Int J Health Life Sci. 2020 January; 6(1):e97085. doi: 10.5812/ijhls.5709.

Published online 2019 November 11. **Research Article**

Household Medicines Disposal Practices in Maiduguri, North-Eastern Nigeria

Roland Nnaemeka Okoro [1,*] and Emmanuel Peter [1]

[1]Department of Clinical Pharmacy and Pharmacy Administration, University of Maiduguri, Maiduguri, Nigeria

[*]*Corresponding author*: Department of Clinical Pharmacy and Pharmacy Administration, University of Maiduguri, Maiduguri, Nigeria. Email: orolandn@gmail.com

Received 2019 August 10; **Revised** 2019 October 05; **Accepted** 2019 October 07.

Abstract

Background: Availability and prompt access to medications are crucial for effective healthcare delivery, but the quantity of pharmaceutical waste generated from unwanted/unused and expired medications is of great concern globally.
Objectives: The present study aimed to investigate the medicines disposal knowledge, attitudes and practice of the residents of Maiduguri metropolis, northeastern Nigeria.
Methods: This cross-sectional, population-based survey was done using a pre-validated questionnaire, during a one-month (November) period of 2018. Conveniently selected residents of the 22 units or wards of the metropolis completed the survey instrument. Statistical analysis was performed using Statistical Package for Social Science (SPSS) version 21. The relationship between variables and demographics of the study population was investigated using the chi-square test. $P < 0.05$ was considered statistically significant.
Results: About 35.0% of the participants kept unused/unwanted medicines at home for future use/until expiration, followed by giving them to friends and relatives (30.2%). More than one-half (59.7%) of the study population got rid of expired medicine through household garbage, while a few (1.3%) gave them to friends/relatives and buried in the ground. There were relationships between participants' gender, age, marital status, educational status and unused/unwanted medicine disposal practices. Similarly, there were relationships between participants' gender, age, marital status and expired medicines disposal practices. Most (80.0%) of the study population knew the harmful impact of inappropriate discarding of expired and unused/unwanted medicines to public well-being and the environment.
Conclusions: This study showed that the most common methods of disposal of unused/unwanted and expired medicine were keeping them for future use or until expiration, and throwing them in the household garbage respectively. The results have shown that a sizeable proportion of the participants were aware of the negative impact of improper disposal of medicines, although appropriate discarding behaviors were lacking, making it a priority for concerned authorities in our country to formulate and implement guidelines to protect public health and environment.

Keywords: Unused/Unwanted Medicines, Expired Medicines, Medicine Disposal, Nigeria

1. Background

There is increasing production and use of medicines worldwide (1). Although prompt access to these medicines is crucial, the quantity of pharmaceutical waste generated from unused/unwanted and expired medicines is of great concern globally (2, 3). Increasing demands for medicines could result to availability of surplus medicines in several homes. Thereafter, most of these medicines may not be needed anymore or may expire, and often end up as pharmaceutical waste.

Due to the shortage of funds for safe disposal of pharmaceutical waste, cost-effective management and methods are needed. Therefore, the WHO recommended the following guidelines for the safe disposal of expired drugs: return to donor or manufacturer wherever practically possible, landfill (open uncontrolled non-engineered dump and engineered landfill) after immobilization by encapsulation or inertization, waste immobilization (encapsulation and inertization), flushing liquid pharmaceuticals into sewers in small quantities over a period of time (4). Others are burning papers and cardboard packaging if they are not to be recycled in open containers, and medium temperature incineration, novel high-temperature incineration, and chemical decomposition in accordance with the manufacturer's recommendations, followed by landfill (4). Similarly, the Food and Drug Administration (FDA) recommended that unused, unwanted,

or expired medicines should be dropped off at a drug take-back site, location, or programme immediately. If peradventure one cannot get to a drug take-back location on time or none is near to such individual and the medicine is on the FDA list, such medicine is to be flushed down the toilet. If the medicine is not on the flush list, such medicine should be disposed in the household trash in accordance with the following steps: mix medicines without crushing tablets or capsules with an unappealing substance such as dirt, cat litter, or used coffee grounds; place the mixture in a container such as a sealed plastic bag; throw away container in the household trash; and delete all personal information on the empty medicine bottles or medicine packaging, then trash or recycle the empty bottle or packaging (5).

In Nigeria, no community consciousness has been created regarding the safe disposal of unused/unwanted and expired medicines. In support of this statement, previous studies done in metropolitan Lagos reported lack of fundamental information on proper discarding of unused medication and non-return of unused medicines to pharmacies for proper disposal in line with the global best practice (6, 7). Therefore, the current status of medicine disposal practices of Maiduguri residents has not been documented.

Inappropriate disposal of medicines constitutes a threat to the community health and the ecosystem (8, 9). For example, improper disposal of these medicines provides avenues for those whom the medicines are not meant to use them wrongly (10). Increased risk of inappropriate self-medication; diversions of medicines particularly narcotic drugs for illicit use, and accidental consumption of medications by children have been reported (11). Accidental ingestion of medicines meant for a different person has been identified as the most common source of drug toxicities in US homes (12). Additionally, the low metabolism of drugs in children can make drug toxicities detrimental (13).

Improper discarding of medicines elicits worries about contamination of surroundings. Disposal of unused/unwanted or expired medicines through unfriendly environmental routes such as flushing in the sink, water closet/latrine or throwing into rubbish bin (14) contribute largely to soil and water pollution with active pharmaceutical ingredients (15). This practice is associated with increased risk of antibacterial resistance. It has been reported that the availability of antibiotics in the water bodies give rise to the emergence of antibiotic resistance (16) which may thereafter result in gene abnormalities in man and aquatic life (17). When there is a concern of unused/unwanted and expired medicine presence at home or in an individual possession, support on appropriate disposal methods of such medicines should be provided (18).

Notwithstanding the negative impacts on human well-being and surroundings, medicine wastage has enormous cost implications (19-21). Therefore; there is an urgent need to address the problems associated with the improper disposal of unused/wanted and expired medications. Safe discarding of medications particularly by the individuals is given much attention worldwide. This is so because; the problem of improper medicine disposal is common to many countries (19, 22). It is evident that discarding of unused/unwanted and expired medicine is an issue of national and global importance. Sadly, programmes or structures for safe medication discarding behaviors are still limited in Africa. Reports from some African nations revealed unsafe medication disposal practices characterized by unregulated, illegal and indiscriminate disposal (23, 24).

Myriads of factors could impact on the medicine disposal practices of the people. Hence, this study tries to answer some questions: what are the current practices adopted by the study population to dispose of unused/unwanted and expired medicines? Are these practices differ by demographic characteristics? Most importantly, is there a need for a formalized national or local protocol for safe discarding of unused/unwanted and expired medicines in order to reduce their potential impact on the environment?

In order to evaluate current medicine disposal practices by the residents of Maiduguri in Nigeria, it is necessary to establish what the reported medicine disposal practices around the world are. Disposal of medicines in the garbage by individuals or households is the most common practice reported in Kuwait (15, 25), United Kingdom (26), and Lithuania (27), especially in the cities and suburban areas; however storage of unused medicine and returning them to pharmacies were predominant practices in Sweden (28). Burning of expired and unused medicines at home was also a common practice in Lithuania (27). In the US, the use of sink or toilet as the method of disposal or returning unwanted medicines to a healthcare provider or the pharmacy were the predominate practices (18). Despite the availability of vast international literature on studies of medicines disposal practices, there is a paucity of data in Nigeria especially in the northeastern part of the country.

2. Objectives

This survey aimed to investigate the medicines disposal knowledge, attitudes and practice of the residents of Maiduguri. The present survey has the capacity to reinforce the need for the policy-makers, health, and environ-

mental regulatory agencies to formulate a formal guideline for safe medicine disposal for the country.

3. Methods

This was a cross-sectional, descriptive survey done in Maiduguri metropolis. Maiduguri is the capital city of Borno state and it is located in the northeastern part of Nigeria. The metropolis is structured into 22 units or political wards of urban settlements. The survey included conveniently selected residents of these units aged 18 years or more.

The ethical approval was obtained from the Faculty of Pharmacy Research Review Board, University of Maiduguri, Nigeria. Data were collected over one-month period (November) of 2018 using structured pre-validated questionnaires (Appendix 1 in Supplementary File) adapted from a previous study (29). Prior to administration of the paper-based questionnaires, potential participants were informed about the objective of the survey and assured them the confidentiality of the collected data. Thereafter, the participants who gave their informed consent completed these paper-based questionnaires either by themselves or with the help of the researcher. On average, 15 minutes was spent to complete the questionnaire. Participation in the survey was voluntary and no incentives were offered to the participants.

Descriptive statistics (frequency and percentage) were used initially. The relationships between nominal variables and demographics of the study population were determined with the chi-square test. $P < 0.05$ was considered statistically significant. Statistical analyses were performed with Statistical Package for Social Science (SPSS) version 21 (SPSS Inc, version 21.0, Chicago, USA).

4. Results

A total of 1100 questionnaires were administered across the study areas, 1010 questionnaires were retrieved with a response rate of 91.8%. Overall, 625 (61.9%) were men and 385 (38.1%) were women. About (78.0%) of the respondents were aged less than 32 years, while 855 (84.7%) of the respondents had formal education. More than one-half of the study populations were single and about 35.0% were students (Table 1).

Table 1. Participants' Social-Demographic Characteristics (N = 1010)

Variable	No. (%)
Gender	
Male	625 (61.9)
Female	385 (38.1)
Age (years)	
< 32	787 (77.9)
≥ 32	223 (22.1)
Marital status	
Single	641 (63.5)
Married	369 (36.5)
Educational status	
None	155 (15.3)
Formal education	855 (84.7)
Employment	
Student	347 (34.4)
Self-employed	327 (32.4)
Working part-or full-time	178 (17.6)
Unemployed	116 (11.6)
Retired/pensioner	42 (4.2)

Table 2 shows that about 35.0% of the study population stored unused/unwanted medicines at home for future use/until expiration. There is a significant association between participants' gender and unused/unwanted medicine disposal practices ($P < 0.05$). While 10.3%, 4.2%, and 2.6% of males returned unused/unwanted medicine to medical store/pharmacy, burnt them at home, and flushed them into toilet/sink, only 3.3%, 2.0%, and 1.5% of females did so. There is also a significant association between participants' age and unused/unwanted medicine disposal practices ($P < 0.05$). Significant proportions of those aged less than 32 years (21.8%, and 3.6%) threw unused/unwanted medicines into household garbage and burnt them at home respectively compared with 13.0%, and 2.6% of those aged 32 years and above. There is also a significant association between participants' marital status and unused/unwanted medicine disposal practices ($P < 0.05$). While 22.3% and 3.6% of single individuals threw unused/unwanted medicines in the household garbage and burnt them at home respectively, only 15.5% and 2.9% of their married counterparts did so. Similarly, a significant association exists between participants' educational status and unused/unwanted medicine disposal practices ($P < 0.05$). Significant proportions of individuals (37.9%, 21.0%, and 2.3%, respectively) that had formal education kept unused/unwanted medicines at home for future use/until expiration, threw them in the household garbage, and flushed them into the toilet/sink compared with 16.5%, 13.4%, and 1.8% of those that had none.

Table 2 also shows that a significant proportion of the study population (59.7%) disposed of expired medicines via household garbage. There is also an association be-

Table 2. The Associations Between Participants' Demographic Characteristics and Unused/Unwanted/Expired Medicine Disposal Practices[a]

Variable	Total	Gender		Age (years)		Marital Status		Educational Status	
		Female	Male	< 32	≥ 32	Single	Married	None	Formal Education
Unused/Unwanted Medicine Disposal Practice (N = 1039)[b]									
Keep at home for future use/until expiration	359 (34.6)	152 (38.3)	207 (32.2)	278 (34.4)	81 (35.1)	221 (33.6)	138 (36.2)	27 (16.5)	332 (37.9)
Give to friends/relatives	314 (30.2)	121 (30.5)	193 (30.1)	241 (29.8)	73 (31.6)	201 (30.5)	113 (29.7)	91 (55.5)	223 (25.5)
Throw in garbage	206 (19.8)	86 (21.7)	120 (18.7)	176 (21.8)	30 (13.0)	147 (22.3)	59 (15.5)	22 (13.4)	184 (21.0)
Return to medical store/pharmacy	79 (7.6)	13 (3.3)	66 (10.3)	55 (6.8)	24 (10.4)	42 (6.4)	37 (9.7)	16 (9.8)	63 (7.2)
Burn at home	35 (3.4)	8 (2.0)	27 (4.2)	29 (3.6)	6 (2.6)	24 (3.6)	11 (2.9)	5 (3.0)	30 (3.4)
Flush into toilet/sink	23 (2.2)	6 (1.5)	17 (2.6)	16 (2.0)	7 (3.0)	11 (1.7)	12 (3.1)	3 (1.8)	20 (2.3)
Donate to hospital	23 (2.2)	11 (2.8)	12 (1.9)	13 (1.6)	10 (4.3)	12 (1.8)	11 (2.9)	-	23 (2.6)
		$\chi^2 = 25.36$, P < 0.001		$\chi^2 = 17.68$, P = 0.007		$\chi^2 = 13.81$, P = 0.032		$\chi^2 = 69.30$, P < 0.001	
Expired Medicine Disposal Practice (N = 1018)[b]									
Throw in garbage	608 (59.7)	244 (63.0)	364 (57.7)	492 (61.9)	116 (52.0)	407 (63.1)	201 (53.9)	96 (61.1)	512 (59.7)
Burn at home	169 (16.6)	50 (12.9)	119 (18.9)	118 (14.8)	51 (22.9)	96 (14.9)	73 (19.6)	31 (19.7)	138 (16.0)
Flush into toilet/sink	148 (14.5)	59 (15.2)	89 (14.1)	119 (15.0)	29 (13.0)	87 (13.5)	61 (16.4)	18 (11.5)	130 (15.1)
Return to medical store/pharmacy	48 (4.7)	11 (2.8)	37 (5.9)	36 (4.5)	12 (5.4)	36 (5.6)	12 (3.2)	4 (2.5)	44 (5.1)
Don't know	19 (1.9)	8 (2.1)	11 (1.7)	11 (1.4)	8 (3.6)	11 (1.7)	8 (2.1)	4 (2.5)	15 (1.7)
Bury underground	13 (1.3)	6 (1.6)	7 (1.1)	10 (1.3)	3 (1.3)	4 (0.6)	9 (2.4)	1 (0.6)	12 (1.4)
Give to friends/relatives	13 (1.3)	9 (2.3)	4 (0.6)	9 (1.1)	4 (1.8)	4 (0.6)	9 (2.4)	3 (1.9)	10 (1.2)
		$\chi^2 = 16.99$, P = 0.009		$\chi^2 = 15.47$, P = 0.017		$\chi^2 = 22.76$, P = 0.001		$\chi^2 = 5.87$, P = 0.439	

[a] Values are expressed as No. (%).
[b] Multiple choices allowed.

tween participants' gender and expired medicine disposal practices (P < 0.05). While 18.9% and 5.9% of males burnt expired medicines at home and returned them to medical store/pharmacy respectively, only 12.9% and 2.8% of females did so. Similarly, there is an association between participants' age and expired medicine disposal practices (P < 0.05). Significant proportions of those aged less than 32 years (61.9% and 15.0%, respectively) disposed expired medicines via household garbage and flushed them into toilet/sink compared with 52.0% and 13.0% of those aged 32 years or more. Lastly, there is also a significant association between participants' marital status and expired medicine disposal practices (P < 0.05). While 63.1% and 5.6%, respectively of single individuals disposed expired medicines via household garbage, and returned them to medical store/pharmacy, 53.9% and 3.2% of those that are married did so. In contrast, 2.4% each of married individuals buried expired medicines in the ground at home, and gave them to others compared with 0.6% each of single individuals that did so (Table 2).

Table 3 shows that 4 out of 10 (47.0%) of the participants said that is the duty of government to create awareness for appropriate disposal of unused/unwanted/expired medicines. On the other hand, more than a three-quarter of the study population (80.0%) knew that the surroundings and public well-being can be impacted by improper discarding of medicines (Table 3).

5. Discussion

In our study, most participants reported that they kept unused/unwanted medicines in the house for future use/until expiration. This result aligns with that obtained from previous studies conducted in Sweden, Afghanistan,

Table 3. Respondents' Knowledge About the Disposal of Unused/Unwanted/Expired Medicines (N = 1010)

Variable	No. (%)
Improper disposal of unused/unwanted/expired medicine can affect the environment and well-being	
Yes	808 (80.0)
Don't know	163 (16.1)
No	39 (3.9)
Who is responsible to create awareness for proper disposal of unused/unwanted/expired medicines?	
Government	475 (47.0)
Pharmacist	338 (33.5)
Pharmaceutical industries	168 (16.6)
Public	29 (2.9)

Pakistan, and Oman (28-31). The plausible reason for this practice in Nigeria is a cost-saving measure adopted by community members since medicines are purchased out-of-pocket by the majority of the population due to low coverage of health insurance. Similarly, a study done in Ireland found that 37% of the participants had viable unused/unwanted medicines in their households, whereas 23% of them had invalid medicines (32). In Portugal, 72% of medications kept in the house were found to be unwanted (33). Of this proportion, 8% had reached an expiration date (33). Maintaining of unused/unwanted medicines at home could be attributed to the inability of some individual to consider these medicines posing any risk at all or the absence of a suitable disposal method. This has public well-being, ecosystem, and economic implications for the citizens and the healthcare delivery system at large (34). In contrast, earlier studies conducted in Nigeria (6, 35) and other countries (22, 26, 27, 36-47) had identified discarding in the household garbage as the most common means of disposal of unused/unwanted medicines. Moreover, an online-based survey conducted in Turkey reported that 34.0% of the respondents returned unused medicines to the health facility (48). A study conducted in New Zealand revealed flushing in the toilet or sink as the commonest method of disposal of unused medicines (14), which was one the least methods of disposal of unused medicines reported by our study. This may not be unconnected to the low availability of water closet at homes in the study setting.

Our study population differed in the medicine's disposal practices according to demographic characteristics. There was a significant relationship between gender and unused/unwanted medicines disposal methods consistent with results of studies done in Saudi Arabia (38, 46). However, Al-Shareef et al. (38) reported that males exhibited a lower drive to find the proper ways of discarding medicines and willingness to return them to collection facilities. Shaaban et al. (46) found that females had a higher likelihood than males to give other people unwanted medicines, whereas our study showed that returning unused/unwanted medicines to medical store/pharmacy, burning them at home, and flushing them in the toilet/sink were significantly exhibited more by males than females. It is worthy to note that 7.6% of our study population claimed that they returned unused/unwanted medicines to a medical store or pharmacy. This figure may be due to dishonesty of a few respondents because to the knowledge of the authors of this present study, medical stores or pharmacies in Nigeria do not accept unused/unwanted medicines back from the public. Therefore, a formal and mandatory protocol for medicine discarding is a necessity for our country. Comparable to our result, another study done in the US also reported a relationship between gender and disposal methods of unused/unwanted medicines (49). In this study, a high proportion of women disposed of unused/unwanted medicines via toilet or sink (49). A more recent Polish study (Survey II) also reported a relationship between gender and disposal methods of unused medicines (39). This study showed that more men than women forgot what happened to their unused medicines. On the contrary, Turkish and Irish studies reported no gender-based significant difference in the disposal methods of unused/unwanted medicines (48, 50).

Our study also revealed a significant relationship between age and disposal methods of unused/unwanted medicines congruent with other published studies (39, 48, 49). Danziger et al. (49) reported participants' lower likelihood to throw these medicines into the household trash with increasing age. Akici et al. (48) found that a significant proportion of the respondents aged below 30 years returned unused/unwanted medicines to the health facility in Turkey. Rogowska et al. (39) in their survey II found that respondents that aged up to 39 years were more likely than older individuals to discard unused medicines with solid waste and flush them into the water closet, whereas our study found that a significantly higher proportion of participants under 32 years of age had a higher likelihood than older ones to dispose unused/unwanted medicines via household trash and by burning them at home.

The analysis of our data for any association between the marital status of the study population unused/unwanted medicine disposal methods also showed a significant association. Interestingly, no marital status-based relationship has been reported earlier, therefore, our finding adds to the knowledge.

In addition, our study found a significant relationship

between the educational status of the participants and unused/unwanted medicine disposal methods comparable with the finding of a similar study done in Saudi Arabia (46). This study found that participants with higher education were more likely to bring back unused/unwanted medicine to a pharmacy than those with lower educational levels, while our study showed that participants with formal education had higher likelihood to keep them at home for future use or until expiration, discard them in the household garbage and flush them into the toilet or sink. Contrasted with these findings, a Polish study did not find any relationship between educational levels and unused/unwanted medicine disposal methods (39). Variations in the study settings and people specific characteristics could account for these differences.

With respect to expired medicines disposal methods, throwing away these medicines in the household garbage was the most common method revealed by our study in agreement with the results of other studies done elsewhere (2, 22, 29, 30, 37, 39, 40, 45). This may be due to ease since the appropriate disposal site near their homes may be lacking. Sadly, discarding medicines in the garbage provides an opportunity for another person to use them and get harmed (10). However, if no other alternatives exist, an acceptable way is to mix the medicine with unappealing substances before throwing it into the household garbage (10). Among all means of disposing of drug waste, the most environmentally friendly way is incineration (51, 52) at high temperature, although this is possible only if medicines are brought back to pharmacy stores. However, the American Pharmacists Association guidance on appropriate medicine disposal recommends crushing or dissolving medications in water prior to mixing with the undesirable substance (53).

The evaluation of our data for significant relationships between demographic characteristics of the study population and expired medicines disposal methods revealed a gender-based relationship in agreement with the findings of earlier studies done elsewhere (39, 49). Rogowska et al. (39) in their survey II showed that males were more likely to forget what happened to their expired medicines than their female counterparts (39). Additionally, Danziger et al. (49) reported that a high proportion of women disposed of expired medicines via toilet or sink, whereas our study revealed that men were more likely to burn their expired medicines at home and return them to a medical store/pharmacy than women.

Similarly, our study showed a significant relationship between age and expired medicines disposal methods congruent with the results of some previous studies (39, 49). Danziger et al. (49) again reported participants' higher likelihood to throw expired medicines into the household trash with decreasing age (46). Rogowska et al. (39) also in their survey II found that participants aged more than 60 years were more likely to return their expired medicines to the pharmacy than younger persons (39), while our study found that participants under 32 years of age were more likely to discard expired medicine in the household garbage and flush them into the toilet/sink respectively than those aged 32 years or more.

Furthermore, our study showed a significant relationship between marital status and expired medicines disposal methods. However, no marital status-based relationship with respect to expired medicines disposal methods have been previously reported, therefore, our finding also adds to the knowledge.

More than a three-quarter of the study population knew the detrimental impacts of inappropriate disposal of medicine on the surroundings and human well-being. In spite of this high proportion, the majority got rid of expired and unused/unwanted medicines in a manner that is deleterious to the public well-being and the surroundings. To lend credence to our finding, previous studies carried out in other countries revealed a similar trend (11, 29, 30, 34, 40, 54). The consciousness of the surroundings may not always translate to proper medicine disposal method; therefore, the existence of operational household medicine disposal guidelines is of the essence in Nigeria. The environment could be adversely affected by active pharmaceutical agents, indicating that improper methods of discarding medicines to a large extent contribute to ecosystem problems (54, 55). Contrasted with these findings, a study conducted in Ghana in 2012 found that only a few of the participants knew that medicines adversely affect the surroundings (41).

Our study was not without limitations. The first limitation is the self-reported nature of the study, thus some respondents may not have told the truth and no validations were performed to confirm these subjective self-report. Secondly, the study was limited to the Maiduguri metropolis; therefore, the findings cannot be generalized to other parts of the country.

5.1. Conclusions

This study showed that the most common methods of disposal of unused/unwanted and expired medicine were keeping for future use or until expiration, and throwing them in the household garbage respectively. Such practices pose possible risks for the population and need to be urgently addressed. However, gender, age, marital and educational status were significantly associated with unused/unwanted medicine disposal practices, while only gender, age and marital status demonstrated significant

associations with the expired medicines disposal practices.

Finally, while many participants were aware of the consequences of inappropriate discarding of unused/unwanted and expired medicines on public well-being and natural surroundings, awareness did not necessarily equate with their disposal practices. Therefore, there is an urgent need for policy-makers to come up with a formal mandatory protocol for disposal of unused/unwanted and expired medicines for the country.

Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

Footnotes

Authors' Contribution: Study concept and design: Roland Nnaemeka Okoro. Acquisition of data: Emmanuel Peter. Analysis and interpretation of data: Roland Nnaemeka Okoro. Drafting of the manuscript: Roland Nnaemeka Okoro. Critical revision of the manuscript for important intellectual content: Roland Nnaemeka Okoro. Statistical analysis: Roland Nnaemeka Okoro. Administrative, technical, and material support: Emmanuel Peter. Study supervision: Roland Nnaemeka Okoro.

Conflict of Interests: The authors declared no conflict of interest.

Ethical Approval: The ethical approval was obtained from the Faculty of Pharmacy Research Review Board, University of Maiduguri, Nigeria.

Funding/Support: This study was self-funded by the authors.

References

1. Levinson W, Kallewaard M, Bhatia RS, Wolfson D, Shortt S, Kerr EA, et al. 'Choosing Wisely': A growing international campaign. *BMJ Qual Saf*. 2015;**24**(2):167–74. doi: 10.1136/bmjqs-2014-003821. [PubMed: 25552584].
2. Paut Kusturica M, Tomas A, Tomic Z, Bukumiric D, Corac A, Horvat O, et al. Analysis of expired medications in Serbian households. *Zdr Varst*. 2016;**55**(3):195–201. doi: 10.1515/sjph-2016-0025. [PubMed: 27703539]. [PubMed Central: PMC5031069].
3. West LM, Diack L, Cordina M, Stewart D. A systematic review of the literature on 'medication wastage': An exploration of causative factors and effect of interventions. *Int J Clin Pharm*. 2014;**36**(5):873–81. doi: 10.1007/s11096-014-9981-2. [PubMed: 25037952].
4. WHO EMRO. *Guidelines for the safe disposal of expired drugs*. 2006, [cited 25 September 2019]. Available from: www.emro.who.int/images/stories/pakistan/documents/pak_documents.
5. FDA. *Disposal of unused medicines: What you should know*. 2019, [cited 25 September 2019]. Available from: https://www.fda.gov.
6. Auta A, Omale S, Shalkur D, Abiodun AH. Unused medicines in Nigerian households: Types and disposal practices. *J Pharmacol Pharmacother*. 2011;**2**(3):195–6. doi: 10.4103/0976-500X.83290. [PubMed: 21897719]. [PubMed Central: PMC3157135].
7. Longe EO, Williams A. A preliminary study of medical waste management in Lagos Metropolis, Nigeria. *Iran J Environ Health Sci Eng*. 2006;**3**(2):133–9.
8. Daughton CG, Ruhoy IS. The afterlife of drugs and the role of pharmEcovigilance. *Drug Saf*. 2008;**31**(12):1069–82. doi: 10.2165/0002018-200831120-00004. [PubMed: 19026025].
9. Paut Kusturica M, Tomas A, Sabo A. Disposal of unused drugs: Knowledge and behavior among people around the world. *Rev Environ Contam Toxicol*. 2017;**240**:71–104. doi: 10.1007/398_2016_3. [PubMed: 27115675].
10. Skinner G. *Easy steps for getting rid of unused medication*. 2018, [cited 30 December 2018]. Available from: http://www.consumerreports.org/drugs/getting-rid-ofexpired-medication/.
11. Abahussain EA, Ball DE. Disposal of unwanted medicines from households in Kuwait. *Pharm World Sci*. 2007;**29**(4):368–73. doi: 10.1007/s11096-006-9082-y. [PubMed: 17273906].
12. Bronstein AC, Spyker DA, Cantilena LJ, Green JL, Rumack BH, Heard SE, et al. 2007 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 25th annual report. *Clin Toxicol (Phila)*. 2008;**46**(10):927–1057. doi: 10.1080/15563650802559632. [PubMed: 19065310].
13. Research Center for Drug Evaluation. *Safe disposal of medicines - medicine disposal: Questions and answers*. 2018, [cited 30 December 2018]. Available from: https://www.fda.gov/Drugs/ResourcesForYou/Consumers/BuyingUsingMedicineSafely/EnsuringSafeUseofMedicine/SafeDisposalofMedicines/ucm186188.htm.
14. Braund R, Peake BM, Shieffelbien L. Disposal practices for unused medications in New Zealand. *Environ Int*. 2009;**35**(6):952–5. doi: 10.1016/j.envint.2009.04.003. [PubMed: 19423167].
15. Glassmeyer ST, Hinchey EK, Boehme SE, Daughton CG, Ruhoy IS, Conerly O, et al. Disposal practices for unwanted residential medications in the United States. *Environ Int*. 2009;**35**(3):566–72. doi: 10.1016/j.envint.2008.10.007. [PubMed: 19081631].
16. Costanzo SD, Murby J, Bates J. Ecosystem response to antibiotics entering the aquatic environment. *Mar Pollut Bull*. 2005;**51**(1-4):218–23. doi: 10.1016/j.marpolbul.2004.10.038. [PubMed: 15757723].
17. Wu M, Janssen S. Dosed without prescription: A framework for preventing pharmaceutical contamination of our nation's drinking water. *Environ Sci Technol*. 2011;**45**(2):366–7. doi: 10.1021/es104032a. [PubMed: 21175201].
18. Seehusen DA, Edwards J. Patient practices and beliefs concerning disposal of medications. *J Am Board Fam Med*. 2006;**19**(6):542–7. doi: 10.3122/jabfm.19.6.542. [PubMed: 17090787].
19. Zargarzadeh AH, Tavakoli N, Hassanzadeh A. A survey on the extent of medication storage and wastage in urban Iranian households. *Clin Ther*. 2005;**27**(6):970–8. doi: 10.1016/s0149-2918(05)00122-0. [PubMed: 16117997].
20. Abou-Auda HS. An economic assessment of the extent of medication use and wastage among families in Saudi Arabia and Arabian Gulf countries. *Clin Ther*. 2003;**25**(4):1276–92. doi: 10.1016/s0149-2918(03)80083-8. [PubMed: 12809973].
21. Morgan TM. The economic impact of wasted prescription medication in an outpatient population of older adults. *J Fam Pract*. 2001;**50**(9):779–81. [PubMed: 11674911].
22. Tong AY, Peake BM, Braund R. Disposal practices for unused medications around the world. *Environ Int*. 2011;**37**(1):292–8. doi: 10.1016/j.envint.2010.10.002. [PubMed: 20970194].
23. Manyele SV, Tanzania V. Effects of improper hospital-waste management on occupational health and safety. *Afr Newsletter Occup Health Safe*. 2004;**14**(2):30–3.

24. Manyele SV, Anicetus H, Bilia MH. Globalization and its effects on medical waste management in Tanzania. *IET Annual Conference and General Meeting, AICC*. Arusha. 2003.
25. Abahussain EA, Ball DE, Matowe WC. Practice and opinion towards disposal of unused medication in Kuwait. *Med Princ Pract*. 2006;**15**(5):352–7. doi: 10.1159/000094268. [PubMed: 16888392].
26. Bound JP, Voulvoulis N. Household disposal of pharmaceuticals as a pathway for aquatic contamination in the United Kingdom. *Environ Health Perspect*. 2005;**113**(12):1705–11. doi: 10.1289/ehp.8315. [PubMed: 16330351]. [PubMed Central: PMC1314909].
27. Kruopienė J, Dvarionienė J. Pharmaceutical pathways to the environment in Lithuania. *Environ Res Eng Manage*. 2007;**41**(3).
28. Persson M, Sabelstrom E, Gunnarsson B. Handling of unused prescription drugs–knowledge, behaviour and attitude among Swedish people. *Environ Int*. 2009;**35**(5):771–4. doi: 10.1016/j.envint.2008.10.002. [PubMed: 19013646].
29. Bashaar M, Thawani V, Hassali MA, Saleem F. Erratum to: Disposal practices of unused and expired pharmaceuticals among general public in Kabul. *BMC Public Health*. 2017;**17**(1):231. doi: 10.1186/s12889-017-4139-5. [PubMed: 28264706]. [PubMed Central: PMC5338081].
30. Ahmed A, Mushtaq N, Tariq M, Durrani M, Akhtar S, Arif M, et al. Disposal practices of unused and expired pharmaceuticals in Karachi and their impact on health and environment. *JUMDC*. 2013;**2007**(4):2.
31. Abdo-Rabbo A, Al-Ansari M, Gunn BC, Suleiman BJ. The use of medicines in Oman: Public knowledge, attitudes and practices. *Sultan Qaboos Univ Med J*. 2009;**9**(2):124–31. [PubMed: 21509288]. [PubMed Central: PMC3074770].
32. Wieczorkiewicz SM, Kassamali Z, Danziger LH. Behind closed doors: Medication storage and disposal in the home. *Ann Pharmacother*. 2013;**47**(4):482–9. doi: 10.1345/aph.1R706. [PubMed: 23535813].
33. Dias-Ferreira C, Valente S, Vaz J. Practices of pharmaceutical waste generation and discarding in households across Portugal. *Waste Manag Res*. 2016;**34**(10):1006–13. doi: 10.1177/0734242X16639388. [PubMed: 27026517].
34. Kusturica MP, Sabo A, Tomic Z, Horvat O, Solak Z. Storage and disposal of unused medications: Knowledge, behavior, and attitudes among Serbian people. *Int J Clin Pharm*. 2012;**34**(4):604–10. doi: 10.1007/s11096-012-9652-0. [PubMed: 22644600].
35. Auta A, Banwat S, Sariem C, Shalkur D, Nasara B, Atuluku M. Medicines in pharmacy students' residence and self-medication practices. *J Young Pharm*. 2012;**4**(2):119–23. doi: 10.4103/0975-1483.96627. [PubMed: 22754265]. [PubMed Central: PMC3385216].
36. Law AV, Sakharkar P, Zargarzadeh A, Tai BW, Hess K, Hata M, et al. Taking stock of medication wastage: Unused medications in US households. *Res Social Adm Pharm*. 2015;**11**(4):571–8. doi: 10.1016/j.sapharm.2014.10.003. [PubMed: 25487420].
37. Osei-Djarbeng SN, Larbi GO, Abdul-Rahman R, Osei-Asante S, Owusu-Antwi R. Household acquisition of medicines and disposal of expired and unused medicines at two suburbs (Bohyen and Kaase) in Kumasi-Ghana. *Pharm Innov*. 2015;**4**(8, Part B):85.
38. Al-Shareef F, El-Asrar SA, Al-Bakr L, Al-Amro M, Alqahtani F, Aleanizy F, et al. Investigating the disposal of expired and unused medication in Riyadh, Saudi Arabia: A cross-sectional study. *Int J Clin Pharm*. 2016;**38**(4):822–8. doi: 10.1007/s11096-016-0287-4. [PubMed: 27001407].
39. Rogowska J, Zimmermann A, Muszynska A, Ratajczyk W, Wolska L. Pharmaceutical household waste practices: Preliminary findings from a case study in Poland. *Environ Manage*. 2019;**64**(1):97–106. doi: 10.1007/s00267-019-01174-7. [PubMed: 31076828]. [PubMed Central: PMC6598946].
40. Ayele Y, Mamu M. Assessment of knowledge, attitude and practice towards disposal of unused and expired pharmaceuticals among community in Harar city, Eastern Ethiopia. *J Pharm Policy Pract*. 2018;**11**:27. doi: 10.1186/s40545-018-0155-9. [PubMed: 30459955]. [PubMed Central: PMC6236888].
41. Sasu S, Kummerer K, Kranert M. Assessment of pharmaceutical waste management at selected hospitals and homes in Ghana. *Waste Manag Res*. 2012;**30**(6):625–30. doi: 10.1177/0734242X11423286. [PubMed: 22081380].
42. Abahussain E, Waheedi M, Koshy S. Practice, awareness and opinion of pharmacists toward disposal of unwanted medications in Kuwait. *Saudi Pharm J*. 2012;**20**(3):195–201. doi: 10.1016/j.jsps.2012.04.001. [PubMed: 23960793]. [PubMed Central: PMC3744962].
43. Al Ruwaili N, Al Balushi A, Alharf A, AlShaharani H, Eldali A. Do parents in Saudi Arabia store medications safely? *Int J Pediatrics Adolesct Med*. 2014;**1**(1):21–5. doi: 10.1016/j.ijpam.2014.09.003.
44. Udofia EA, Gulis G, Fobil J. Solid medical waste: A cross sectional study of household disposal practices and reported harm in Southern Ghana. *BMC Public Health*. 2017;**17**(1):464. doi: 10.1186/s12889-017-4366-9. [PubMed: 28521776]. [PubMed Central: PMC5437398].
45. Zorpas AA, Dimitriou M, Voukkali I. Disposal of household pharmaceuticals in insular communities: Social attitude, behaviour evaluation and prevention activities. *Environ Sci Pollut Res Int*. 2018;**25**(27):26725–35. doi: 10.1007/s11356-017-9551-y. [PubMed: 28647879].
46. Shaaban H, Alghamdi H, Alhamed N, Alziadi A, Mostafa A. Environmental contamination by pharmaceutical waste: Assessing patterns of disposing unwanted medications and investigating the factors influencing personal disposal choices. *J Pharmacol Pharm Res*. 2018;**1**(1):3.
47. Chung SS, Brooks BW. Identifying household pharmaceutical waste characteristics and population behaviors in one of the most densely populated global cities. *Resour Conserv Recycl*. 2019;**140**:267–77. doi: 10.1016/j.resconrec.2018.09.024.
48. Akici A, Aydin V, Kiroglu A. Assessment of the association between drug disposal practices and drug use and storage behaviors. *Saudi Pharm J*. 2018;**26**(1):7–13. doi: 10.1016/j.jsps.2017.11.006. [PubMed: 29379327]. [PubMed Central: PMC5783817].
49. Danziger L, Owens L, Anand S. *Medication disposal survey: Final report. SRL study 1060*. University of Illinois at Chicago Survey Research Laboratory, College of Urban Planning and Public Affairs; 2009. 16 p.
50. Vellinga A, Cormican S, Driscoll J, Furey M, O'Sullivan M, Cormican M. Public practice regarding disposal of unused medicines in Ireland. *Sci Total Environ*. 2014;**478**:98–102. doi: 10.1016/j.scitotenv.2014.01.085. [PubMed: 24530589].
51. Boehringer SK. *What's the best way to dispose of medications? Pharmacist's letter/Prescriber's letter*. Stockton: Environmental Protection Authority; 2004.
52. Smith CA. Managing pharmaceutical waste-what pharmacists should know? *J Pharm Soc*. 2002:17–22.
53. American Pharmacists Association. *APhA provides guidance on proper medication disposal: Use with respect and discard with care*. 2007, [cited 30 December 2018]. Available from: http://www.aphanet.org/AM/Template.cfm?Section=News_Releases1&CONTENTID=7481&TEMPLATE=/CM/ContentDisplay.cfm.
54. Arkaravichien W, Ruchipiyarak T, Thawinwan W, Benjawilaikul S. Genotoxicity assessment of mercuric chloride in the marine fish therapon jaruba: A threat to the environment from practice of drug disposal in Thailand. *Environ Asia*. 2014;**7**(1):13–8.
55. Daughton CG. Cradle-to-cradle stewardship of drugs for minimizing their environmental disposition while promoting human health. II. Drug disposal, waste reduction, and future directions. *Environ Health Perspect*. 2003;**111**(5):775–85. doi: 10.1289/ehp.5948. [PubMed: 12727607]. [PubMed Central: PMC1241488].