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 (F₂, F), very toxic (T⁺), toxic (T),
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. 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.

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
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Harmonized System of Classification and Labeling of Chemicals (GHS). 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. 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). 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 (+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. 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.

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...
| Substance                                                                 | CAS        | EU⁵ | R⁶ | GHS² | %⁸ | N¹⁰  | Product type | Reference¹¹ |
|--------------------------------------------------------------------------|------------|-----|----|------|----|------|--------------|-------------|
| Isopropyl alcohol                                                       | 67-63-0    | F   | R11|      |    |      | FC, GPC, CC, BC, PP | 34–36       |
|                                                                          |            | Xi  | R20/21/22 |      |    |      |              |             |
|                                                                          |            | Xn  | R36         |      |    |      |              |             |
|                                                                          |            |     | R36/38 R67 |      |    |      |              |             |
| Diethylene glycol monoethyl ether                                         | 111-90-0   | Xi  | R36         |      |    |      |              |             |
| Poly(oxy-1,2-ethanediyl), alpha-tridecyl-                                | 69011-36-5 | Xn  | R22         |      |    |      |              |             |
|     omega-hydroxy-, branched                                             |            |     | R41         |      |    |      |              |             |
| Diallylene glycol monoethyl ether                                         | 34590-94-8 | na  | na          |      |    |      |              |             |
| Citric acid                                                             | 77-92-9    | Xi  | R36         |      |    |      |              |             |
| Deceth-4                                                                | 26183-52-8 | Xi  | R22         |      |    |      |              |             |
|                                                                          |            | Xn  | R41         |      |    |      |              |             |
| Ethanol                                                                 | 64-17-5    | F   | R11         |      |    |      |              |             |
| Sulfonic acids, C13–17-,                                                 | 85711-69-9 | Xi  | R38         |      |    |      |              |             |
|     sec-alkane, sodium salts                                             |            |     | R41         |      |    |      |              |             |
| Monoethanolamine                                                         | 141-43-5   | C   | R20         |      |    |      |              |             |
|                                                                          |            | Xn  | R21         |      |    |      |              |             |
|                                                                          |            |     | R22         |      |    |      |              |             |
|                                                                          |            |     | R34         |      |    |      |              |             |
|                                                                          |            |     | R37         |      |    |      |              |             |
| Benzenesulfonic acid, (1-methylethyl)-, sodium salt (1:1)                | 28348-53-0 | Xi  | R36         |      |    |      |              |             |
| Alcohol, C13–15-branched and linear, butyloxyethoxylated                | 111905-53-4| Xi  | R36/38      |      |    |      |              |             |
| Propane                                                                  | 74-98-6    | F+  | R12         |      |    |      |              |             |
| Alcohol, C12–14, ethoxylated                                            | 68439-50-9 | Xn  | R22         |      |    |      |              |             |
|                                                                          |            |     | R22         |      |    |      |              |             |
|                                                                          |            |     | R41         |      |    |      |              |             |
| Alcohol, C12–14, ethoxylated                                            | 100-51-6   | Xn  | R20/22      |      |    |      |              |             |
|                                                                          |            |     | R36         |      |    |      |              |             |
| Butanol                                                                  | 106-97-8   | F+  | R12         |      |    |      |              |             |
| Butoxypropanol                                                          | 5131-66-8  | Xi  | R36/38      |      |    |      |              |             |
| Substance                                                                 | EU1  | GHS2 | Product3                        | Reference4 |
|--------------------------------------------------------------------------|------|------|---------------------------------|------------|
| C12–15 Pareth-11                                                         | Xi R22 | H318 | 0.1–15 5 PP, FC, GPC            | 58         |
| Diethylene glycol mono-n-butyl ether                                    | Xi R36 | H319 | 5–30 5 FC, SRP, PP              | 59–61      |
| Ethylene glycol                                                          | Xi R20 | H315 | 1–20 5 GPC, FC, PP              | 62–64      |
| Ethylene glycol mono-n-butyl ether                                      | Xi R21 | H319 | 1–20 5 GPC, FC, GC              | 65–67      |
| Diethylene glycol mono-n-butyl ether                                    | Xi R38 | H318 | 1–15 5 FC, PP, GPC              | na         |
| Ethylene glycol                                                          | Xi R41 | H319 | 1–10 5 GPC, FC, GPC             | 68         |
| Poly(oxy-1,2-ethanediyl), alpha-isodecyl-omega-hydroxy-                 | Xi R36/38 | H315 | 3–15 5 SRP                       | na         |
| Phenoxyethanol                                                           | Xi R41 | H319 |                                  |            |
| Poly(oxy-1,2-ethanediyl), alpha-sulfo-omega-hydroxy-, C10–16-alkylethers, sodium salts | Xi R41 | H319 | 1–15 5 GPC, FC, GPC             | na         |
| Sodium ethasulfate                                                       | Xi R38 | H315 | 1–5 4 FC, BC                    |            |
| Trif(2-butoxyethyl) phosphate                                            | Xi R38 | H315 | 1–5 4 FC, BC                    | 66         |
| Alkylalkoholalkoxylat                                                   | Xi R36 | H315 | 1–5 4 FC, GPC                   | na         |
| Alcohols, C10–12, ethoxylated propoxylated                              | Xi R38 | H315 | 1–10 4 FC, GPC                  | na         |
| Alpha-terpineol                                                          | Xi R41 | H319 | 1–10 4 FC, GPC                  | na         |
| Ammonium hydroxide                                                       | Xi R34 | H315 | 0.01–15 3 GPC, GC               | 33, 70, 71 |
| Cyclohexanol, 4-(1,1-dimethylethyl)-, 1-acetate                         | Xi R50 | H315 | 0.01–1 3 PP, GPC                | 72         |
| Substance | CAS | EU¹ | GHS² | %³ | N⁴ | Product⁵ | Reference⁶ |
|-----------|-----|-----|------|----|----|---------|------------|
| (D)-Limonene | 5989-27-5 | Xi | Flam.Liq3 | H226 | 0.1–1 | 3 | GC, CC | 73–75 |
| Genapol X 080 | 9043-30-5 | Xi | AquaticAcute1 | H400 | 0.1–1 | 3 | PP, GPC | na |
| Hydrocarbons, terpene processing by-products | 68956-56-9 | Xn | AquaticChronic1 | H319 | 0–5 | 3 | GPC, FC | na |
| Fatty acids, coconut oil, potassium salts | 61789-30-8 | Xi | SkinIrrit.2 | H316 | 0.1–1 | 3 | GPC, FC | 76 |
| Naphtha (petroleum), hydrotreated heavy | 64742-48-9 | Xn | AcuteTox4 | H302 | 0.01–1 | 3 | GPC, FC | 77 |
| Silicic acid, disodium salt, pentahydrate | 10213-79-3 | C | SkinCorr1B | H314 | 0.01–1 | 3 | KC, FC | na |
| Sodium hydroxide | 1310-73-2 | Xn | AquaticChronic2 | H304 | 0.01–1 | 3 | GPC, FC | 78 |
| Alkaline alcohohol ethoxylate | 1569-01-3 | na | Flam.Liq3 | H226 | 0.01–1 | 3 | GC, GPC | 81 |
| 1-Propoxy-2-propanol | 106-25-2 | F | Flam.Gas1 | H220 | 0.01–1 | 3 | GPC, FC | 82 |
| Alkanes, C9–12-iso- | 90622-57-4 | Xn | AquaticChronic2 | H314 | 0.01–1 | 3 | GPC, FC | 83 |
| Coconut acid | 61788-47-4 | Xi | Flam.Gas1 | H220 | 0.01–1 | 3 | GPC, FC | 84 |
| Decyl D-glucoside | 54549-25-6 | Xi | Flam.Liq3 | H226 | 0.01–1 | 3 | GPC, FC | 85 |
| Diphosphoric acid, tetrapotassium salt | 7320-34-5 | Xi | Flam.Gas1 | H220 | 0.01–1 | 3 | GPC, FC | 86 |
| Substance                                                                 | EU1                      | GHS2                      | Product3                        | Reference4 |
|---------------------------------------------------------------------------|--------------------------|---------------------------|---------------------------------|------------|
| Heptane                                                                   |                         |                           |                                 |            |
| Name                                                                       | CAS                      | L^5                       | R^6                             |            |
| Heptane                                                                   | 142-82-5                 | F                         | R11                             |            |
|                                                                            |                          | Xn                        | R38                             |            |
|                                                                            |                          | N                         | R50,53                           |            |
|                                                                            |                          | R65                       | R67                             |            |
| Isobutane                                                                 | 75-28-5                  | F+                        | R12                             |            |
| Linalool                                                                  | 78-70-6                  | Xi                        | R38, R43                         |            |
| Non-ionic tensides                                                        | na                       | Xn                        | R38                             |            |
|                                                                            |                          | N                         | R50                             |            |
| Oxirane, methyl, polymer and oxibane, butyl ether                         | 9038-95-3                | Xn                        | R22                             |            |
| Polymer dispersion                                                        | na                       | na                        | na                              |            |
| Quaternary ammonium compounds, benzyl-C12-16-alkyldimethyl, chlorides    | 68424-85-1               | C                         | R21,22                           |            |
|                                                                            |                          | N                         | R34                             |            |
| PEG-15 cocotage                                                           | 61791-29-5               | Xi                        | R36                             |            |
| Sodium dichloride                                                         | 7647-14-5                | C                         | R34                             |            |
| Sulfuric acid, mono-C12-16-alkyl esters, sodium salts                     | 73296-89-6               | Xi                        | R38                             |            |
|                                                                            |                          | R37                       | na                              |            |
| (L)-(−)-Ethyl lactate                                                     | 687-47-8                 | Xi                        | R10                             |            |
|                                                                            |                          | R7                        | R41                             |            |
| 1,4-Dioxacycloheptadecane-5,17-dione                                       | 105-95-3                 | N                         | R10                             |            |
|                                                                            |                          | R51                       | R63                             |            |
| 1-Penten-3-one, 1-(2,6,6-trimethyl-2-cyclohexen-1-yl)-2-Diethylaminoethanol| 7779-30-8                | N                         | R51/53                           |            |
|                                                                            |                          | R10                       | R20,21/22                       |            |
|                                                                            |                          | R34                       | R34                             |            |
| 2-Trans-3,7-dimethyl-2,6-octadien-1-ol                                     | 106-24-1                 | na                        | na                              |            |
| 3,7-Dimethyl-6-octen-1-ol                                                 | 106-22-9                 | Xi                        | R38                             |            |
|                                                                            |                          | N                         | R43                             |            |
|                                                                            |                          | R51/53                    | R53                             |            |
| 6-Octenenitrile, 3,7-dimethyl-Acetyl cedrene                              | 51566-62-2               | na                        | R52/53                           |            |
| Alcohol, C12-18, ethers with polyethylene glycol mono-Bu ether             | 146340-16-1              | Xi                        | R38                             |            |
| Acid blue 3                                                                | 3536-49-0                | na                        | na                              |            |

Table 1 Continued
| Substance | CAS     | EU1 | GHS2 | Product3 |
|-----------|---------|-----|------|----------|
| Alcohols, C10–16, ethoxylated propoxylated | 69227-22-1 | Xi | na | na | 5–15 | 1 | FC |
| Alcohols, C16–18 and C18-unsatd., ethoxylated | 68920-66-1 | Xn | R41 | na | 1–3 | 1 | PP |
| Alkyletherphosphatesodiumsalt | na | Xi | R36 | na | 1–5 | 1 | SP |
| Alpha-o-glucopyranoside, 2-ethylhexyl | 125590-73-0 | Xi | R41 | EyeDam1 | H318 | 3–10 | 1 | BC |
| Alpha-isomethylionone | 127-51-5 | Xi | R43 | SkinSens1 | H317 | 0.1–1 | 1 | CC |
| Alpha-methyl-4-(1-methylethyl)benzenepropanal | 103-95-7 | N | R43 | Repr.2 | H361 | 0.1–1 | 1 | CC |
| Amides, coconut oil, N-(2-((sulfosuccinyl)oxy)ethyl), sodium salts | 68784-08-7 | Xi | R41 | Na | 0.1–1 | 1 | FC |
| Amyl salicylate | 2050-08-0 | N | R51/53 | na | <5 | 1 | GPC |
| Anethole, trans | 4180-23-8 | N | R51/53 | na | <5 | 1 | GPC |
| Aromatic naphtha, type I | 64742-95-6 | Xi | R10 | Na | na | 0.1–1 | 1 | FC |
| Benzaldehyde | 100-52-7 | Xn | R22 | SkinCorr.1C | H314 | 3–10 | 1 | SRP |
| Benzenesulfonic acid, 4-C10–13-sec-alkyl derivs. | 85536-14-7 | C | R22 | AcuteTox4 | H302 | 3–10 | 1 | FC |
| Benzenesulfonic acid, mono-C10–13-alkyl derivs., compds. With ethanolamine | 85480-55-3 | Xn | R22 | EyeDam1 | H318 | 3–10 | 1 | GPC |
| Benzenesulfonic acid, mono-C10–13-alkyl derivs., sodium salts | 90194-45-9 | Xn | R22 | SkinCorr.1C | H314 | 3–10 | 1 | SRP |
| Benzyl acetate | 140-11-4 | Xi | R36/37/38 | EyeIrrit.2 | H319 | oct.20 | 1 | CC |
| Benzyl benzoate | 120-51-4 | Xn | R22 | AcuteTox4 | H302 | 1–3 | 1 | CC |
| Benzyl salicylate | 118-58-1 | Xn | R37 | SkinSens1 | H317 | 0.1–1 | 1 | CC |
| Substance | CAS      | L<sup>e</sup> | R<sup>e</sup> | EU<sup>e</sup> | GHS<sup>e</sup> | Product<sup>e</sup> | Reference<sup>e</sup> |
|-----------|----------|--------------|--------------|--------------|----------------|------------------|---------------------|
| Beta-pinene | 127-91-3 | Xn           | R65          | N            | R50           | R53              | SkinCorr.1B H314     |
| Butanedioic acid, sulfo-, 1-ester with N-(2-hydroxyethyl)dodecanamide, disodium salt C11–15 Pareth-20 | 25882-44-4 | Xi             | R36/38       | Na           | Na            | Na              | Na                  |
| Camphene | 79-92-5  | Xn           | R41          | F            | R11           | R36              | SkinCorr.1B H314     |
| Citral    | 5392-40-5 | Xi           | R38          | N            | R43           | R43              | SkinCorr.1B H314     |
| Coumarin  | 91-64-5  | Xn           | R22          | F            | R43           | R43              | SkinCorr.1B H314     |
| o-Glucopyranose, oligomeric, decyl octyl glycosides | 68515-73-1 | Xi           | R41          | Na           | Na            | Na              | Na                  |
| Diethylene glycol monomethyl ether | 111-77-3 | Na         | Na           | Na           | Na            | Na              | Na                  |
| Dimethyl ether | 115-10-9 | F+        | R12          | Na           | Na            | Na              | 50–75  CC         |
| Disodium phosphate | 7558-79-4 | Na         | Na           | Na           | Na            | Na              | 50–75  CC         |
| Ethylene glycol monomontanate | 73138-45-1 | Na         | Na           | Na           | Na            | Na              | Na                  |
| Eugenol  | 97-53-0  | Xi           | R36          | Xi           | R36           | R43              | SkinSens.1 H317     |
| Fatty acids, coco, 2-(2-butoxyethoxy)ethyl esters | 91031-83-3 | Xi           | R36          | Na           | Na            | Na              | 1–5  FC            |
| Fatty acid amides | 1222-05-5 | N           | R50/53      | Na           | R50          | R53              | Na                  |
| Galaxolide | 1222-05-5 | N           | R50/53      | Na           | R50          | R53              | Na                  |
| Hydroxyacetic acid | 79-14-1 | C           | R34          | R34          | R21/22       | R36/38           | SkinCorr.1B H314     |
| Isoeugenol | 97-54-1  | Xn           | R22          | R43          | R43          | R36/38           | SkinCorr.1B H314     |
| Laurylamine dipropylene diamine | 2372-82-9 | C           | R22          | N            | R35          | R38/22           | SkinCorr.1A H314     |
| Lilial   | 80-54-6  | Xi           | R22          | Xn           | R38          | R43              | Repr.2 H36.1         |

Table 1 Continued

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| Substance | EU | GHS | CAS | S | P |
|-----------|---|----|-----|---|---|
| Lyral     | R4 | Xi  | 31986-04-4 | H317 | 0.1–1  1 |
| Methanesulfonic acid | R34 | Xi | 68939-46-6 | H314 | 0.1–1  1 |
| Mineral oil | R65 | Xi | 8012-95-1 | H318 | 0.1–1  1 |
| Naphtha (petroleum), heavy alkylate | R10 | Xi | 64761-55-7 | H319 | 0.1–1  1 |
| Sodium lauryl ether sulfate | R38 | Xi | 68939-46-6 | H314 | 0.1–1  1 |
| n-Octylpolyoxyethylene | R41 | Xi | 68939-46-6 | H314 | 0.1–1  1 |
| Phenoxi-2-ethoxyethanol | R43 | Xi | 68939-46-6 | H314 | 0.1–1  1 |
| Sodium 2-butoxyethyl sulfate | R36 | Xi | 67656-24-0 | H318 | 0.1–1  1 |
| Sodium benzoate | R36 | Xi | 100-51-6 | H318 | 0.1–1  1 |
| Sodium carbonate | R36 | Xi | 530-02-0 | H318 | 0.1–1  1 |
| Sodium naphthalene (petroleum), heavy aromatic | R66 | Xi | 68439-49-6 | H314 | 0.1–1  1 |
| Solvent naphtha (petroleum), medium alkyl | R36 | Xi | 67656-24-0 | H318 | 0.1–1  1 |
| Sodium oleate | R36 | Xi | 6032-89-2 | H318 | 0.1–1  1 |
| Sodium C14–16 olefin sulfonate | R36 | Xi | 64742-88-7 | H318 | 0.1–1  1 |

Table 1 Continued
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

![Figure 2](image-url)

**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).

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**Table 1** Continued

| Substance name | P (%) |
|----------------|------|
| Linalool       | 20   |
| Butylphenyl methylpropional | 16   |
| Benzisothiazolinone | 16   |
| Hexyl cinnamal  | 15   |
| Limonene       | 14   |
| Methylisothiazolinone | 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 | 9–10 |
| Hydroxycitronellol | 9–10 |
| Hydroxyscinovyl 3-cyclohexene carboxaldehyde | 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   |
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 other (R41, R62, R63, R65, R66, R67) R-phrases in section 3 of safety data sheets (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. Depending on the characteristics of the substances (e.g., persistence, bioaccumulation, and toxicity), the concentration levels requiring listing are 1 or 0.1%. Sensitizers were listed as a cleaning product ingredient under section 15 in the SDSs only if required by other regulations. 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.

The main challenges in conducting an occupational exposure assessment for professional cleaners are the large 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 monooctadecylamine 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.

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 ethanamines 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 ethanolamines, 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.

Acknowledgements
The authors thank the Federal Office for Public Health of Switzerland (Office fédérale de la santé publique [OFSP], Bundesamt für Gesundheit [BAG]) for funding this study.

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