The practices of Brazilian internet users on the environmental impacts associated with the use of medicines in the COVID-19 pandemic: are we practicing ecopharmacovigilance?

As práticas dos internautas brasileiros sobre os impactos ambientais associados ao uso de medicamentos na pandemia de COVID-19: estamos praticando a ecofarmacovigilância?

Rafaela dos Santos Costa[1] ⓘ, Amanda Nogueira Medeiros[1] ⓘ, Viviane Souza do Amaral[1] ⓘ, Julio Alejandro Navoni[1] ⓘ

ABSTRACT

Pharmaceutical contamination represents an environmental and public health threat. One of the sources of entry of these compounds into the environment is the disposal of expired or unused medicines. However, it is necessary to understand how the population recognize this problem to subsidize management actions on this theme. Mitigating and/or reducing the entry of pharmaceuticals into the environment is one of the main lines of action of the ecopharmacovigilance (EPV). Thus, the present study aimed to analyze the environmental habits of medicines disposal by Brazilian web users, in accordance with current legislation, as well as the environmental impacts resulting from pharmacological contamination, during the COVID-19 pandemic, besides evaluating the implementation of the EPV concept. An online questionnaire was developed on the Google Forms platform with 26 questions, and was disseminated for six months on social networks, websites, and emails. The sampling method used was the convenience. The results indicated the predominance of consumption of the pharmacological group associated with COVID-19 treatment. In addition, it was observed that most participants discarded medicines for human (62.0%) and veterinary (33.6%) use in common waste. Moreover, there was a concern among respondents regarding the occurrence of pharmaceuticals in the environment and their implications in different environmental matrices as well as in human health. Disseminating the current Brazilian legislation and improving the effectiveness of reverse logistics programs, as well as making society aware of the impacts associated with pharmaceuticals can help mitigate this environmental problem.

Keywords: emerging contaminants; pharmaceutical contamination; inappropriate disposal; socio-environmental habits; legislation; environmental risk; human and environmental impacts.

RESUMO

A contaminação por fármacos representa uma ameaça ambiental e de saúde pública. Uma das fontes de entrada desses compostos no meio ambiente é o descarte de medicamentos vencidos ou não utilizados. No entanto, é preciso entender como a população reconhece esse problema, para subsidiar ações de gestão perante esse tema. Essas formas de mitigar e/ou reduzir a entrada de fármacos no meio ambiente é uma das principais linhas de atuação da ecofarmacovigilância (EPV). Assim, o presente estudo teve como objetivo analisar os hábitos ambientais do descarte de medicamentos dos internautas brasileiros, de acordo com a legislação vigente, bem como os impactos ambientais decorrentes da poluição por fármacos, durante a pandemia de COVID-19, além de avaliar a implantação do conceito EPV para evitar a entrada de fármacos no meio ambiente. Foi desenvolvido um questionário *online* na plataforma Google Forms com 26 questões, divulgado durante seis meses em redes sociais, *sites* e *e-mails*. O método de amostragem utilizado foi o de conveniência. Os resultados indicaram a predominância de consumo de classes terapêuticas associadas ao tratamento da COVID-19. Além disso, observou-se que a maioria dos participantes descartava medicamentos de uso humano (62.0%) e veterinário (33,6%) no lixo comum. Além disso, constatou-se que existe uma preocupação do entrevistado sobre a influência dessas substâncias na contaminação da água e do solo, na saúde humana e animal associada a doenças. Divulgar a legislação brasileira vigente e melhorar a eficácia dos programas de logística reversa, bem como conscientizar a sociedade sobre os impactos ambientais associados aos fármacos, pode auxiliar na mitigação dessa problemática ambiental.

Palavras-chave: contaminantes emergentes; contaminação farmacêutica; descarte inadequado; hábitos socioambientais; legislação; risco ambiental; impactos humanos e ambientais.

Introduction

Pharmaceutical contamination has gained prominence due to its adverse ecological effects (Rzymski et al., 2017), such as feminization and behavioral change in fish (Thrupp et al., 2018), inhibition of cyanobacterial growth (Costa et al., 2021), among others. One of the sources of pharmaceuticals entering the environment is the lack of technologies for their removal in wastewater treatment plants in several countries, such as Brazil (Marson et al., 2022). It should be noted that, in Brazil, 49.2% of sewage is not treated (SNIS, 2020). Another way of introducing pharmaceuticals into different environmental matrices is associated with the disposal of expired and out-of-use medicines, which is usually done inappropriately, through common waste, toilets, burning, among others (Ayele and Mamu, 2018; Quadra et al., 2019).

The increase in medicine consumption can be exacerbated by adverse situations, such as pandemic events (Singer et al., 2014). In this sense, the COVID-19 pandemic, decreed by the World Health Organization on March 11, 2020 (WHO, 2020), favored the increase in the use of medicines (Horn et al., 2020). In addition, in Brazil, patients diagnosed with COVID-19, used drugs such as hydroxychloroquine, chloroquine, azithromycin, ivermectin, and vitamin D, among others, adopted as "early" treatment (Covid kit), even without scientific proof of their therapeutic effectiveness (Melo et al., 2021). Therefore, this pandemic situation and the treatments adopted may have further caused the load of pharmaceuticals in the environment in the Brazilian scenario, and consequently, increased the potential ecological risks to the affected biome (Farias et al., 2020).

In this way, ecopharmacovigilance (EPV) presents itself as a new area of study that addresses the issue of pharmaceutical contamination transdisciplinary, from prevention to monitoring, to analyze the effects of these substances on the environment (Wang et al., 2021). In this sense, one of the forms of prevention is the awareness of the population about the correct use and disposal of drugs (Wang et al., 2021; Vatovec et al., 2021). Besides public awareness, the countries' governments should also include in their legislation the responsibilities of medicines industry up to the final consumer, ensuring the reduction of the impacts of these products on ecosystems (Souza et al., 2021; Vatovec et al., 2021).

In Brazil, for example, Decree No. 10,388 was approved in 2020, which determines that drug stores in municipalities with a population of more than 10,000 are required to receive expired or unused packaging and medicines from home use for the reverse logistics delivery system (Brasil, 2020). The country also has collection points for medicines products disposal (Souza et al., 2021), as a result of the implementation of this decree. However, it is important to understand whether Brazilian society recognizes the environmental impacts associated with pharmaceuticals.

In view of the above, the present study aimed to investigate the environmental habits of medicines disposal by Brazilian web users in accordance with current legislation, and analyze the environmental impacts resulting from pharmacological contamination during the COVID-19 pandemic, as well as to evaluate the implementation of the EPV concept to prevent the entry of pharmaceuticals into the environment.

Materials and Methods

This study was conducted during the pandemic period from July 2020 to January 2021. In Brazil, social distancing already existed in this period, medicines used as early treatment for COVID-19 were made available in the months prior to this study, and July 25 was the peak of the first wave (Machado and Freitas, 2021). During this work, the possible start of a second wave of infections also occurred in the month of November 2020. Moreover, in the last month of the research, vaccination began in Brazil and the Ministry of Health, that previously recommended early treatment based on self-diagnosis, suspended it (Machado and Freitas, 2021).

The Brazilian population was estimated at 213,317,639 inhabitants (IBGE, 2021). Different factors defined the choice for web users as the target public, such as: greater number of participants from different locations in Brazil, more access to information available on the internet since the country had 82.7% of households with internet access (PNAD, 2019), and social isolation caused by the pandemic that increased the time of internet use with new models of work and social relationships (De' et al., 2020).

Thus, a descriptive type of research with qualitative and quantitative approaches was developed to assess the consumption and impact of pharmaceutical contamination based on previous studies (Servidoni et al., 2006; Quadra et al., 2019). The survey was applied virtually through the Google Forms platform, and configured so that participants were limited to answering only once. The dissemination of this research took place through the social networks (Facebook, WhatsApp, Instagram) of the authors, allowing free sharing with people from all over Brazil. The convenience sampling method was employed to obtain the results. The questionnaire was available on the internet for six months.

The survey was developed with 26 multiple-choice and discursive questions written in Portuguese, considering the population's sociodemographic characteristics and habits regarding the use and destination of medicines in the environment (Supplementary Material). Sociodemographic information about participants included age group, sex, education, and place of residence. In addition, the participants were asked about the consumption of medicines they frequently used, disposal of expired or out-of-use medications, as well as the implications of pharmaceutical contamination on the environment.

The Research Ethics Committee of the Universidade Federal do Rio Grande do Norte (CAAE: 30106120.8.0000.5537) approved the questionnaire realization. The inclusion criteria adopted in this study were that the participants should be 18 years or older and agree to the Free and Informed Consent Form (ICF).

The results obtained in this study were interpreted using descriptive analysis and categorical variables presented in percentages. The open questions were analyzed in Nvivo software by means of descriptive analysis through word cloud generation. Some prepositions and terms were removed from the questions to facilitate the analysis of the answers.

Results

Sociodemographic characteristics

The study had 592 participants. Of the total number of questions asked about sociodemographic characteristics, more than 99% of responses were obtained. Most of the participants were female, aged between 25 and 35 years, and with a complete postgraduate degree (Table 1).

It was observed that most participants come from the Southeast Region (n = 288) of Brazil, followed by the Northeast Region (n = 243) (Figure 1).

Table 1 – Sociodemographic profile of the participants.

| Variable	Categories	Response % (n)
Gender	Female	72.5 (429)
	Male	27.5 (163)
Age group (years)	18–25	21.1 (125)
	25–35	42.1 (249)
	35–45	16.0 (95)
	45–55	9.8 (58)
	55–65	9.3 (55)
	> 65	1.5 (9)
Scholarity	Complete elementary education	0.8 (5)
	Incomplete elementary school	0.2 (1)
	Complete high school	6.6 (39)
	Incomplete high school	0.8 (5)
	Completed higher education	17.2 (102)
	Incomplete higher education	20.3 (120)
	Complete postgraduate	41.4 (245)
	Incomplete postgraduate	12.7 (75)
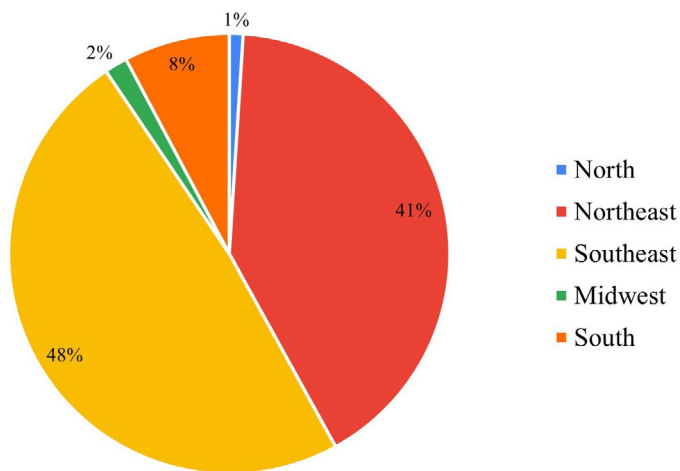
Figure 1 – Distribution of participants by Brazilian regions.

Participants' medicines consumption habits

Regarding the information on habits of medicine use, a total of 95% responses were obtained. When asked if respondents were in the habit of consuming medication frequently, 60.3% (n = 357) said they used regularly, while 39.5% (n = 234) did not have this habit. As for the frequency of medicines purchases, 4.7% (n = 28) bought medicines daily, 10.1% (n = 60) weekly, and 83.6% (n = 495), on a monthly basis. Concerning self-medication habits, 43.2% (n = 256) used medicines without a medical prescription, while 56.6% (n = 335) did not have this habit; 32.6% (n = 193) usually recommended medication to friends and family, but the majority 67.1% (n = 397) did not do this practice.

Concerning the need for continuous use of medication, 42.7% (n = 253) of respondents indicated this demand. Furthermore, 39.9% (n = 236) of respondents had the habit of using different types of medicines concomitantly, while 60% (n = 355) did not. When asked about reading the package insert of the medicines consumed, 79.4% (n = 470) stated having this habit; and 87.3% (n = 517) checked the expiration date. About the negative effects associated with medication consumption, 59.5% (n = 352) responded that they already had adverse reactions; therefore, 40.4% (n = 239) had not.

When participants were asked which medicines they consumed most often, 96.6% (n = 572) answered this question, with the most consumed being dipyrone, Dorflex (composed of dipyrone, caffeine, and orphenadrine citrate), ibuprofen, and paracetamol (Figure 2).

When analyzing the pharmacological group most consumed, it was found that analgesics were the most frequently consumed by respondents (n = 241) (Figure 3).
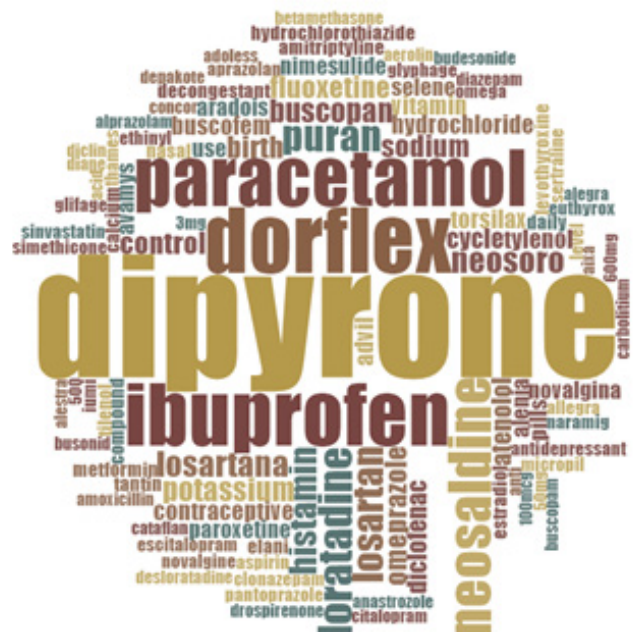

Figure 2 – Word cloud generated from participants' responses about the medicines they consumed most frequently.
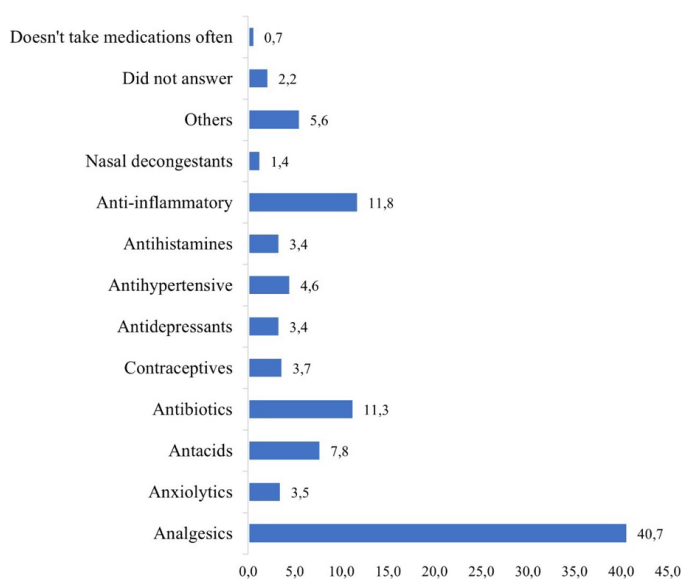
Figure 3 – Pharmacological group consumed by respondents.

Table 2 – Participants response on the forms about medicines disposal for human and veterinary use.

	Human use	Veterinary use
Ways to dispose of medicines	Response % (n)	Response % (n)
Donation*	0.2 (1)	0.7 (4)
More than one way of disposal **	5.2 (31)	1.4 (8)
Common garbage	62.0 (367)	33.6 (199)
Sink	0.8 (5)	0.2 (1)
Collection points	18.1 (107)	6.4 (38)
Burn	0.5 (3)	0.5 (3)
Flush down the toilet	4.4 (26)	1.7 (10)
No answer	2.0 (12)	47.1 (279)
Others***	6.8 (40)	6.1 (36)
Unidentifiable answer	-	2.4 (14)

*Donation of medicines within the validity period; **common waste and/or toilet, sink, donation, and collection points; ***medicines stored at home and responses not described in detail which made their interpretation impossible.

Disposal of medicines and their relationship with the environment

Regarding medicines disposal, 62% of respondents usually discard them in common waste; the same happens either with veterinary or human pharmaceuticals (Table 2).

When analyzed, it was found that the participants who discarded their medicines for human use (n = 107) at collection points (drug stores, universities, and health centers) mostly resided in three states: Rio Grande do Norte (30.8%), followed by Rio de Janeiro (15.0%), and São Paulo (13.1%). Moreover, 50.5% (n = 54) of the participants who carried out this practice had completed postgraduate studies.

Regarding the disposal of pharmaceuticals in the environment and its consequences, 95.0% of responses were obtained, of which 35.6% (n = 211) of participants believed that the way they disposed was correct, and consequently, 63.5% (n = 376) judged their way incorrect. About 37.8% (n = 224) considered that the way they disposed of medicines caused no impact on the environment, while 61.0% (n = 361) believed that their way had a negative impact.

Of the 95.0% of respondents who answered about the quality of the water they consumed, 53.4% (n = 316) believed that this resource is beneficial for their health while 46.3% (n = 274) did not consider the drinking water they consumed to be of good quality. Accordingly, 61.5% (n = 364) stated that drinking water quality may be related to the presence of pharmaceuticals, while 37.8% (n = 224) did not perceive this relationship. When questioned about the form of disposal of medicines and the occurrence of these substances in the water, 65.4% (n = 387) believed in this influence and 34.5% (n = 204) indicated the option of not having such a relationship.

In general, the participants perceived the influence of pharmaceuticals on the environment and their impact on human health, as evidenced in the answers, in which 95.8% of the respondents answered in the affirmative. When asked about how pharmaceuticals in the environment might influence people's health, it was found that there was a particular concern about contamination of water and soil (Figure 4A) among the 515 participants who responded to this question.

When analyzing whether the respondent believed that the occurrence of pharmaceuticals in the environment could impact the health of animals, it was observed that 501 (84.6%) participants who answered this question mentioned concerns related to contamination, water, soil, and health (Figure 4B).

Still in relation to the presence of pharmaceuticals in the environment, when asked about their impacts on plant health, 482 participants who answered this question showed care about the themes soil, contamination, and water (Figure 4C).

Discussion

Medicines consumption

The results found in this study demonstrated that medicine disposal practices, the population's knowledge about the environmental risks of inappropriate medicine use, and the habit of self-medication need to be disseminated more effectively in Brazil.

Data showed that 43.2% of participants had the habit of practicing self-medication. This habit was also common in other countries such as Saudi Arabia (Alghadeer et al., 2018) and Ethiopia (Ayalew, 2017).
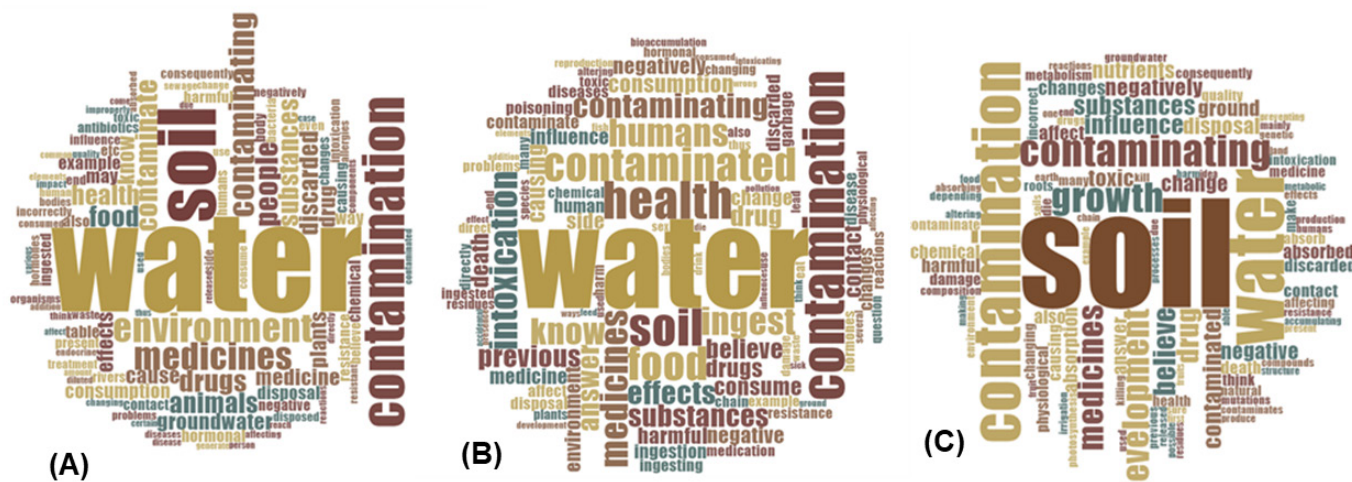
Figure 4 – Word clouds generated based on the participants' answers when asked about the occurrence of pharmaceuticals in the environment and their impact (A) on human health; (B) on fauna; (C) on the flora.

In Brazil, according to the study of the Institute of Research and Graduate Studies for the Pharmaceutical Market (ICTQ), conducted in 2022, with 2,099 people in 151 municipalities, 89% of the participants practiced self-medication. The interviewees in this study reported using search engines and/or applications as a source of support for this practice (ICTQ, 2023). Additionally, the use of the internet also contributes to this matter.

The study carried out by Coelho et al. (2013) where questionnaires were applied to 84 physicians and 221 patients in the city of Santos, São Paulo, Brazil, showed that more than 60% of physicians were aware of the practice of self-medication by patients based on internet searches. It can also be noted that the COVID-19 pandemic contributed to the increase in the practice (Malik et al., 2020). Therefore, the present study, carried out during the pandemic, and the previous studies reported in a pre-pandemic scenario, ratify the findings.

The habit of self-medication can cause serious adverse reactions (Montastruc et al., 2016), which was declared by 59.5% of the participants who felt some negative effect associated with the use of medicines.

The pharmacological group most consumed by respondents were analgesics. Similarly, Quadra et al. (2019) in their study carried out in Brazil before the COVID-19 pandemic, found that 30% of 540 participants also reported this pharmacological group as the most used. In the present study, carried out during the SARS-CoV-2 virus pandemic, it was observed that 41% of respondents used analgesics frequently. It is speculated that the results obtained indicate an increase in the consumption of this therapeutic class compared to the aforementioned study to treat the fever and painful symptoms associated with the disease.

Concerning analgesics, the study carried out by Do and Do (2011) described an increase in internet searches for this over-the-counter therapeutic class during the pandemic in the United States.

In Brazil, painkillers were prescribed for patients with COVID-19, confirming the hypothesis of increased consumption as a therapeutic alternative for the disease treatment (Santos et al., 2021). The present study also found that dipyrone was the participants' most used analgesic (Figure 2). In countries such as the United States, Sweden, Australia, Norway, Denmark, and the United Kingdom, this medicine is banned due to the possibility of causing blood dyscrasia (Pamplona et al., 2011).

Anti-inflammatory were the second most reported of medicines products (12%). This therapeutic class is widely used, inexpensive, and requires no prescription (Madikizela and Ncube, 2021). The consumption of anti-inflammatory drugs occurred as a result of population growth and life expectancy (He et al., 2017). Ibuprofen, for example, was listed by respondents as one of the most used medicines (Figure 2). This information corroborated the literature data that included this medicine as one of the most consumed worldwide (He et al., 2017).

Furthermore, 28.9% (n = 171) of the participants mentioned consuming medicines used for flu symptoms, which may be related to self-medication due to COVID-19, during the period of the questionnaire application. In addition, in Brazil, certain pharmaceuticals such as azithromycin, hydroxychloroquine, chloroquine, ivermectin, nitazoxanide, zinc supplements, and vitamins C and D were used as an "early" treatment against COVID-19, called the "Kit-Covid", even without scientific evidence of their effectiveness for this disease (Melo et al., 2021). It should be noted that 1.5% (n = 9) of the participants consumed some type of medication included in the "Kit-Covid". We speculate that the low mention of the consumption of these medications may be related to the impacts and controversies of the media on the dissemination of false information or without scientific arguments, which could have caused underreporting.

Disposal of human use medicines

The present study showed that the main route of medicines disposal was the common waste (62%). It should be noted that most participants had postgraduate degrees (41.4%), which describes a population with a good academic education. This factor could influence the correct destination of this type of waste, following the reverse logistics policies for medicines, nevertheless, it was not evidenced in this research.

Similar studies as Bashaar et al. (2017) in Kabul, Afghanistan, revealed that out of 301 survey participants, 77.7% reported disposing of expired medicines in the garbage. In developed countries, such as the United States, studies showed the habit of discarding drugs products in the sanitary sewage system. On the contrary, in Sweden and Germany, expired medicines were commonly deposited at collection points (Kusturica et al., 2017). The behavior differences in these countries may be related to management strategies and the effectiveness of their application at the social level.

The disposal of medicines in common waste must be debated with the population, moreover, medicines can reach the final disposal areas of solid waste such as dumps and controlled landfills, which are the most used systems in Brazil (SNIS, 2019). The country has one of the largest underground freshwater reservoirs in the world (Maia et al., 2020). Dumps are characterized by not having waterproofing systems, thus, substances present in discarded waste can reach groundwater bodies as a consequence of natural leaching. On the other hand, controlled and sanitary landfills have waterproofing technologies to prevent residues, including pharmaceuticals, from contaminating groundwater.

Therefore, solid waste final disposal sites are niches where people in a situation of socioeconomic vulnerability, seek subsistence and survive in conditions of basic human needs deprivation. Direct contact with household waste can impact the health of these people; when collecting products with potential economic utility, they can accidentally ingest medicines (Pimentel et al., 2018).

The second method of medicines disposal was the collection points. Brazil has reverse logistics programs for medicines (Souza et al., 2021). In addition, the 2020 national decree obliges drug stores to receive expired medicines (Brasil, 2020). Only 18.1% of the participants in this research said they adopted the habit of discarding at collection points. This result indicated the need for new environmental habits, in addition to the importance of disseminating current legislation, and the implementation of reverse logistics programs that are still incipient. Therefore, dissemination through awareness campaigns and environmental education is necessary for the population to consolidate this practice. The relevance of these actions is exemplified by Persson et al. (2009) who demonstrated the influence of publicity and awareness campaigns on changes in the Swedish population's disposing habit of their medicines in drug stores. Therefore, the behavioral differences between developing and developed countries must be considered within the strategies used.

Another factor that also needs to be highlighted, is that the Brazilian northeastern region had the second largest contribution of participants in this study. This is a very relevant factor, given that previous studies did not contemplate significantly this region (Quadra et al., 2019). Thus, it is possible to realize the relevance of the extension of the Brazilian territory for the understanding of this theme.

Disposal of veterinary medicines

The veterinary pharmaceutical industry generated 7.5 billion reais in net revenues in Brazil in 2020 (SINDAN, 2020), with an expansion in medicines sales for this sector (Barros and Cavalcanti, 2021). Brazilian agribusiness has high activity in animal production and, consequently, veterinary drugs are largely used in disease control and prevention (Regitano and Leal, 2010). In addition to animal production, it is important to highlight the impact associated with the use of medicines for domestic animals, which, in 2018, represented a population of 139.3 million individuals (Instituto Pet Brasil, 2018). Considering large animals that need higher doses of medication as well as the increasing population of pets, it is necessary to verify how society understands this problem and possible environmental consequences, since medicines products for use in animals go into the environment with no treatment (Quadra et al., 2017).

Therefore, the population needs to understand the consequences of veterinary medicines on the environment. Vatovec et al. (2021) conducted a study with 421 residents of the state of Vermont, in the United States of America, where they demonstrated that 54% of participants had already researched about ways to dispose of medicines. In the present study, the results were not different from those previously reported for disposal of human medicine. Participants who had pets or who worked with animal sales and breeding mentioned no concern about the correct way of pharmaceuticals disposal. Additionally, Vatovec et al. (2021) also revealed that 53% of respondents never received information from veterinarians about the correct way to dispose of medicines.

It should be noted that in Brazil, some initiatives for veterinary medicine disposal were created, although, such projects were not approved or are still in validation. Therefore, there is no specific legislation for the disposal of these drugs. Issues related to veterinary drugs are included in CONAMA Resolution 358/2005 (Brasil, 2005), RDC nº 222/2018 (Brasil, 2018), and RDC nº 306/2004 (Brasil, 2004). In addition to these regulations, there is the National Solid Waste Policy (NSWP) – 2010, which provides for reverse logistics and hazardous waste (Brasil, 2010). However, the NSWP does not specifically describe the disposal of expired or out-of-use veterinary medicines (Oliveira et al., 2020). Consequently, the lack of correct disposal knowledge for people who have pets or animals for commercial purposes, associated with the absence of specific public policies, emphasizes the need to spread this problem from an environmental point of view.

Pharmaceuticals in the environment

Expired or out-of-use medicines can reach the environment through different sources, such as common waste, as already mentioned. In addition, other ways for these substances to enter the environment is through the disposal of pharmaceutical products in sinks or toilets. The results obtained in this study showed that 5.2% of the participants had the habit of medicine disposing in these places. In Brazil, sewage treatment systems are conventional and not effective for the removal of these substances (Lumaret et al., 2012), which favor the entry of pharmaceuticals into different environmental matrices, causing negative effects on the biota (Quadra et al., 2017).

The participants in this study verified a relationship between the presence of drugs in the environment and the disposal of these products. Similarly, Ariffin and Zakili (2019) demonstrated in a survey of 103 families in Selangor, one of the Malaysian states, that 85.5% of respondents perceived that incorrect disposal of pharmaceuticals was a threat to water bodies.

The increase in medicine consumption impacts the environment. This was intensified during the COVID-19 pandemic, as already mentioned in the present study. Studies indicated the presence of these pharmaceuticals associated with the pandemic context in a more accentuated way in different environmental matrices. An example was demonstrated by Morales-Paredes et al. (2022), who in their review described that the medicines azithromycin, chloroquine, and hydroxychloroquine presented an increase in aquatic environments.

Another relevant aspect evidenced in the present study was that most part of the respondents (46.3%) did not consider the water they consumed to be of good quality. In Brazil, water potability standards include the monitoring of certain substances and organoleptic properties (Brasil, 2021) but do not cover pharmaceutical monitoring and limits. Studies have shown the occurrence of pharmaceuticals in drinking water (Reis et al., 2019), and these substances did not change their organoleptic characteristics. Therefore, the need to monitor pharmaceuticals in the public water supply is evident, especially considering the potential risks associated with chronic exposure to these pharmaceuticals.

The participants herein perceived the influence of pharmaceuticals on environmental quality. The terms most described in their answers were: water, soil, contamination, health, and disease (Figures 4A, 4B and 4C). The stated results agreed with those described in the literature, where drugs were detected in surface waters, groundwater, soil, and sediments (Aznar et al., 2014; aus deer Beek et al., 2016), changing the quality of these resources.

In addition, it is worth noting that pharmaceutical contamination can be related to antimicrobial resistance, which is currently considered a threat to public health (Silva et al., 2020). For instance, during the COVID-19 pandemic, microbial resistance may have increased with the overuse of antibiotics (Getahun et al., 2020).

Another issue associated with health is the consumption of animals present in the human diet since the literature reports the occurrence of pharmaceuticals in seafood, for example in oysters and fish (Mello et al., 2022). The detection of these compounds in biota can be harmful due to the bioaccumulation processes. Bioaccumulation is the assimilation or long-term exposure to substances (Ferreira and Mendes, 2021). Nakamura et al. (2008) demonstrated the bioaccumulation of fluoxetine in the fish *Oryzias latipes*.

The environmental concern about pharmaceutical waste described by the participants in this study emphasizes the need for EPV to act. Likewise, EPV considers ways to prevent the entry of drugs into the environment (Wang et al., 2021). The present study showed that it is essential to publicize the effect of pharmaceuticals on the environment for the whole society. Souza et al. (2021) highlighted the importance of creating advertising campaigns focused on health professionals, to propagate correct forms of medicines disposal and develop scientific divulgation materials.

In order to reduce the introduction of pharmaceuticals into the environment, the study carried out by Alshemari et al. (2020) pointed out the possibilities of using the circular economy within the pharmaceutical industry from management to disposal. Thus, the application of EPV and the circular economy are initiatives that can contribute to a more sustainable society.

Conclusion

The complexity of this topic needs a transdisciplinary approach through the interaction of concepts, as described by the EPV. This study of environmental habits showed a lack of understanding by the participants regarding the environmental impacts of inappropriate disposal of human and veterinary medicines. Even though this topic has environmental relevance, and consequently there are laws that establish reverse logistics for the disposal of medicines, its effectiveness and implementation are incipient, possibly due to the lack of disclosure of actions involving manufacturers to consumers of medicines. An alternative would be the insertion of forms of correct disposal of expired or out-of-use drugs in the package leaflet or in the package itself. Accordingly, this study revealed the need for socio-environmental awareness actions through the implementation of strategies that allow the democratization of knowledge about the consequences of pharmaceutical contamination. We encourage further research to verify the consumption of medicines and their disposal after the COVID-19 pandemic declaration of end, and environmental education actions in formal and non-formal methods.

Contribution of authors:

COSTA, R. S.: conceptualization; data curation; formal analysis; investigation; methodology; writing – original draft. MEDEIROS, A. N.: investigation; formal analysis; data curation; writing – original draft. AMARAL, V. S.: writing – review and editing. NAVONI, J. A.: conceptualization; project administration; original draft; writing – review and editing.

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