinIrrit.2	H315				na			
				SkinCorr.1b	H314							
Monoethanolamine	141-43-5	C	R20	AcuteTox4	H302	1-15	8	FC, DP, GPC	9, 47-49			
		Xn	R21 R22 R34 R37	STOTSE3 EyeDam1 AcuteTox4	H335 H318 [H302, H312, H332]							
Benzenesulfonic acid, (1-methylethyl)-, sodium salt (1:1)	28348-53-0	Xi	R36	Eyelrrit.2	H319	1-10	7	FC, GPC, CC, BC	na			
Alcohols, C13-15-branched and linear, butoxylated ethoxylated	111905-53-4	Xi	R36/38	SkinIrrit2	H315	1-30	6	FC, GPC, CC	na			
				Eyelrrit.2	H319							
Propane	74-98-6	F+	R12	Flam.Gas1	H220	1-30	6	CC, GPC	50			
				Press.Gas	H280							
Alcohols, C12-14, ethoxylated	68439-50-9	Xn	R22	EyeDam1	H318	1-10	5	FC, GPC, SRP	na			
			R41	AcuteTox4	H302							
Benzyl alcohol	100-51-6	Xn	R20/22	Eyelrrit.2	H319	1-20	5	FC, GPC	51-53			
		N	R36	AcuteTox4	[H302, H332]	15-75	5	CC				
Butane	106-97-8	F+	R12	Flam.Gas1	H220				54-56			
				Press.Gas	H280							
Butoxypropanol	5131-66-8	Xi	R36/38	SkinIrrit2	H315	1-30	5		57			
				Eyelrrit.2	H319							

Table 1 Continued

Substance	EU ¹				GHS ²			Product ³		Reference ⁴
	Name	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹	N ¹⁰	Product type	
C12-15 Pareth-11	68131-39-5	Xi Xn N R41 R50 R36 R22 R20 R21 R22 R36 R38 R41 R50 R36 R22 R41 R36/38 R52/53	Xi Xn N Xi Xn Xi Xn Xi Xn Xi na	R22 R41 R50 R36 R22 R20 R21 R22 R36 R38 R41 R50 R36 R22 R41 R36/38 R52/53	EyeDam1 AquaticAcute1 AcuteTox4 EyeIrrit.2 AcuteTox4 SkinIrrit.2 EyeIrrit.2 SkinSens.1 AcuteTox4	H318 H400 H302 H319 H302 H315 H319 [H302, H312, H332]	0.1-15	5	PP, FC, GPC	58
Diethylene glycol mono- <i>n</i> -butyl ether	112-34-5	Xi R36	Xi Xn	R36	EyeIrrit.2	H319	5-30	5	FC, SRP, PP	59-61
Ethylene glycol	107-21-1	Xi R20	Xi Xn	R20	AcuteTox4	H302	1-20	5	GPC, FC, PP	62-64
Ethylene glycol mono- <i>n</i> -butyl ether	111-76-2	Xi Xn	Xi Xn	R20 R21	SkinIrrit.2 EyeIrrit.2 SkinSens.1 AcuteTox4	H315 H319 [H302, H312, H332]	1-20	5	GPC, FC, GC	65-67
PEG-10 tridecyl ether	24938-91-8	Xi R41 R50	Xi N	R41 R50	EyeDam1	H318	1-15	5	FC, PP, GPC	na
Phenoxyethanol	122-99-6	Xi R22 R36	Xi Xn	R22 R36	AcuteTox4 EyeIrrit2 na	H302 H319 na	1-10	5	PP, FC, GPC	68
Poly(oxy-1,2-ethanediyl), alpha-isodecyl-omega-hydroxy- Sulfamic acid	61827-42-7 5329-14-6	Xi Xn Xi	Xi Xn Xi	R22 R41 R36/38 R52/53	SkinIrrit2 EyeIrrit.2 AquaticChronic3 Flam.Liq.3	H315 H319 H412 H226	1-15	5	GPC, PP, OSC	na
Poly(oxy-1,2-ethanediyl), alpha- isodecyl-omega-hydroxy- Phosphoric acid	107-98-2 7664-38-2	na C	na C	R10 R34	SkinIrrit.2 EyeIrrit.2 AquaticChronic3 Flam.Liq.3 SkinCorr.1B Met.Corr.1	H315 H319 H412 H226 H314 H290	0.1-<10	4	FC, CC, GPC	na
Poly(oxy-1,2-ethanediyl), alpha-sulfo-omega- hydroxy-, C10-16-alkylethers, sodium salts	68585-34-2	Xi R41 R22 R38 R41	Xi Xn Xi Xn	R38 R41 R22 R38 R41	EyeDam1 SkinIrrit.2 EyeDam1 SkinIrrit.2	H318 H315 H318 H315	1-15	4	GC, BC, KC, GPC	na
Sodium ethasulfate	126-92-1	Xi Xn	Xi Xn	R22 R38 R41	EyeDam1 SkinIrrit.2	H318 H315	1-5	4	FC, BC	na
Tri(2-butoxyethyl) phosphate Alkylalkoholalkoxylat	78-51-3 na	na Xi	na Xi	na R36 R38	na SkinIrrit2 EyeIrrit.2	na H315 H319	1-5 1-10	4 4	PP FC, GPC	69 na
Alcohols, C10-12, ethoxylated propoxylated	68154-97-2	N R51 R53	N	R51 R53	AquaticChronic2	H411	1-5	3	SRP, FC	na
Alpha-terpineol	98-55-5	Xi Xn	Xi Xn	R22 R41 R38	SkinIrrit.2	H315	0.01-15	3	GPC, GC	33, 70, 71
Ammonium hydroxide	1336-21-6	C N R50	C N	R34 R50	SkinCorr.1B AquaticAcute1	H314 H400	0.01-1	3	PP, GPC	72
Cyclohexanol, 4-(1,1-dimethylethyl)-, 1-acetate	32210-23-4	N R51/53	N	R51/53	AquaticChronic2	H411	0.1-<5	3	GPC, CC	na

Table 1 Continued

Substance	EU ¹				GHS ²			Product ³		Reference ⁴
	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹	N ¹⁰	Product type		
(D)-Limonene	5989-27-5	Xi N	R10 R38 R43 R50/53	Flam.Liq3 AquaticAcute1 AquaticChronic1 SkinIrrit.2 SkinSens.1 EyeDam1 AcuteTox4	H226 H400 H410 H315 H317 H318 H302	0.1-1	3	GC, CC	73-75	
Genapol X 080	9043-30-5	Xi Xn	R22 R41 R51 R53			0.1-5	3	PP, GPC	na	
Hydrocarbons, terpene processing by-products	68956-56-9	Xn	R51/53 R65	Asp.Tox.1 AquaticChronic2	H304 H411	0.01-1	3	GC, GPC	na	
Fatty acids, coconut oil, potassium salts	61789-30-8	Xi	R36/38	EyeIrrit2 SkinIrrit.2	H319 H316	1-5	3	GPC, FC	na	
Naphtha (petroleum), hydrotreated heavy	64742-48-9	Xn	R10 R65 R66	na	na	3->30	3	GPC, FC	76	
Silicic acid, disodium salt, pentahydrate	10213-79-3	C	R34 R37	SkinCorr1B STOTSE3	H314 H335	1-15	3	KC, FC	na	
Sodium hydroxide	1310-73-2	C	R35	SkinCorr.1A	H314	0.01-10	3	FC, GC, KC	77	
Alkylalkolethoxylat	na	Xi Xn	R22 R41	na	na	<5-15	2	FC, GPC	na	
1-Propoxy-2-propanol	1569-01-3	na	R10	Flam.Liq3 EyeIrrit2	H226 H319	1-50	2	GC, GPC	78	
Nerol	106-25-2	F Xi	R12 R38	SkinIrrit2 Flam.Gas1 Press.Gas	H315 H220 H280	0.01-10	2	GC, GPC	79-81	
2-tButylcyclohexyl acetate	88-41-5	N	R51, R53	AquaticChronic2	H411	0.1-1	2	CC, BC	na	
Alanine, N,N-bis(carboxymethyl)-, sodium salt (1:3)	164462-16-2	na	na	na	na	1-<5	2	CC, FC	na	
Alkanes, C9-12-iso-	90622-57-4	Xn	R10 R63 R65 R66	na	na	30-75	2	CC, FC	82	
Coconut acid	61788-47-4	Xi	R36/38	SkinCorr.1B EyeDam1 AcuteTox4	H314 H318 H302	na	2	GPC, FC	83	
Decyl D-glucoside	54549-25-6	Xi	R36	AquaticAcute1	H400	1-5	2	KC, SRP	na	
Diphosphoric acid, tetrapotassium salt	7320-34-5	Xi	R36	EyeIrrit.2	H314	1-3	2	GPC, FC	na	

Table 1 Continued

Substance	EU ¹			GHS ²			Product ³			Reference ⁴
	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹	N ¹⁰	Product type		
Heptane	142-82-5	F Xn N	R11 R38 R50/53 R65 R67	Flam.Liq.2 Asp.Tox.1 AquaticAcute1 AquaticChronic1 SkinIrrit.2 STOTSE3 Flam.Gas1 Press.Gas	H225 H304 H400 H410 H315 H336 H220 H281 H315, H317 na	5-20	2	CC	84, 85	
Isobutane	75-28-5	F+	R12	Flam.Gas1	H220	3-20	2	CC	86	
Linalool	78-70-6	Xi	R38, R43	SkinIrrit2, SkinSens.1	H315, H317	0.01-3	2	GC, CC	87, 88	
Non-ionic tensides	na	Xi Xn N	R22 R38 R50	na	na	5-30	2	FC	na	
Oxirane, methyl, polymer and oxibane, butyl ether Polymer dispersion	9038-95-3 na	Xn na	R22 na	AcuteTox4 na	H302 na	3-10 na	2	FC PP	na na	
Quaternary ammonium compounds, benzyl-C12-16-alkyldimethyl, chlorides	68424-85-1	C	R21/22	SkinCorr.1B	H314	3-10	2	GPC	na	
PEG-15 cocoate	61791-29-5	Xi	R36	AquaticAcute1	H400	1-5	2	FC, GPC	na	
Sodium chloride	7647-14-5	C	R34	SkinCorr.1B	H314	0.01-10	2	GC, SRP	na	
Sulfuric acid, mono-C12-16-alkyl esters, sodium salts	73296-89-6	Xi	R38 R37	na Met.Corr.1	na H290	5-15	2	CC	na	
(L)-(-)-Ethyl lactate	687-47-8	Xi	R10	STOTSE3	H335	3-10	1	CC		
1,4-Dioxacycloheptadecane-5, 17-dione	105-95-3	N	R10 R51 R53	EyeDam1 Flam.Liq.3 STOTSE3 na	H318 H226 H335 na	<5	1	GPC		
1-Penten-3-one, 1-(2,6,6-trimethyl-2-cyclohexen-1-yl)- 2-Diethylaminoethanol	7779-30-8 100-37-8	N C	R51/53 R10	AquaticChronic2 SkinCorr.1B	H411 H314	0.1-1 1-3	1	CC GPC		
2-Trans-3,7-dimethyl-2,6-octadien-1-ol	106-24-1	na	R20/21/22 R34	Flam.Liq.3 AcuteTox4	H226 [H302, H312, H332]	0.01-0.1	1	GC		
3,7-Dimethyl-6-octen-1-ol	106-22-9	Xi	R38 R43 R38 R43	EyeDam1 SkinSens.1 SkinIrrit.2 SkinIrrit2	H318 H317 H315 H315 H317	<0.01	1	GC		
6-Octenenitrile, 3,7-dimethyl- Acetyl cedrene	51566-62-2 32388-55-9	na N	R51/53 R52/53	AquaticChronic2 AquaticChronic3	H411 H412	0.01-0.1 0.1-1	1	GC CC		
Alcohols, C12-18, ethers with polyethylene glycol mono-Bu ether	146340-16-1	N	R50	AquaticAcute1	H400	1-5	1	FC		
Acid blue 3	3536-49-0	Xi na	R38 na	AquaticChronic1 AcuteTox4 na	H410 H315 H400 na	<0.01	1	GC		

Table 1 Continued

Substance	EU ¹			GHS ²			Product ³			Reference ⁴
	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹	N ¹⁰	Product type		
Alcohols, C10–16, ethoxylated propoxylated	69227-22-1	Xi Xn	R22 R41	na	na	5–15	1	FC		
Alcohols, C16–18 and C18-unsatd., ethoxylated	68920-66-1	Xn	R22 R38 R41 R43 R50 R36 R38	EyeDam1 AquaticAcute1 AcuteTox4 SkinIrrit.2 na	H318 H400 H302 H315 na	1–3	1	PP		
Alkyletherphosphatesodiumsalt	na	Xi	R38			1–5	1	SRP		
Alpha-D-glucopyranoside, 2-ethylhexyl	125590-73-0	Xi	R41	EyeDam1	H318	3–10	1	BC		
Alpha-isomethylolone	127-51-5	Xi	R43	SkinSens1	H317	0.1–1	1	CC		
Alpha-methyl-4-(1-methylethyl)benzenepropanal	103-95-7	Xn	R52/53 R38 R43 R51/53 R62	AquaticChronic3 Repr.2 SkinIrrit.2 SkinSens.1 AquaticChronic2 na	H412 H361 H315 H317 H411 na	0.1–1	1	CC		
Amides, coconut oil, N-(2-((sulfo)succinyl)oxy)ethyl), sodium salts	68784-08-7	Xi	R41	na	na	na	1	CC		
Amyl salicylate	2050-08-0	N	R51/53	na	na	<5	1	GPC		
Anethole, trans	4180-23-8	N	R51/53	na	na	<5	1	GPC		
Aromatic naphtha, type I	64742-95-6	Xi	R10 R37	na	na	0.1–1	1	FC		
Benzaldehyde	100-52-7	Xn	R53							
Benzenesulfonic acid, 4-C10–13-sec-alkyl derivs.	85536-14-7	C	R22 R34	na SkinCorr.1C AcuteTox4	na H314 H302	na 3–10	1	GPC SRP		
Benzenesulfonic acid, mono-C10–13-alkyl derivs., compds. With ethanolamine	85480-55-3	Xn	R22 R38 R41	EyeDam1 AcuteTox4 SkinIrrit.2	H318 H302 H315	3–10	1	FC		
Benzenesulfonic acid, mono-C10–13-alkyl derivs., sodium salts	90194-45-9	Xn	R22 R38 R41 R36/37/38	EyeDam1 AcuteTox4 SkinIrrit.2 SkinIrrit.2	H318 H302 H315 H315 H319	3–10	1	GPC		
Benzyl acetate	140-11-4	Xi		EyeIrrit.2 STOTSE3	H315 H302	oct.20	1	CC		
Benzyl benzoate	120-51-4	Xn	R22	AcuteTox4	H302	1–3	1	CC		
Benzyl salicylate	118-58-1	Xi	R51/53 R43 R51/53	AquaticChronic2 SkinSens1 AquaticChronic2	H411 H317 H411	0.1–1	1	CC		

Table 1 Continued

Substance	EU ¹			GHS ²			Product ³			Reference ⁴
	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹	N ¹⁰	Product type		
Beta-pinene	127-91-3	Xn N	R65 R50 R53	SkinCorr.1B EyeDam1 AcuteTox4	H314 H318 H302 H400	na	1	PGPC		
Butanedioic acid, sulfo-, 1-ester with <i>N</i> -(2-hydroxyethyl)dodecanamide, disodium salt	25882-44-4	Xi	R36/38	AquaticAcute1 SkinIrrit2 EyeIrrit.2 na	H315 H319 na	3-10	1	CC		
C-11-15 Pareth-20	68131-40-8	Xi	R22	na	na	1-5	1	GPC		
Camphene	79-92-5	Xn F Xi N	R41 R11 R36 R50	SkinCorr.1B EyeDam1 AcuteTox4	H314 H318 H302 H400	na	1	FC		
Citral	5392-40-5	Xi	R38 R43	AquaticAcute1 SkinIrrit2 SkinSens.1	H315 H317 H301 H317	0.01-0.1	1	GC		
Coumarin	91-64-5	Xn	R22 R43	AcuteTox3 SkinSens.1	H301 H317	0.1-1	1	CC		
D-Glucopyranose, oligomeric, decyl octyl glycosides	68515-73-1	Xi	R41	na	na	1-5	1	BC		
Diethylene glycol monomethyl ether	111-77-3	na	R63	na	na	na	1	PP		
Dimethyl ether	115-10-6	F+	R12	na	na	50-75	1	CC		
Disodium phosphate	7558-79-4	na	na	na	na	0.1-1	1	CC		
Ethylene glycol monomontanate	73138-45-1	na	na	na	na	3-10	1	PP		
Eugenol	97-53-0	Xi	R36 R43	EyeIrrit.2 SkinSens.1	H319 H317	0.1-1	1	CC		
Fatty acids, coco, 2-(2-butoxyethoxy)ethyl esters	91031-83-3	Xi	R36	na	na	1-5	1	FC		
Fatty acid amides	na	Xi	R38 R41	na	na	<5	1	GPC		
Galaxolide	1222-05-5	N	R50/53	AquaticAcute1 AquaticChronic1	H400 H410	0.1-1	1	CC		
Hydroxyacetic acid	79-14-1	C	R34	na	na	1-5	1	SRP		
Isoeugenol	97-54-1	Xn	R21/22 R36/38 R43	SkinIrrit.2 EyeIrrit.2 SkinSens.1	H315 H319 H317	0.1-1	1	CC		
Laurylamine dipropylenediamine	2372-82-9	C	R22	AcuteTox4	[H302, H312]	0.1-1	1	DP		
Lilial	80-54-6	Xi Xn N	R35 R48/22 R50 R22 R38 R43 R62 R51/53	AcuteTox.3 SkinCorr.1A STOTRE2 AquaticAcute1 Repr.2 Acute Tox4 SkinIrrit.2 SkinSens.1 AquaticChronic2	H301 H314 H373 H400 H361 H302 H315 H317 H411	<0.01	1	GC		

Table 1 Continued

Substance	EU ¹			GHS ²			Product ³			Reference ⁴
	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹	N ¹⁰	Product type		
Lyral	31906-04-4	Xi	R43 R52/53 R34 R65	SkinSens1 AquaticChronic3 SkinCorr.1B	H317 H412 H314	0.1–1	1	CC		
Methanesulfonic acid	75-75-2	C	R34	SkinCorr.1B	H314	3–10	1	BC		
Mineral oil	8012-95-1	Xn	R65			5–15	1	FC		
Naphtha (petroleum), heavy alkylate	64741-65-7	Xn	R10 R53 R65 R66	AcuteTox.3 Asp.Tox.1 Flam.Liq.3 AquaticChronic4	H331 H304 H226 [H413, EUH006]	>75	1	PP		
Natriumlaurylethoxysulfate	na	Xi	R38 R41	na	na	<5	1	GPC		
n-Octyl-polyoxyethylene	27252-75-1	Xi	R41	na	na	1–5	1	FC		
Pentapotassium triphosphate	13845-36-8	Xi	R36/38	na	na	5–15	1	GPC		
Phenol, 2-methoxy-4-propyl-	2785-87-7	Xi	R36 R43	EyeIrrit.2 SkinSens.1	H319 H317	0.1–1	1	CC		
Poly(oxy-1,2-ethanediyl), alpha-sulfo-omega-hydroxy-, C12–14-alkyl ethers, sodium salts	68891-38-5	Xi	R38	EyeDam1	H318	<10	1	FC		
Poly(oxy-1,2-ethanediyl), alpha-(2-propylheptyl)-omega-hydroxy-	160875-66-1	Xi	R41	SinIrrit.2	H315	03–10	1	FC		
Polyoxyl 20 cetostearyl ether	68439-49-6	N	R41 R50	na	na	0.1–1	1	PP		
Potassium hydroxide	1310-58-3	C	R22 R35	na	na	1–5	1	FC		
Silicon dioxide	7631-86-9	na	na	na	na	0.1–1	1	CC		
Sodium 2-butoxyethyl sulfate	67656-24-0	Xi	R36/38	na	na	1–5	1	FC		
Sodium benzoate	532-32-1	na	na	na	na	0.1–1	1	CC		
Sodium carbonate	497-19-8	Xi	R36	EyeIrrit.2	H319	1–3	1	DP		
Sodium sulfate	7757-82-6	na	na	na	na	0.01–0.1	1	GC		
Solvent naphtha (petroleum), heavy arom.	64742-94-5	Xn	R51/53 R65	Asp.Tox.1 STOTSE3	H304 H336	0.1–1	1	PP		
Solvent naphtha (petroleum), medium aliph.	64742-88-7	Xn	R10 R66	AquaticChronic2 na	[H411, EUH006] na	25–50	1	OSC		
Sulfuric acid, mono-C10–16-alkyl esters, sodium salts	68585-47-7	Xi	R38 R41	EyeDam1 SkinIrrit.2	H318 H315	3–10	1	CC		
Sulfuric acid, mono-C12–14-alkyl esters, sodium salts	85586-07-8	Xi	R38 R41	na	na	na	1	CC		
Sulfuric acid, mono-C12–16-alkyl esters, sodium salts	73296-89-6	Xi	R38	na	na	5–15	2	CC		
Sodium C14–16 olefin sulfonate	68439-57-6	Xi	R41 R38 R41	SkinIrrit.2 EyeDam1	H315 H318	1–5	1	CC		

Table 1 Continued

Substance	EU ¹		GHS ²		Product ³		Reference ⁴	
	CAS	L ⁵	R ⁶	C ⁷	S ⁸	% ⁹		N ¹⁰
Terpinolene	586-62-9	Xn N	R10 R51/53 R65	na	na	<5	1	GPC
Triethanolamine	102-71-6	Xi	R36/38	na	na	1-5	1	GPC
Waxmixture	na	na	na	na	na	na	1	PP

NA: not available; FC: floor cleaner; GPC: general purpose cleaner; PP: polishing product; SRP: scale removing product; BC: bathroom cleaner; GC: glass cleaner; DP: disinfection product; KC: kitchen cleaner; OSC: other surfaces cleaner.

1 Directives 1999/45/EC and 67/548/EEC.
 2 Regulation (EC) No. 1272/2008.
 3 Information about amount and frequency in selection of professional cleaning product.
 4 Studies about substances listed in Table 1, when substances where present in at least two cleaning products.
 5 Danger letter.
 6 Risk-phrase.
 7 Hazard class.
 8 Hazard statement.
 9 Amount of substance in selected professional cleaning products.
 10 Number of selected professional cleaning products that contain the listed chemical substance.

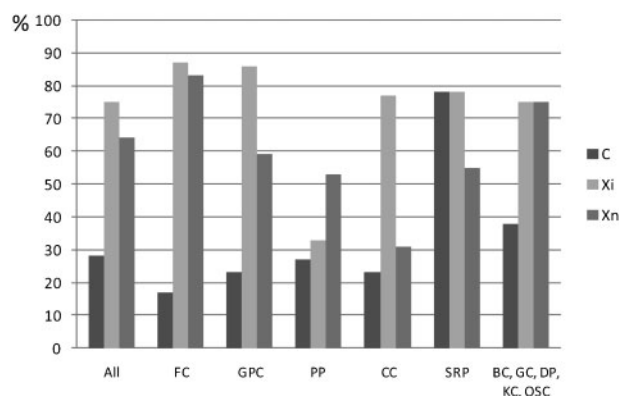


Figure 2 Percentages of products by product categories containing at least one substance labeled as corrosive (C), irritant (Xi), and harmful (Xn) in section 3 of SDSs. Floor cleaner (FC), general purpose cleaner (GPC), polishing product (PP), carpet cleaner (CC), scale removing product (SRP), bathroom cleaner (BC), glass cleaner (GC), disinfection product (DP), kitchen cleaner (KC), and other surfaces cleaner (OSC).

were listed in addition to hazard classifications and statements (GHS). In all, 4 substances were listed in SDSs of more than 10 products, 17 substances in SDSs of 5–10 products, 38 in SDSs of 2–4 products, and 69 were mentioned only once in the SDSs of the 105 selected cleaning products.

By product categories, usually less than 40% of cleaning products were labeled corrosive (C) in section 3 of SDSs, with exception SRPs (78%, Fig. 2). In most product categories, more than 70% of the products were labeled irritant (Xi), except for PPs (33%). More than 50% of the products were

Table 2 Fraction of selected cleaning products (%) that contain the listed chemical substance

Substance name	P (%)
Linalool	20
Butylphenyl methylpropional	16
Benzisothiazolinone	16
Hexyl cinnamal	15
Limonene	14
Methylisothiazolione	12
Aliphatic carbohydrates	9-10
Amyl cinnamal	9-10
Benzyl salicylate	9-10
Citronellol	9-10
Formaldehyde deposit alpha mixture with 5-chloro-2-methyl-2H-isothiazol-3-one	9-10
2-methyl-2H-isothiazol-3-one	
Hydroxycitronellol	9-10
Hydroxyisohexyl 3-cyclohexene carboxyaldehyde	9-10
Isoeugenol	9-10
Sodium hydroxymethylglycinate	9-10
Alpha-isomethyl ionone	<7
Benzyl alcohol	<7
Benzyl benzoate	<7
Cinnamal, citral	<7
Coumarin	<7
Eugenol	<7
Geraniol	<7
Glutaral	<7
Octylisothiazolinone	<7
Phenoxyethanol	<7

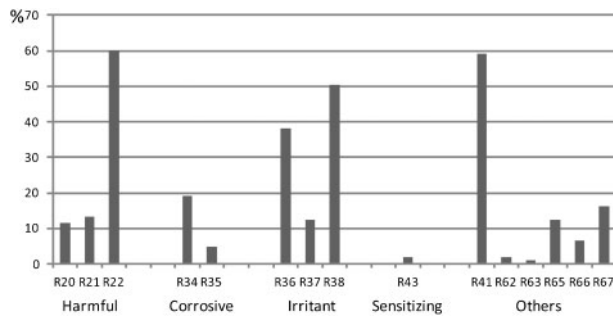


Figure 3 Percentages of cleaning products that have been labeled with corrosive (R34, R35), irritant (R36, R37, R38), harmful (R20, R21, R22), sensitizing (R43), and other (R41, R62, R63, R65, R66, R67) R-phrases in section 3 of safety data sheets (SDSs).

labeled harmful (Xn), except for product category CCs (31%).

A total of 15 R-phrases regarding human health were identified (Fig. 3): corrosive (R34, R35), irritant (R36, R37, R38), harmful (R20, R21, R22), sensitizing (R43), and others (R41, R62, R63, R65, R66, R67). Figure 3 shows the percentages of products (all categories) that have been labeled with these R-phrases in section 3 of SDSs.

Discussion

Frequently used professional cleaning products contain a multitude of chemical substances with known health effects. Cleaners may therefore be exposed to mixtures of health hazardous substances during their cleaning activity.

It is important to note that SDSs do not list all chemical substances present in a product, as regulations define substances and concentrations that must be listed.^{21,23} Depending on the characteristics of the substances (e.g. persistence, bioaccumulation, and toxicity), the concentration levels requiring listing are 1 or 0.1%.³⁰ Sensitizers were listed as a cleaning product ingredient under section 15 in the SDSs only if required by other regulations.^{25–27} Interestingly, several substances found under section 15 of SDSs have been associated with sensitizing mechanisms and/or allergic reactions.

In our study, we selected frequently used cleaning products known from cleaning companies with five or more employees. The cleaning products included the four most popular brands that, according to a professional association for cleaning companies in Switzerland, account for >50% of the Swiss professional cleaning products market.

As mentioned above, we estimated that our results include products used by about 50% of the Swiss cleaning workforce. This is because the large cleaning companies reported to have high numbers of employees (more than several thousand). Most cleaning products identified in this study were sold by global companies that sell and distribute their products

worldwide. The results of this study may hold true for other industrialized countries similar to Switzerland, although the cleaning product might be given a different brand name.

Not only is there a great diversity of chemical substances within cleaning products but also numerous companies offer hundreds of different cleaning products, which makes the task of assessing chemical substances used in professional cleaning products complicated. Indeed, responses showed cleaning companies using products from 36 different product companies, and some reported that they produced their own products. Thus when investigating exposures among professional cleaners, a SDS review is a requirement. We believe our results provide important information regarding type of cleaning products used in this industry, and common chemical substance classes found in these products and their health hazards. This knowledge should help in monitoring professional cleaners and their exposures to cleaning products and substances with known health effects. In addition, not only cleaning workers or those who are cleaning are at risk of exposure but also persons in rooms that were recently cleaned can potentially be exposed.^{31–33}

The main challenges in conducting an occupational exposure assessment for professional cleaners are the great number of cleaning products available and the large number of substances in these products. For further investigation, we recommend to focus on the 21 substances found in ≥ 5 products (Table 1). Especially of interest are the recognized sensitizers monoethanolamine and glycol ethers, frequently found in cleaning products. Substances found in professional cleaning products may likely also be ingredients in cleaning products sold to the general public; however, we did not survey these products.²⁸

Conclusion

This work contributes to the efforts to better understand possible exposures to chemicals during the use of professional cleaning products. We found that hazardous substances in cleaning products are in particular fragrances, glycol ethers, surfactants, solvents, and to a lesser extent phosphates, salts, detergents, pH-stabilizers, acids, and bases. Cleaning workers who are handling these products are therefore a group at risk for several occupational exposures. Section 15 in the SDS should be consulted, as several substances involved in sensitizing mechanisms and/or allergic reactions were also listed here. Especially glycol ethers and ethanolamines are frequently used in cleaning products, and could therefore be involved in the development of adverse health effects like irritant or sensitizer-induced asthma, which has been found to be elevated among professional cleaners. Concerning asthma, the presence of different aldehydes as

fragrances is also of special interest. Besides some sensitizers like ethanalamines, mainly irritants were found, suggesting that pathologies of the skin and the respiratory tract may also occur without mechanisms of sensitization. A simultaneous exposure to several hazardous chemical substances could potentially be involved in these pathologies. As professional cleaners represent a large workforce, and cleaning products are widely used, including in private cleaning, it is of great environmental and public health importance to better understand the exposures that may be caused by the use of cleaning products. Our list of substances provides important information about which chemicals and hazards are relevant for further investigations in this field, and we plan to use these results for field exposure studies.

Conflict of Interest

The authors have declared no conflict of interest.

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