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Evaluation of pharmaceuticals in household waste in Senador Canedo, State of Goiás, Brazil

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The disposal of pharmaceuticals has become a problem for society and public health and causes risks to the environment. Therefore, the objective of this work was to evaluate the number of pharmaceuticals and the classes of the most discarded pharmaceuticals in household waste in Senador Canedo, Goiás, Brazil. The study was conducted in Senador Canedo, GO, Brazil (16° 42' 28'' S, 49° 5' 34'' W, and altitude of 801 m), which presents maximum air temperature of 35 to 37°C and a minimum of 11 to 13°C, along with mean annual rainfall depth of approximately 1,350 mm. Exploratory and descriptive research was conducted to characterize and quantify the disposal of pharmaceuticals in household wastes in the municipality of Senador Canedo, GO. The sample size required to estimate the production of household pharmaceuticals waste in a population (considered infinite) was defined through the following statistical criteria: 95% confidence level and 5% sampling error. The research consisted of a collection of 10 random samples (garbage bags) in each neighbourhood of Senador Canedo, GO. The most disposed pharmaceuticals in household wastes are from the analgesic, anti-inflammatory, antihypertensive, and antibiotic pharmaceutical classes, with percentages above 10%. Antiulcer, diuretics, and antidepressants are the other pharmaceutical classes that present the highest quantity in household wastes.

Key words: Analgesic, anti-inflammatory, antibiotic, toxic medicines, solid urban.

INTRODUCTION

The metropolitan region of Goiânia is the most populous urban centre of the state of Goiás (GO), Brazil. This region produces most of the solid urban waste of the state, with the municipalities of Aparecida de Goiânia, Goiânia, and Senador Canedo presenting solid waste production per capita ranging from 0.83 to 1.00 kg day^{-1} (Goiás, 2014; Ribeiro, 2017). Part of these wastes consists of medicine leftovers that are disposed of by the population; moreover, the use of medicines has been increased and the continuous introduction of new, highly bioactive and potent medicines has increased the diversity of toxic medicines disposed of to the environment (Daughton, 2003; Medeiros et al., 2014).

The disposal of pharmaceuticals has become a

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problem for society and public health and causes risks to the environment; they are a toxic waste that can contaminate the environment and cannot have the same final destination of common wastes (Vaz et al., 2011; Feitosa, 2016).

Even though medical waste is classified as chemical waste (health care waste), it has commonly been disposed of together with urban solid waste when it is from people that consume them at home. The medicine disposal made by these people is a great concern because of the lack of control and management of this waste (Boer and Fernandes, 2011; Vargas, 2014).

Concerns about medicine disposal are not new but have been little addressed and left to the constituted authorities and agents directly involved, such as pharmacies, laboratories, and users of medicines; consequently, scientific information can be important to further this issue in all contexts, including environmental (Rosa, 2017).

Therefore, the objective of this work was to evaluate the number of pharmaceuticals and the classes of the most discarded pharmaceuticals in household waste in Senador Canedo, GO, Brazil.

MATERIALS AND METHODS

The study was conducted in Senador Canedo, GO, Brazil (16° 42' 28" S, 49° 5' 34" W, and altitude of 801 m), which presents maximum air temperature of 35 to 37°C and a minimum of 11 to 13°C, and mean annual rainfall depth of approximately 1,350 mm.

Exploratory and descriptive research was conducted to characterize and quantify the disposal of pharmaceuticals in household wastes in the municipality of Senador Canedo, GO. In general, exploratory researches obtain qualitative and quantitative descriptions of the study object that conceptualize the interrelationships between the properties of the phenomenon, fact, or environment observed (Lakatos and Marconi, 2010).

The descriptive process is used to identify factors or variables that are related to the phenomenon or process under study; after data collection, the analysis of the relationships between variables is performed for subsequent determination of the effects (Perovano, 2014; Calimerio and Miyasato, 2016). Exploratory and descriptive researches are, in general, a preliminary step to obtain scientific explanations (Gil, 1991).

The sample size required to estimate the production of household pharmaceuticals waste in a population (considered infinite) was defined through the following statistical criteria: 95% confidence level and 5% sampling error.

Quantity of pharmaceuticals in household waste (QFW) and quantity of discarded blister packs containing tablets (DBPCT) were evaluated.

The research consisted of the collection of 10 random samples (garbage bags) in each neighbourhood of Senador Canedo, GO. The collection of garbage bags and separation of the material was done as indicated by the current Brazilian legislation (Brasil, 2004, 2005); personal protective equipment (PPE) was used to avoid contact and contamination with the collected material. Thus, after the collection of garbage bags, the common waste was separated from pharmaceutical waste to discriminate and classify the medicines.

The pharmaceutical waste classified was placed in plastic bags and identified according to pharmaceutical classes: antibiotics, antifungals, antivirals, anthelmintics, anti-inflammatory medicine, analgesics, antispasmodics, digestive, antiulcer, antiemetic, anti-flatulent, laxative, vitamins, nutrient, mineral salts, antihypertensives, diuretics, cardiotonic glycosides, antiarrhythmics, antidepressants, anxiolytics, antipsychotics, antiallergics, anti-vertigo, and vasodilators, expectorants, bronchial dilators, antivirals, antilipemic, hypoglycemics, hormones, herbal, homoeopathic, and unidentified medicines.

Data related to pharmaceutical waste were tabulated and later analyzed, using the Microsoft Excel 2016 program.

RESULTS AND DISCUSSION

The disposal of medical waste as a function of the antibiotic, antifungal, antiviral, and anthelmintic pharmaceutical classes (Figure 1A) showed that the disposal of medicines from the antibiotic class is higher, representing approximately 10.6% of all medicines. Even though their marketing is restricted (requiring a prescription), their consumption is high, indicating that the prescription of this type of medicine by physicians may be considered relevant. The control of the market of these medicines was expected to reduce substantially its consumption, mainly due to the inhibition of self-medication; however, this has not been observed.

Ramos et al. (2017) evaluated the disposal of medicines and found that 78.9% of the respondents had this practice; the main reason reported for the disposal was the expiration date (62.9%) and the most discarded medicines were anti-infectious and antibiotics for systemic use (26.3%) and respiratory tract medicines (24.2%).

The disposal of antifungals and antivirals in household waste was approximately 0.5%, whereas the disposal of anthelmintics was approximately 1% of the total pharmaceutical waste found. Most antiviral medicines present moderate environmental hazards, and all show degradation persistence; thus, the overall toxicity of these compounds can be classified as low to moderate (Wennmalm and Gunnarsson, 2005; Oliveira, 2015).

A proper collection and disposal of medicines helps to reduce the burden of medicine pollution when providing the medicine disposal in an environmentally safe location, which may also assist in preventing the accumulation of unnecessary medicines in homes to avoid medicine intoxication accidents, traffic of controlled medicines, and misuse of medicines (Medeiros et al., 2014).

Pinto et al. (2014) found that 91% of the total respondents dispose expired medicines from their homes in an environmentally incorrect manner; they dispose these medicines together with common or recyclable wastes and in running water, and only 4% dispose of medicines properly in health centers, pharmacies, or community centres.

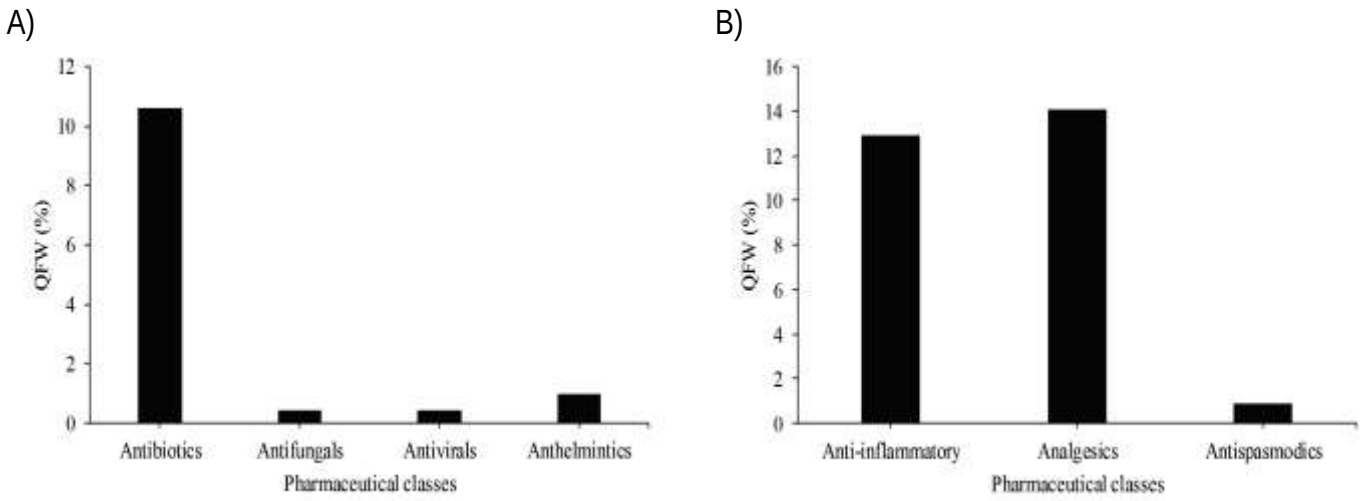

Figure 1. Quantity of pharmaceuticals in household waste (QFW) as a function of (A) pharmaceutical classes—antibiotics, antifungals, antivirals, and anthelmintics (B) and anti-inflammatory medicine, analgesics, and antispasmodics.

The quantity of antispasmodics was 0.9%, which is close to that found for the anthelmintic medicine class. Despite some pharmaceutical classes presented low quantities in household waste, their cumulative power should be considered, since pharmaceutical chemical wastes have an inherent potential of environmental risk that extends to the micro polluters, which may have serious consequences due to their cumulative effect (Heberer, 2002; Daughton, 2003).

The waste quantity of pharmaceuticals of the anti-inflammatory, analgesic, antibiotic classes was significant in the household waste evaluated, which were the predominant pharmaceutical classes of the medicines disposed of by the population (Figure 1B). Anti-inflammatory medicines and analgesics are readily available products and are generally purchased in large quantities by the population, which can be confirmed by the high quantity of these products in the household waste evaluated, which reached 13 and 14%, respectively.

The classes of the most discarded pharmaceuticals found by Rocha et al. (2009) were anti-inflammatory (13.2%) and analgesic (10.2%) ones. They reported that pharmaceuticals of both these classes are freely marketed in drugstores, and are only used when the user needs it, thus, they end up accumulating in homes, expiring, and should be discarded. They also reported that antimicrobials represented one-third of the most discarded group (9.2%). The disposal of pharmaceuticals of these classes found by Rocha et al. (2009) was similar to that found in the present study.

The disposal of medicines from the antiulcer class in household waste represented 4.65% (Figure 2A). Almeida et al. (2016) found that the most discarded pharmaceuticals in pediatric units were from the antimicrobial (22.7%), electrolyte (14.8%), analgesic (14.6%), diuretic (9.5%), and antiulcer (6.7%) classes.

Pharmaceuticals from the digestive and antiemetic classes showed similar disposal in household wastes, which were 2.56 and 2.65%, respectively. This was probably because medicines from these pharmaceutical classes are consumed together by the population for digestive problems. Medicines from the laxative class were not significantly found in household wastes, showing a percentage of only 0.41%. Durães et al. (2015) evaluated pharmaceutical classes of medicines discarded in a university and found that the most pharmaceuticals were from the classes of the analgesics and antipyretics, representing 19% of the total quantity found, followed by the anti-inflammatory (11%), anti-flatulence (7%), laxative (5%), and antiemetic (4%) classes.

Disposal of vitamin, nutrient, and mineral salts supplements in household wastes showed little difference, with approximately 2.40, 2.22, and 2.35%, respectively (Figure 2B). Similar percentages of disposal were found for the digestive and antiemetic classes. Oliveira et al. (2015) applied a questionnaire in health facilities and found that 30.6% of the discarded pharmaceuticals were antihypertensives, followed by anticoagulants (10.15%), benzodiazepines (7.97%), antidiabetics (7.96%), and vitamins (2.06%).

Antihypertensives had a high disposal percentage in household waste, reaching approximately 11%; pharmaceuticals from this class were among the most commonly found in the household waste (Figure 3A). Diuretics also presented a significant percentage in the household wastes, approximately 4.12%; and the cardiotonic glycosides, and antiarrhythmic presented

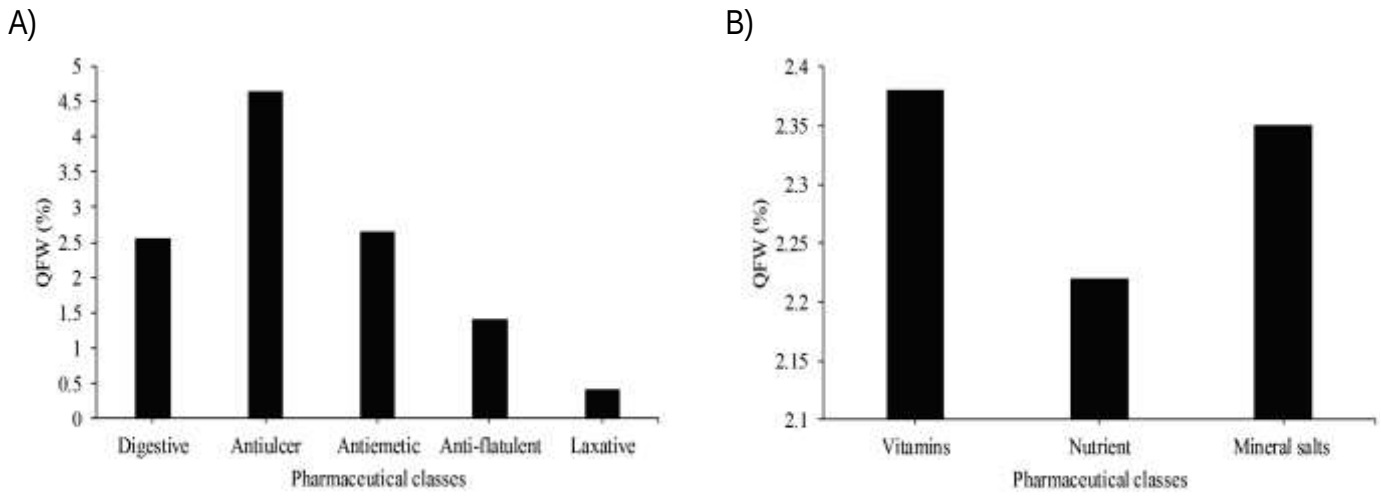

Figure 2. Quantity of pharmaceuticals in household waste (QFW) as a function of (A) pharmaceutical classes—digestive, antiulcer, antiemetic, anti-flatulent, and laxative (B) and vitamins, nutrient, and mineral salts supplements.

lower quantities, only 0.29 and 0.51%, respectively. Baldoni et al. (2015) found that the profile of discarded expired pharmaceuticals by users of health units were predominantly from the antihypertensive (22.0%), oral hypoglycemic (10.7%), and antiplatelet agent (10.6%) classes.

The high quantity of discarded antihypertensives and diuretics may be related to non-adherence to the treatment by the patient, which may be due to side effects of these medicines, forgetfulness, fear of administrating these medicines while using others, and unawareness of the need for treatment continuity (Barbosa and Lima, 2006; Oliveira et al., 2015), since medicines will reach the expiration date due to the interruption of the treatment and will be disposed as household waste. Most medicine users do not know what to do with expired medicines and are unaware of the damages caused by their inappropriate disposal (Carvalho et al., 2009).

The number of antidepressants within the pharmaceutical wastes evaluated was relevant (4.11%) (Figure 3B), and their disposal in household waste brings serious risks to the environment. Borrely et al. (2012) conducted toxicity tests and found higher death of aquatic organisms (*Vibrio fischeri* and *Hyalella azteca*) when these species were in contact with antidepressant medicine. It is estimated that the pharmaceutical classes that cause most impacting are: antibiotics (76.6%), hormones (73.6%), and antidepressants (69.4%); these percentages represent the number of medicines of each class with inherent environmental risk (Rodrigues, 2009; Paut Kusturica et al., 2017).

The percentages of anxiolytic and antipsychotic pharmaceutical classes were low in the household wastes evaluated, with averages not exceeding 0.30% (Figure 3B); however, Brazil is the third largest world consumer of benzodiazepine anxiolytic medicines, lagging behind only the United States and India (UN, 2018), the low percentage of anxiolytics found may be related to a greater adherence to treatment by patients.

Antiallergics, antivertigo, and vasodilators presented percentages in household pharmaceutical waste of approximately 2% (Figure 4A); and expectorants, bronchial dilators, and antivirals presented 0.84, 0.66, and 0.42%, respectively (Figure 4B). Marques and Xavier (2018) attributed the high use of vasodilators, antipyretics, and analgesics by the population to unstable climate periods and rapid drops in temperatures, which favour the emergence of symptoms of cold; moreover, they also found a high use of antiviral, antibiotic, anti-inflammatory, and antiallergic medicines in these periods.

The quantity of antiallergics, anti-vertigo, vasodilators, expectorants, bronchial dilators, and antivirals in household wastes in central Brazil, where medicines from these pharmaceutical classes are used for treatment of respiratory diseases, is mainly related to high air temperature and low relative humidity, which was confirmed by Murara and Amorim (2010) who correlated the days that presented the highest occurrences of diseases with dry periods combined with high thermal amplitudes, or with days that had low relative humidity values.

The percentage of antilipemic and hypoglycemic medicines found in household wastes was approximately 3.4 and 4.0%, respectively, and the presence of hormone medicines did not exceed 0.5% (Figure 5A).

Sodré et al. (2010) evaluated water supply samples in Campinas, SP, Brazil, and found that estrone and 17β-

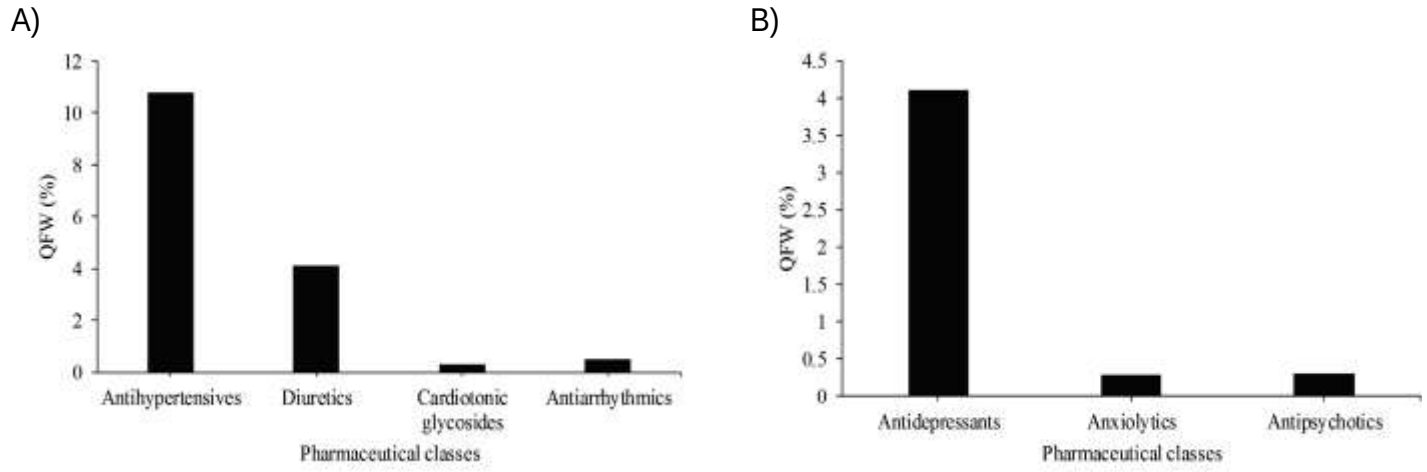

Figure 3. Quantity of pharmaceuticals in household waste (QFW) as a function of (A) pharmaceutical classes-antihypertensives, diuretics, and cardiotonic glycosides, and antiarrhythmics (B) and antidepressants, anxiolytics, and antipsychotics.

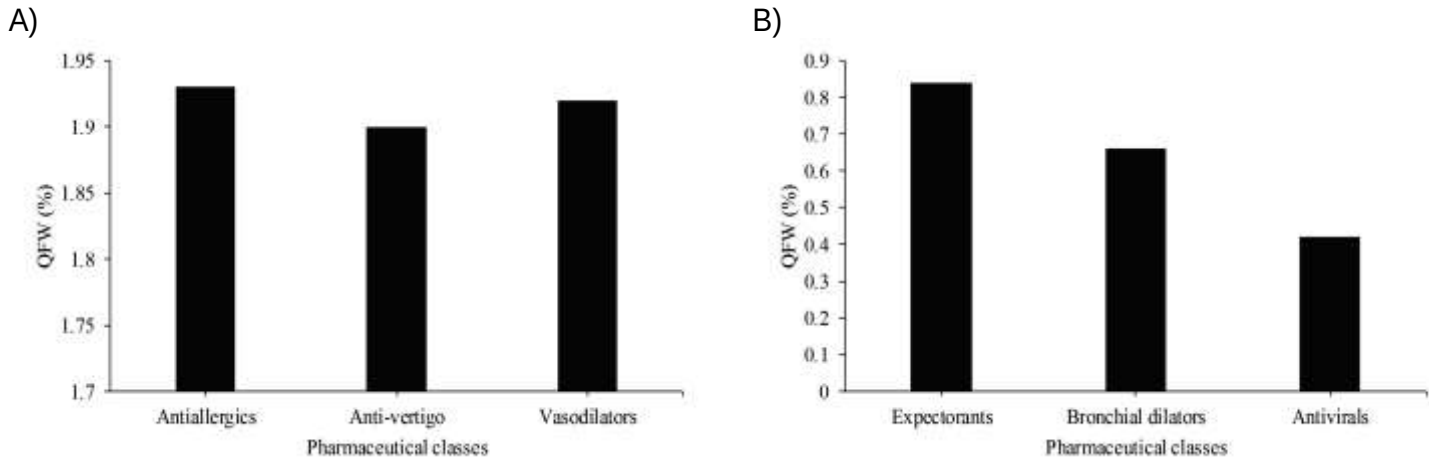

Figure 4. Quantity of pharmaceuticals in household waste (QFW) as a function of (A) pharmaceutical classes—antiallergics, anti-vertigo, and vasodilators and (B) expectorants, bronchial dilators, and antivirals.

estradiol were detected below the limits of quantification. Also, stigmasterol had the highest concentration, followed by cholesterol and caffeine.

Regarding the disposal of hypoglycemic agents, Cavalcante et al. (2016) reported that there are no clear guidelines to control the disposal of collection containers; and, in some cases, the maximum capacity of the collection box is insufficient for the correct separation of the waste generated in a month, indicating that, in the absence of enough containers, the population discard part of their antidiabetic medicine waste in ordinary household waste.

According to Carvalho et al. (2009) in the United States, about 41 million citizens receive drinking water contaminated with several pharmaceutical products, such as antibiotics and hormones.

Phototherapic and homoeopathic medicines showed similar disposal in household wastes, with an average percentage of 0.7%. Guerrieri and Henkes (2017) conducted interviews about types of pharmaceuticals that the respondents used and had in their homes and found that 36.25% of them had only analgesics and antipyretics; 16.25% had antibiotic and anti-inflammatory medicines; 4.68% of respondents had others (e.g. contraceptive, homoeopathic, and herbal medicines); and 1.56% had antidepressants.

The number of pharmaceuticals found was not large due to their high packaging degradation level; besides,

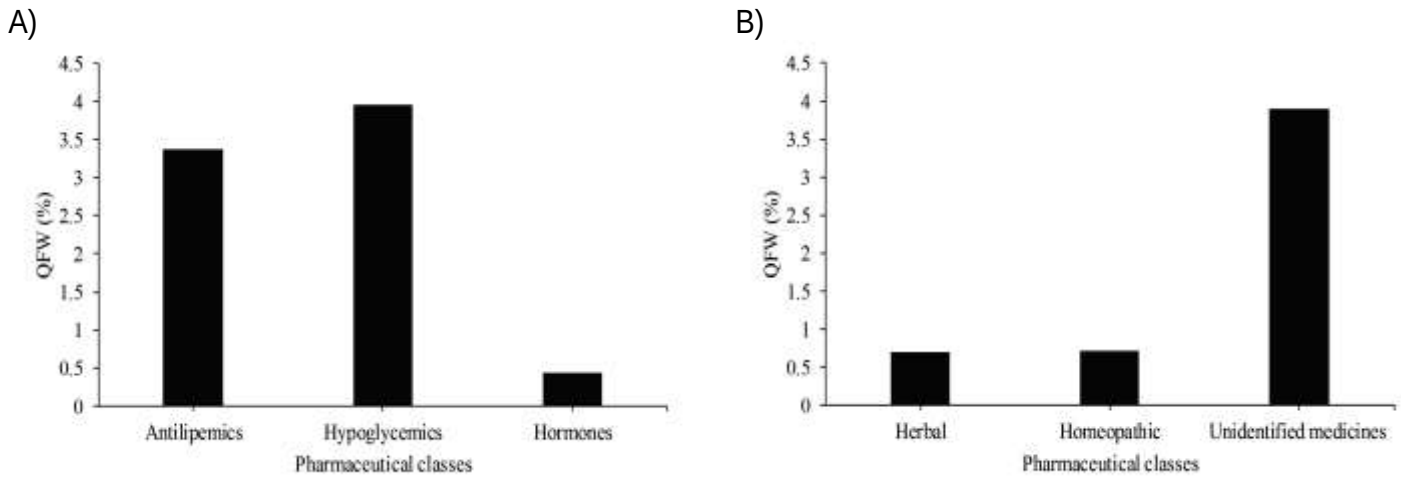

Figure 5. Quantity of pharmaceuticals in household waste (QFW) as a function of (A) pharmaceutical classes—antilipemic, hypoglycemics, and hormones and (B) herbal, homoeopathic, and unidentified medicines.

the number of unidentified medicines was 3.90% (Figure 5B).

The most commonly found anti-inflammatory medicines in the household wastes evaluated were ibuprofen, nimesulide, and diclofenac. Considering these three anti-inflammatory medicines, ibuprofen represented 58.8% of the quantity found (Figure 6A). Xu et al. (2009) found that ibuprofen has a short residence time in different soils, indicating a high percolation potential, easily reaching groundwater.

Among the antibiotics found, amoxicillin and cephalexin represented 62.5% of the medicines from this pharmaceutical class (Figure 6B). Some of the most used classes such as antibiotics, which are used to prevent and treat bacterial infections, deserve to be highlighted since their intensive use has contaminated environmental matrices such as soil, water, sediment, plants, and animals with effects on the biota. After contaminating the environment, such drugs have the potential to cause adverse effects to the aquatic, terrestrial and also to humans (Botelho et al., 2015). According to a study in the United Kingdom, amoxicillin is one of the main substances considered by environmental monitoring studies because of the intense use, transport potential in the environment, and toxicity of these compounds (Capleton et al., 2006).

The most discarded medicines were dipyrone monohydrate, ibuprofen, amoxicillin, nimesulide, and ranitidine hydrochloride. Among these pharmaceuticals, dipyrone monohydrate and ibuprofen were more discarded than amoxicillin, nimesulide, and ranitidine hydrochloride, probably due to the high availability, continued use, and the low price of these medicines (Figure 6C). Bandeira et al. (2019) reported that the most common pharmaceuticals found in environments are: ibuprofen, paracetamol, dipyrone, simvastatin, fluoxetine, and contraceptives; and the improper use of these pharmaceuticals can lead to health problems.

In a research conducted by Serafim et al. (2007), most respondents affirmed to use of dipyrone-containing medicines; to have no-expired medicines in their homes (93.3%); and to dispose them together with the household waste (79%), thus emphasizing that this inappropriate disposal of medicines is a worrying factor as it may pose a health risk to children or people who may reuse them.

Figure 7A shows the percentages of discarded blister packs containing tablets as a function of the number of tablets per pack.

The percentages of discarded blister packs containing tablets were approximately 41.4% (up to two tablets), 32.5% (two to five tablets), 19.2% (five to eight tablets), and 7.0% (over eight tablets) (Figure 7A). Pinto et al. (2014) conducted similar study and found that most respondents (55%) dispose packs with small quantity, up to 4 tablets per year; however, the study pointed out that although this result seems insignificant, at the end of a year, about 1,300 tablets would be discarded in the environment, only in the context of the research.

Figure 7B shows the percentages of discarded blister packs containing tablets as a function of pharmaceutical classes. The most common pharmaceutical classes were antibiotics, anti-inflammatory, antihypertensives, analgesics, antidepressants, and diuretics. Analgesics, anti-inflammatory, and antibiotics represented 66.4% of these pharmaceuticals. The results found for analgesic and anti-inflammatory medicines were due to the high availability and low cost of many of the medicines from these two pharmaceutical classes. Analgesics, anti-inflammatory, steroid hormones, anti-parasites, and

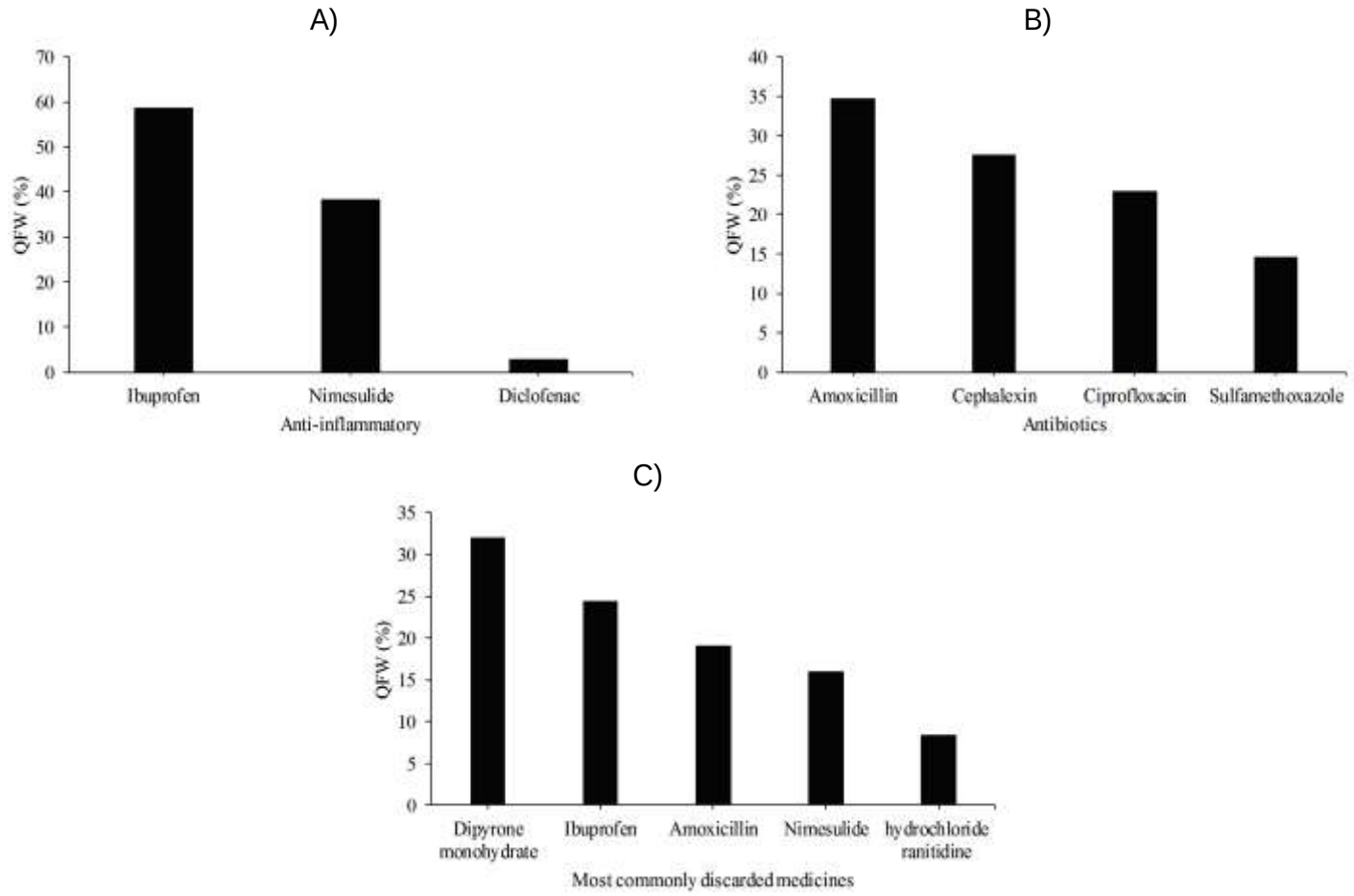

Figure 6. Quantity of pharmaceuticals in household waste (QFW) as a function of (A) pharmaceutical classes—anti-inflammatory and (B) antibiotics and (C) the most commonly discarded medicines—dipyrone monohydrate (dipyrone M), ibuprofen, amoxicillin, nimesulide, and hydrochloride ranitidine.

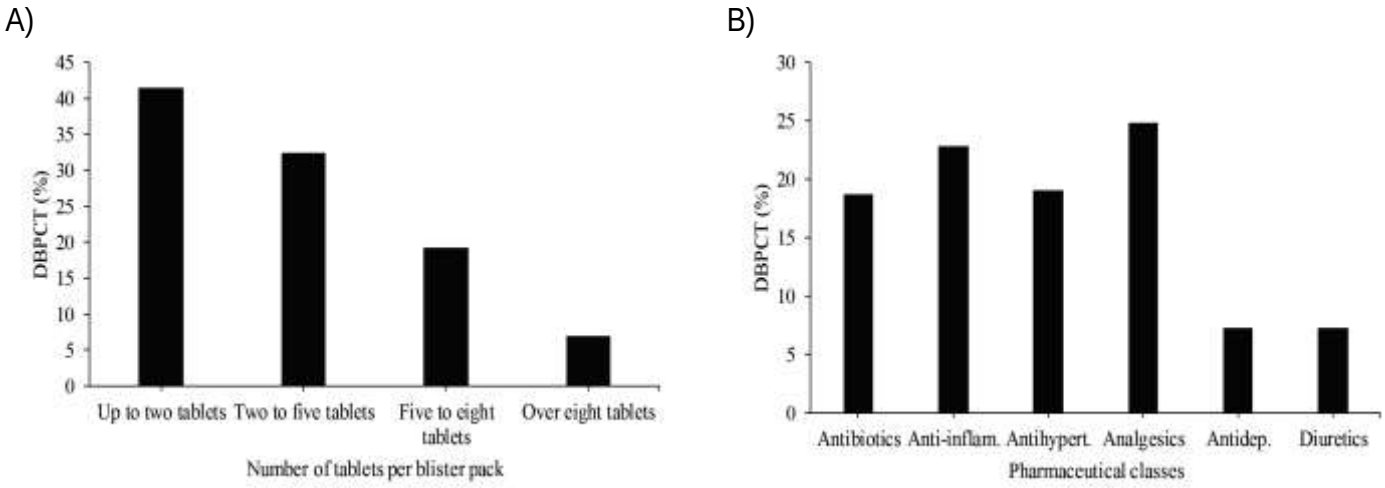

Figure 7. Quantity of discarded blister packs containing tablets (DBPCT) as a function of (A) a number of tablets per blister pack (B) and quantity of discarded blister packs containing tablets as a function of pharmaceutical classes—antibiotics, anti-inflammatory, antihypertensives, analgesics, antidepressants, and diuretics.

antibiotics are among the medicines of environmental importance due to the quantity consumed, toxicity, and persistence in the environment (soil and water) (Carvalho et al., 2009; Salomão et al., 2019).

Household waste has a wide variety of debris. It is very common to find pharmaceuticals waste or similar dispensed by the population, which can be harmful to human health and the environment. This problem is mostly caused by people not knowing the risks of this waste and lack of a communication policy that can inform the population of the damage that this pharmaceuticals waste can cause to living and environmental beings in a region.

Conclusion

The most disposed pharmaceuticals in household wastes are from the analgesic, anti-inflammatory, antihypertensive, and antibiotic pharmaceutical classes, with percentages above 10%. Antiulcer, diuretics, and antidepressants are the other pharmaceutical classes that present the highest quantity in household wastes.

The most commonly found medicine of the anti-inflammatory pharmaceutical class in household wastes is ibuprofen; and for the antibiotic class, it was the amoxicillin.

The medicines of most discarded blister packs containing tablets are from the analgesic, anti-inflammatory, and antibiotic pharmaceutical classes, and 73.9% of these blister packs have up to five tablets.

CONFLICT OF INTEREST

The authors have not declared any conflict of interest.

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