Storage and Utilization Patterns of Cleaning Products in the Home: Toxicity Implications

Ansam F. Sawalha, Ph.D
Assistant Professor of Pharmacology and Toxicology

Corresponding author:

Ansam F. Sawalha, Ph.D.
Director of Poison Control and Drug Information Center (PCDIC)
An-Najah National University, Nablus, Palestine
e-mail: *ansam@najah.edu*
e-mail: *poison@najah.edu*

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Abstract

Background and aims: Cleaning products are used to achieve cleaner homes. However, they have been responsible for a considerable number of poisoning cases. The aims of this study were to investigate the storage and utilization patterns of cleaning products in the home, as well as the risk of adverse and toxic effects produced by them. **Methods**: This study has been performed using a questionnaire that was developed by the Poison Control and Drug Information Center (PCDIC). The questionnaire was distributed randomly in northern Palestine. The questionnaire included questions regarding storage, utilization habits, and the adverse effects experienced by respondents upon handling the cleaning products. **Results:** All respondents utilized and stored cleaning products in their homes. Chlorine bleach and acidic cleaning products were the most common. Respondents stored cleaning products at different places in their homes, but most of those storage places were suboptimal and were within the reach of children. The daily utilization rate of cleaning products was 1.6± 0.8 with chlorine bleach being the most commonly used. Of the respondents, 27% reported experiencing a wide range of acute adverse and toxic effects resulting from cleaning product use and that exposure occurred mainly via inhalation. Caustic substances, bleach, and kerosene were the agents mainly involved in producing these adverse and toxic effects. About half of those who experienced adverse and toxic effects sought medical help, and 22% of them were children younger than 6 years of age. Finally, most respondents reported mixing and discarding cleaning product leftovers and their containers improperly. **Conclusion and recommendations:** Correct utilization and safer storage of cleaning products is encouraged. Several preventive strategies should be implemented in order to decrease the incidence of accidental harmful exposure that is due to cleaning agents. The role of the PCDIC is very important in the education, prevention, and management of cleaning product-induced adverse effects.

Keyword: cleaning products, poisoning, accidental, storage, mishandling.

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Introduction:

Cleaning products stored in homes are responsible for many accidental poisonings among children [1-3]. In the USA, 229,040 poisoning cases were attributed to accidental poisoning by cleaning products in the year 2004 [4]. One possible reason for this large number of accidental poisonings is the improper storage and utilization of cleaning products. Studies have shown that parents do not always store poisonous substances out of children's reach, and few homes had locked storage space [5-9]. In fact, most accidental poisonings occur at home [10] where children are at risk from improperly stored poisonous substances [11].

Cleaning product ingredients can cause serious toxicity. Some cleaning products contain caustic materials, the ingestion of which has become a significant concern since the late 1800s [12]. Caustic agent ingestion causes severe gastrointestinal toxicity [13]. Acids cause more caustic burns than alkalis and the damage is worse in cases of intentional ingestion [14-16]. Chlorine bleach causes mucosal erosions, GI irritation, ear, nose, and throat lesions, and it is also associated with asthma symptoms [12, 17]. Usually bleach ingestion is benign; however, rare cases of fatal bleach ingestion with hypernatremia, hyperchloremia, adult respiratory distress syndrome, and lung injury have been reported [18, 19]. Bleach reacts with acids to produce chlorine gas, which if inhaled, even in small amounts, may cause acute lung injury [19].

Cleaning products are very effective in disinfecting homes and reducing the spread of disease. However, their improper use might be associated with adverse health outcomes. Studies investigating the storage and utilization patterns of cleaning products have not been

performed in Palestine. The aims of this study were to examine the storage and utilization patterns of cleaning products in homes and assess the adverse and toxic effects that respondents have experienced upon utilizing these products. This is of great importance in order to identify risks imposed on the community due to improper storage and exposure to cleaning products.

Methods:

A questionnaire was designed at the Poison Control and Drug Information Center (PCDIC) at An-Najah National University in Palestine, and was distributed randomly to homes in northern Palestine. The distribution process was carried out by pharmacy students. Each student distributed four questionnaires in his/her residential area. For the purpose of this study, the lady of the house was asked to fill out the questionnaire since she will be the one mainly involved in utilizing the cleaning products. The questionnaire was composed of four sections. Questions in the first section were designed to assess the parents' demographic characteristics such as age, education, income, type of work, place of residence, number of people living in the house, and number of children younger than 6 years old. The second section was mainly concerned with the storage, daily utilization, and reading of the instruction label for certain cleaning products (commercial brand names of cleaning products were presented for respondents to choose among, then the PCDIC staff classified the products into acidic-, basic-cleaning products, chlorine bleach, kerosene, cresol, and others). In section two, respondents were asked to indicate what cleaning products were present in their homes, how many cleaning products do they use daily, whether or not they have read the label instructions, and whether they consider the information written on the label enough for the proper use of the item.

The utilization rate was defined as the number of different types of cleaning products used in the cleaning process in the house per day. It was calculated by dividing the number of cleaning products used by the total number of positive respondents. This rate was calculated independent of the composition, concentration, or type of cleaning agent. Respondents were asked about storage places that they used to store cleaning products. Respondents were asked to indicate whether they keep cleaning products in their original containers, or if they store them in other containers (such as empty water bottles, empty cleaning bottles, or empty soft drink bottles). Section two also contained questions about the ability of children in the home to reach cleaning products. The third section of the questionnaire contained questions regarding adverse effects that respondents or any of their family members had encountered as a result of utilization of cleaning products, what cleaning products caused it, and whether they had sought professional medical treatment. The last section was about the mishandling of cleaning products. Questions within this section were about mixing of cleaning products, which cleaning products were mixed, and whether adverse effects had been experienced from such practices. Finally, respondents were asked to indicate how they dispose of the empty cleaning product bottles, and the material that may be left inside these containers.

Results:

A total of 1150 questionnaires were distributed, 739 were returned which gives a response rate of 64.3%. Four questionnaires were excluded because they were incomplete. Thus, 735 questionnaires were used in the analysis. The mean age of the respondents was 39.9 years (range 19-80, S.D. ±10.7). The average number of people living in each house was 6, and approximately half of the respondents had children less than 6 years

of age. In this study, most of the respondents were of moderate income, lived in cities, finished high school, and were not working. It was difficult to asses the relationship between work-related materials and the toxic effects of such materials since many of the parents were employees and all what they bring home is paperwork, which is safe. Detailed demographic characteristics of the respondents are shown in Table 1.

Analysis of data indicated that all respondents store cleaning products in their home. The average number of cleaning products stored per home was 3.5±1.2 (range: 1-6; mode = 3). In respondents' homes, chlorine bleach was the cleaning products that was most commonly reported to be stored (96.7%) followed by acidic cleaning products (86.4%). Among all categories of household cleaning products reported to be stored, bleach constituted 27.9%, whereas acidic cleaning products constituted 24.9%. The local manufacturing companies provide only the major active ingredient(s) of their products. Examining the available cleaning products revealed the composition of most of them. For example, bleach is made of sodium hypochlorite (4.5%), while different brand names of acidic cleaning products are composed of hydrochloric acid (15%). Basic cleaning products are made of caustic soda (50%) as a major ingredient. Floor cleaners are mainly composed of sodium alkyl benzene sulfonate with no concentration given on the label. Kerosene is obtained from local gas stations since it is a hydrocarbon. Cresol is made of cresylic acid with no concentration given by manufacturer. Dettol® is composed of chloroxylenol (4.8%) and also contains pine oil, isopropanol, castor oil soap, caramel, and water. Finally, paint thinner contains acetone, mineral spirits, mineral turpentine, wood turpentine, naphtha, toluene, and xylene.

Respondents stored cleaning products mainly in the bathroom, kitchen closets, and in under-the-sink cabinets. About one-third of the respondents reported that their children can reach the cleaning products stored at home. The daily utilization rate was 1.6 ± 0.8 product (range: 1-5, mode =1) with chlorine bleach being the most commonly used. Among respondents, 36.7% indicated that they had read the label on the acidic cleaning product while 28.9% had read the instructions on the chlorine bleach products. Most of those who read the label indicated that the information regarding the instructions for use were clear and understandable in the native language regarding the proper use as recommended by the manufacturer (Figure 1).

Approximately 27% of the respondents' family members have reported experiencing acute adverse and toxic effects upon using household cleaning products. The majority of the reported adverse and toxic effects were mainly due to caustic agents, chlorine bleach and kerosene (Figure 2). Adverse effects that were reported were respiratory problems, allergy, vomiting, headache, mouth ulcers, colic, burns, gastrointestinal problems, and loss of consciousness. Among people who reported experiencing adverse effects, 22% were children below 6 years of age. When analyzing the routes of toxic exposure to cleaning products, the majority were through inhalation, followed by dermal exposure, ingestion, and finally ocular exposure. Among people who reported suffering adverse outcomes due to cleaning products, 51.3% sought professional medical treatment. Mild symptoms or financial constraints might be the reason behind not seeking medical advice. A significant correlation existed between reported adverse effects and the number of stored cleaning products (P= 0.02) (Figure 3). Similar significant correlation also existed with the number of cleaning products used daily

(P = 0.01) (Figure 4). A higher incidence of adverse effects was reported by families that store cleaning products within the reach of children (37.8%), while it was lower (27.9%) for families that store cleaning products out of the reach of children (p=0.000).

One hundred and sixty-three respondents reported mixing cleaning products. The cleaning products that were mixed included bleach with dishwashing detergent, bleach with hydrochloric acid, bleach with laundry detergent, and finally, bleach with floor cleaners. Among those respondents who mixed the cleaning products, 48 reported experiencing one or more adverse health outcomes mentioned earlier.

In this study, 20.5% of respondents reported reusing the empty containers of the cleaning products for different purposes, and 67.3% reported discarding them with municipal waste. The data indicated that 26.9% of the respondents stored cleaning products in something other than their original containers. A number of respondents (10.2%) reported storing some cleaning products in water and empty soft drinks bottles. One hundred and eighty-one respondents reported emptying the remaining contents in the sink before discarding or reusing the bottle (Table 2).

Discussion:

Cleaning products are used to provide cleaner and safer homes. However, these products contain active ingredients that can cause different types of toxicity upon mishandling, improper storage, or extensive daily use. In this study, all respondents' homes contained cleaning products that were not stored properly. Approximately one-third of the respondents reported storing these products in unsafe places where

children could reach them. In our study, the majority of adverse effects were caused by caustic agents and chlorine bleach. Accidental poisonings and/or exposure to hazardous materials could happen anywhere, but they most often occur in the kitchen and the bathroom. It has been shown that practicing safe storage habits at home has saved the lives of many children. A study in Saudi Arabia by Al-Sekait has shown that proper storage of drugs and chemicals, as well as the health education of parents, will help in reducing the incidence of poisonings at home [20]. In a Canadian study, mothers have engaged in a high number of safety practices to prevent burns, poisonings, and drownings [21] in order to decrease the incidence of morbidity and mortality resulting from such mishaps.

In other parts of the world, different cleaning products have been reported to produce undesirable health effects [20, 22-28]. A retrospective study by Arevalo-Silva in Israel (from 1988-2003) showed that the most common caustic agents ingested among all patients with clinical signs of aerodigestive system injury were alkalis (42%), followed by acids (32%), and chlorine bleach (26%) [15]. A second retrospective study in Turkey (from 1995-2002) for all patients with signs of caustic agent poisoning found that 47% ingested acids, while 21% ingested alkalis [16]. A third study in Zimbabwe found that household chemical poisoning admissions were mainly due to paraffin (kerosene), while bleach and caustic agents contributed to a minor percentage of cases [22]. A fourth study by Bert O'Malley in the USA found that the substances causing burns in pediatric accidental poisonings most frequently were alkalis (60-80%), and the rest were due to acids, Lysol (phenol-based), and bleach [12]. A fifth study in France found that accidental bleach ingestion was found to be frequent in children [29].

In our study, empty cleaning product containers, as well as cleaning products that remain in such bottles, were discarded improperly. Household wastes, when disposed of improperly, are hazardous to health and are a major environmental contaminant [30, 31]. No studies have been done in Palestine to evaluate the components of household waste. However, a study in Mexico had shown that cleaning products make up between 19.5-39% of hazardous household waste [27]. More research is needed to assess the impact of household cleaning products on human health. Data indicate that 20.5% of respondents reuse cleaning product containers for several purposes, such that potential toxicity may arise from such practices since respondents may not wash the containers properly before reuse.

When cleaning products are used improperly indoors, residents are exposed to ingredients and air pollutants that could lead to health risks [32]. Cleaning products have substantial perceived benefits, but can also produce toxicity both on short term and on chronic bases. The adverse and toxic effects resulting from acute exposure to cleaning products vary based on the cleaning agent of interest and the route of exposure. For example, ingestion of caustic cleaning products mainly leads to gastric and duodenal injuries. Inhalation of caustic agents, on the other hand, leads to a wide range of symptoms that are mainly related to the respiratory system [13, 14, 16]. Serious undesirable effects may also result due to the mixing of different cleaning products, as this can generate hazardous fumes sufficient to cause those exposed to seek medical attention. Several reports have been published documenting such episodes. In agreement with our study, bleach was the cleaning agent commonly used in such processes. The mixing of bleach with ammonia-based cleaners causes the production of chloramines and possibly

ammonia that can volatilize [33, 34]. On the other hand, when bleach was mixed with an acid-based cleaner, it could release gaseous chlorine or hypochlorous acid [35-38]. Additionally, chronic exposure to cleaning products and the gases that result from them can produce a variety of different effects such as asthma and chronic bronchitis [17]. This has been extensively investigated by Wolkoff *et al* and Nazarof [32, 39].

This study has several limitations. This is a retrospective study conducted via a questionnaire to establish association and not causation. The methodology of this study was not designed to generate dose-effect relationships or to compare respondents' exposure with the acceptable daily threshold.

Recommendations

Reduction of accidental poisoning caused by cleaning products can be attained by collaborative efforts carried out by parents, the general public, the PCDIC, and governmental agencies. Poisoning in children is an important issue worldwide, and several steps must to be taken in order to reduce this preventable cause of morbidity and mortality. Parents and childcare providers must ensure that cleaning products are kept out of children's sight and reach, in their original containers and never in food or beverage containers, caps should be replaced immediately after use, and household products should be purchased in child-proof packages if available. When considering a cleaning product to buy, get the minimum amount needed and the least toxic product, check storage areas at least twice a year and properly dispose of products that have outlived their usefulness, and do not combine different cleaning products.

Adverse and toxic effects that are caused by cleaning products received attention only after the establishment of the first PCDIC at An-

Najah National University at Palestine. This center provides information on management of poisoning cases using the most up-to-date literature. Utilization of the services provided by the PCDIC will result in significant savings of health care expenditures. Furthermore, accidental non-toxic ingestions can be managed on site effectively, rather than at emergency departments, thereby decreasing unnecessary hospital visits. PCDIC, in collaboration with responsible authorities and ministries can develop and implement preventive strategies such as safe manufacturing practices and public education programs about the dangers of cleaning products. The PCDIC provides lectures to high school students and the general public on safe methods of storing and using cleaning products and how to avoid adverse effects from such items.

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Table 1: Demographic description of the respondents.

Demographic Characteristic	**Number (%)**
Place of residence	
City	440 (59.9)
Suburbs	295 (40.1)
Monthly income	
<300 JD	239 (32.5)
300-500 JD	298 (40.5)
> 500 JD	183 (24.8)
Mother's education	
Illiterate	38 (5.2)
School	388 (52.7)
University	306 (41.6)
Mother's job	
Governmental job	105 (14.3)
Private job	106 (14.4)
No job	524 (71.2)
Father's Job	
Governmental job	178 (24.2)
Private job	426 (57.9)
No job	107 (14.5)
Work-related material at home	
Yes	212 (28.8)
No	415 (56.4)

JD: Jordanian Dinnar which was equivalent to 1.5 dollars at the time of the study.

School: the respondent has graduated from high school.

Figure 1: Cleaning products found in the home and their utilization patterns.

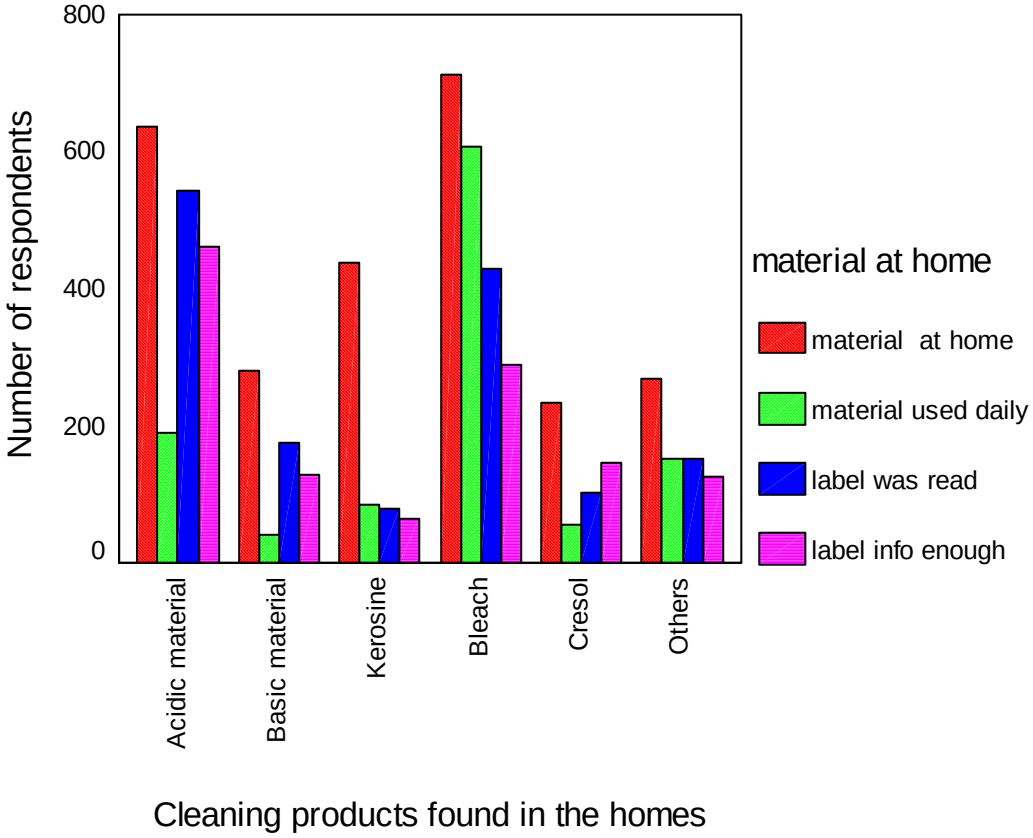

Figure 2: Cleaning products found in the home that were associated with the largest number of adverse health effects among respondents.

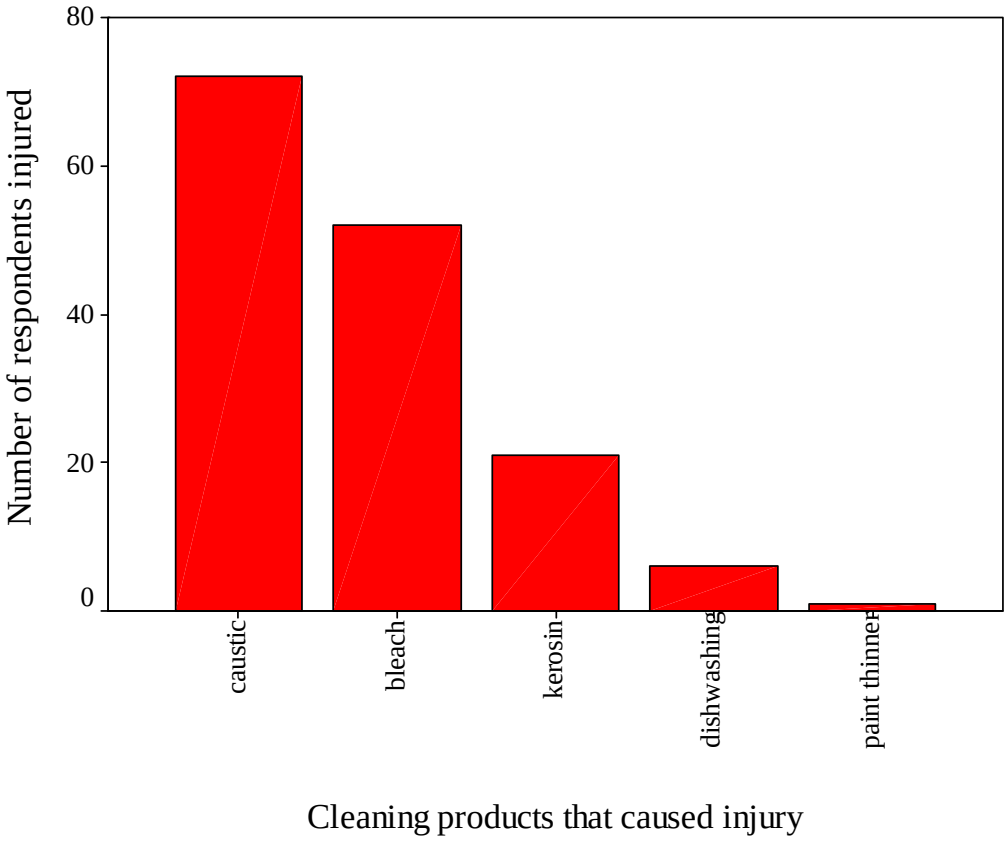

Figure 3: The relationship between the numbers of cleaning products used daily and reported injuries among respondents.

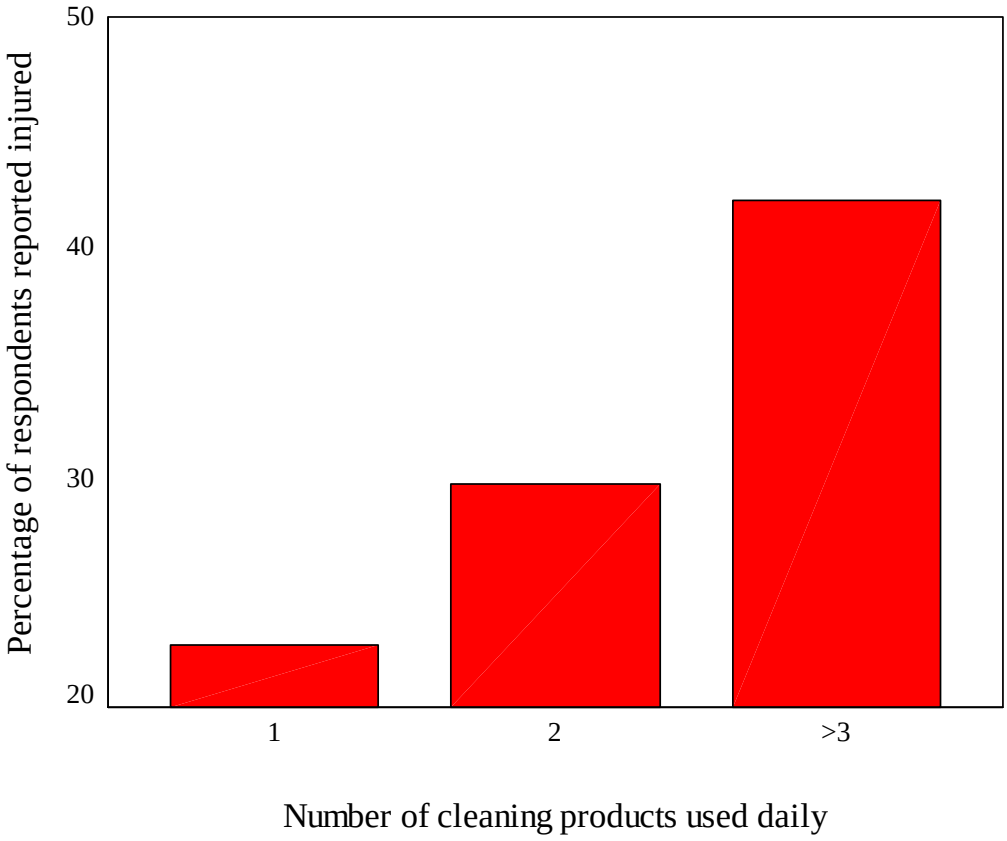

Figure 4: The relationship between the numbers of cleaning products stored in the home and reported injuries among respondents.

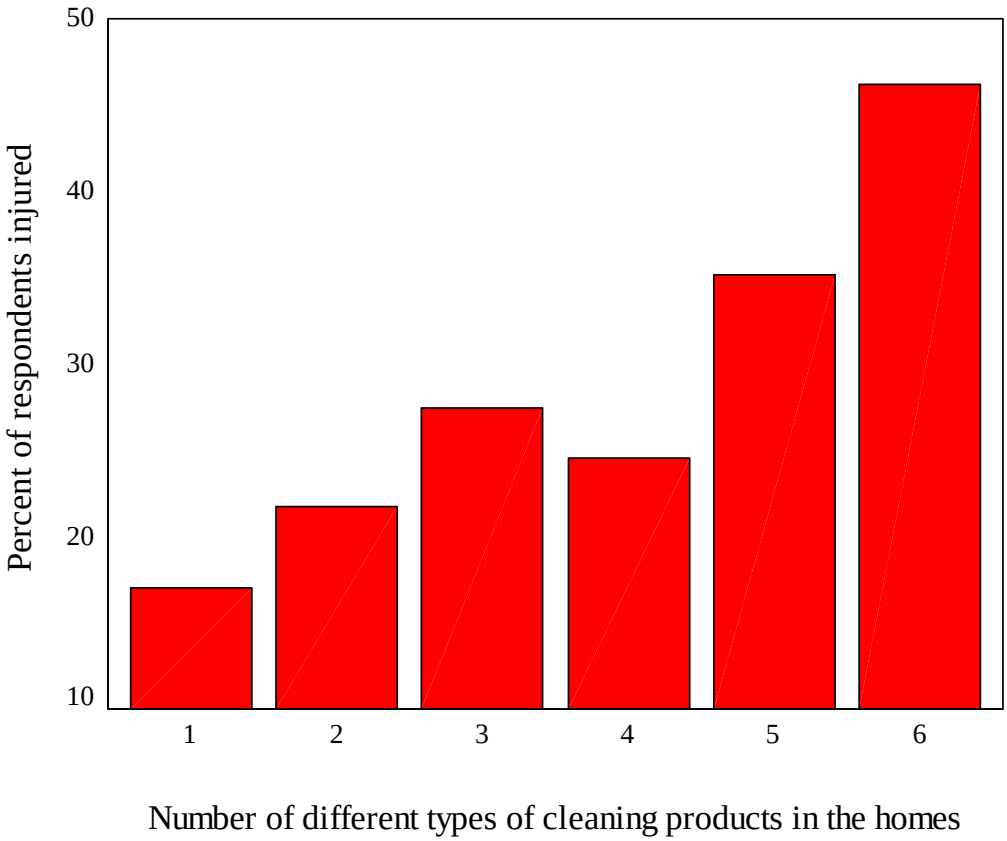

Table 2: Storage and disposal of cleaning products and their containers.

Practice by respondents	**Number (%)**
Reusing empty containers	151 (20.5)
Discarding the containers and what is leftover in municipal garbage	495 (67.3)
Store cleaning products in other than their original container	198 (26.9)
Store cleaning products in empty water or soft drink bottles	75 (10.2)
Empty cleaning product leftovers in the drain	181 (24.6%)