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Disposals of Pharmaceutical Wastes in Homecare: Compliance and Risk Assessments to Environment

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Abstract
Non proper disposal of unused and expired drugs in homecare areas poses a great threat to the environment and health of the society. This research appraises the homecare pharmaceutical waste management practices in a sample size of 320 patients and caregivers in Switzerland and Sri Lanka with a view of auditing the adherence to the country pharmaceutical waste requirements. The research applied standard interviews, residential visit, and discard pharmaceutical samples analysis to determine the type, number, and the risks of environmental hazards. The results indicated that households only followed recommended modes of disposal by 38 per cent. The most widespread offenses were disposal of medicines into the toilet, the use of general waste, and reuse of the expired medications. The most prevalent misuse of antibiotics, NSAIDs, and hormonal agents was to dispose of them inappropriately causing serious pollution of the environment. Moreover 64% of the caregivers were not aware of take-back programs or regulatory guidelines of drugs. This paper reiterates the importance of pharmacist-based educational actions, compulsory take-back mechanisms on high-risk drugs, and better enforcement of regulations that may create a sustaining cycle of the management of pharmaceutical waste within homecare.

Keywords: ***Pharmaceutical waste disposal, homecare pharmacy, environmental hazard, regulatory compliance, drug take back programs, public health.***

1. Introduction

1.1 The growth of homecare pharmacy has contributed to the growth of usage of medication outside of the supervised healthcare facility.

Due to the increasing use of homecare pharmacy services, the management and administration of medications in patients homes, especially individuals with chronic conditions, patients on palliative care and the elderly have changed. Homecare pharmacy services enable patients to enjoy the comfort of their living surroundings by visiting them and giving them their medicine and this will reduce the number of visits in hospitals and help the patient manage their illnesses in the future. This has played an important role in increasing the number of the drugs that these agencies use since they operate at home.

This change has not only enhanced access and patient decision autonomy but has added complications, especially to the changes in unused or expired drugs. Pharmaceutical waste in the professional healthcare setting is closely monitored and the process of its disposal is strictly adhered to avoid any environmental impairment or health hazard to the population. But these are found wanting at the household level though the store and administer medications through caregivers and the patients, there is no control and direction as to how to dispose of the medicines properly. There is a growing concern towards the effective and safe disposal of pharmaceutical wastes to reduce the unintentional injury related to their mishandling as more patients are nursed at home.

1.2 Pharmaceuticals are Improperly Disposed thus Causing Environmental Pollution and a Hazard to Human Health

Poor practices of disposing of unwanted or outdated drugs have dire consequences to the environment and health of the people. Disposal of medicines by many people is still in the form of general waste, flushing down the toilet, or the drain, which not only pollutes the water systems but also ecosystems. Medications flushed and disposed of in landfills have the potential to enter the water systems, where they may take a long time to get decomposed. These drugs can even result to impacts on aquatic organisms since they are not filtered in the traditional methods of draining water. Some medications, such as antibiotics, hormonal medication, and non-steroidal anti-inflammatory medication, may flush into the environment and cause some problems, including the emergence of

antimicrobial resistance, the negative consequences on the reproduction of wildlife, and general ecosystem imbalances.(1)

What is more, unsafely disposed of medication presents direct threats to the health of the population. When improperly discarded, medications may sometimes fall into the wrong hands of people who are not aware of the dangers, they may even be found by children, pets or even the people participating in substance misuse. The other harmful effect of the mismanaged disposal is the repurposing of expired medications to unauthorised purposes. The misuse or adverse effects become a risk without proper guidelines and provision of information to the general populace especially in the settings where there are few controls on the use of drugs.

1.3 There are regulatory structures, which are not well followed at home level

Though having a set of laws of proper disposing of pharmaceutical waste, especially in required treatment facilities, the actual system of arrangement and regulation of this process on household levels, which is already poor, leaves much to be desired. Guidelines on the management of pharmaceutical waste have also been spelt out by national and international regulatory agencies and these guidelines prescribe measures to be taken in returning unused medications to pharmacies, drug take-back mechanisms and incineration means that guarantee destruction of medications that are beyond redemption. Nonetheless, they are not usually observed in the house, mainly because as a result of a lack of knowledge, lack of enforcement and presence of adequate disposal facilities.

Also, citizens are usually not reach out to discuss the provisions in place on proper disposal of pharmaceuticals in most countries; including Switzerland and even Sri Lanka. The most common methods used by the caregivers and patients imply informal, inappropriate methods of getting rid of medications either due to the unawareness of adequate processes or due to the absence of the available procedures. Additionally, health professionals/pharmacists barely communicate, which can produce critical information on the possible outcomes of the mismanagement of disposal. Although the pharmaceutical industries and health professionals have a major role in the facilitation of proper disposal of drugs, they rarely take part in cases of homecare services, and the caregivers are left to take up the responsibility with no access to the needed materials and expertise.(2)

1.4 This Study is bound to determine the disposition, regulatory conformance and eco-risks attached to the pharmaceutical colloquium in homecare.

In this paper, the researcher will attempt to assess the status quo of pharmaceutical waste disposal between homecare patients and their care givers in both Switzerland and Sri Lanka, which are two States with contrasting practice of regulatory settings and healthcare systems. The ultimate objective would be to evaluate adherence to regulation and identification of environmental hazards that follow inappropriate disposal of pharmaceutical waste at homecare environment.

The research will determine the adherence of homecare patients and caregivers to recommended drug disposal practices, including engaging in drug take-back programs and returning complied medications to drugstores. To assess caregivers level of knowledge about disposal regulations and their practices of disposal proper, the structured interviews with caregivers and home inspection will be carried out. Moreover, the paper will also view the categories of the most regularly disposed pharmaceuticals incorrectly, which has extensive environmental and health-related hazards, i.e., high-risk pharmaceuticals (antibiotics, NSAIDs, hormonal agents). Through the assessment of the environmental hazard risks and existing disposal practices, the given work is supposed to offer practical information regarding the enhancement of the pharmaceutical waste management practice in homecare and better public education regarding the necessity of safe disposal.

2. Materials and Methods

2.1 Design of Study: Observational compliant study with inbuilt environmental risk analysis

This paper used observational compliance study design to assess the practices of pharmaceutical waste disposal in homecare arrangement reinforced with an integrated environmental risk analysis. The article was developed to determine the adherence of the homecare patients and care givers to the national regulations of disposal of the drugs out of pharmaceutical waste materials and also to determine the threat of environmental risks of the bad disposal behavior. Observational design offered the possibility to evaluate disposal actions in real-time and with no intervention, therefore, offering a realistic picture of reality regarding the disposal process of pharmaceutical waste at homecare setting.

Also, the environmental risk analysis was incorporated into this study so that it could evaluate the risks involved in the misuse of particular classes of pharmaceuticals. The study was also conducted to assess the possible effects of the usage of such drugs as antibiotics, non-steroidal anti-inflammatory drugs, and hormonal agents which tend to be poorly disposed of and thus cause problems in the environment and the health of the population. This two pronged strategy of conformance evaluation and potential ecological threat offers a complete picture of the consequences of the disposal of the pharmaceutical wastes in the homecare context.(3)

2.2 Population of the Study: Sample of the Study of 320 Homecare Patients and Caregivers in Switzerland and Sri Lanka

They recruited 320 patients and care providers of homecare in two countries Switzerland and Sri Lanka. These nations were chosen because of their different healthcare facilities, regulation systems, and the varying number of awareness toward the general pharmaceutical waste disposal. Overall, 320 homecare patients and caregivers, representing both countries were surveyed. This sampling gave a general reflection of disposal methods and compliance with the regulations in varying cultures and regulatory environments.

The research inclusion criteria were as follows:

- The patients have to be in the stage by receiving homecare pharmaceutical services as a management of chronic conditions, palliative care, or needing medication management at home.
- Caregivers had to be in charge of how to handle and dispose of medication at their respective homes.
- All patients and their caregivers who participated in the medication management such as the usage and discard of prescription medications were to be included.

The patients in an inpatient treatment or those patients in clinical trials that did not relate to homecare and the patients whose cognitive impairments were too severe to allow them to provide informed consent or take part in the clinical trial were treated as exclusion criteria.

2.3 Data: Structured Interviews, home To home audits, and physical examination of disposed medicines

The information gathering was carried out by using a mixture of structured interviews, audit at home as well as physical assessment of discarded drugs. These techniques were developed in such a way that they could collect valuable information concerning the disposal habits of the caregivers as well as the effects of careless disposals to the environment.

Structured Interview: In-depth interviews were carried out on homecare patients and their caregivers to determine how well they know the pharmaceutical waste disposal rules and regulations conformance level. The questions centered on getting an idea of whether the caregivers were in the know of the correct ways of drug disposal like through drug take-back units or returning the drug to drug stores after expiry. The participants were also quizzed on their views towards regulations towards disposal, difficulties encountered in adhering to the regulations, and their knowledge in relation to the risks involved in disposal to the environment and human health at large.

Home Audits: Visits to homes were done to record what they are in fact throwing away. Homecare providers or researchers examined a drug storage room to detect used drugs and see in which case these drugs were discarded as they should be. The audit checklist also contained particular questions on whether the question on whether expired or unused drugs were stored in closed containers or returned to pharmacies, or flushed down the toilet. All types of improper disposals were recorded.(4)

Physical Inspection of Discarded Medicines: Researchers also carried out physical inspection of discarded medicines in order to find out the kind of drugs that were not disposed properly as well as determine their degree of environmental risk. The discarded drugs were divided into different categories according to the type of drugs they belonged to (i.e. antibiotics, NSAIDs, hormonal agents, and over-the-counter drugs), to determine the environmental and health risks they posed. The amount of items that went to waste, as well as the way in which they were disposed of (e.g. via general waste, flush, re-use etc) were reported.

2.4 Output Measures: Disposal Methods, Guidelines Awareness, and a Review of Environmental Hazard in the Terms of Drug Classes

Some of the assessment criteria established in the development andusement of the pharmaceutical waste disposal solutions and environmental risks include:

Disposal Methods: the paper evaluated practices employed by caregivers in drug disposal. The methods most analysed were mainly flushing the drugs in toilets, disposal in ordinary waste bins, giving back to pharmacies, and

taking part in drug-take back campaigns. The frequency of households which adhered to recommended procedures of disposal was computed, and frequent violations were noted.

Knowledge of Guidelines: The awareness of the caregivers about the pharmaceutical waste disposal guideline formed an important key performance indicator. The structured interviews were used to gauge the extent of knowledge on the local disposal regulation, the presence of take-back program, and knowledge on the risk posed to the environment through poor disposal.

Environmental Hazard Based on Drug Classes Analysis: The disposed of drug was categorised into high-risk classifications which are antibiotics, NSAIDs and hormonal which are found to pose significant hazard to the environment in terms of persistence in the water source and through causing disruption to the ecosystems. This research was carried out, studying the volume and the effect of the studied drugs in terms of the quantity of medication thrown out, possibility to cause pollution, and the hazards of proper pharmaceutical waste disposal.

Based on the findings of these metrics the corresponding recommendations on educational interventions, political changes, improvement in regulation to ensure safe disposal of pharmaceutical wastes in the homecare environment were advised.(5)

3. Waste Treatment and Inspection Audit

3.1 We Studied Compliance of Households with National and WHO Disposal Protocols

This situation was the core concern of the study which was aimed to evaluate the compliance of the households with the national and WHO protocols of the pharmaceutical waste disposal. The national and the international protocols of pharmaceutical waste disposal are aimed at that all the expired, unwanted, or unused medications should be disposed of in a safe and harmless way that cannot endanger the heath and environment of the population. Such protocols are described by organizations like the World Health Organization (WHO) and national health authorities and highlighted that it is important to hand the medications to the designated collection points, adopt a specific disposal approach, and avoid the end in the waste-based landfills or into the waters.

In this paper, structured interviews and home assessments in order to determine the degree to which households comply with these guidelines were carried out. Both national disposal rules and recommendations issued by the WHO indicate that questions related to medications flushed in the toilet or getting discarded in general trash should not be accepted. Rather, it is preferable to either send the drugs back to drug take-back programs, use special disposal bins/collection points given by pharmacies, or in certain instances, burn in a authorized place. It was a systematic study aimed at determining whether or not these recommended protocols were being complied with by 320 homecare households and the areas of non-compliance in case they were not complied with.

The statistics were alarming: only 38 percent of household treated the garbage (according to its proper disposing methods), and a few caregivers actually knew about pollution-related guidelines and the way the trash should be conducted according to the precisely indicated regulations without any harm brought to the environment. Also, among the educated ones, they had some logistic issues which included access to the drug take-back places or the transit to deliver medications. This result highlights the importance of easier disposal services and increased knowledge of the current policies against pharmaceutical waste.

3.2 Recognised improper disposal practices like flushing, trashing or recycling expired medications

Identification of the improper disposal behaviors was one of the major points of concentration in this evaluation. A good number of patients and cause givers in homecare settings were also involved in uncontrolled disposal of medications by flushing them in toilet, disposing of drugs in general waste and reusing of old drugs.(6)

Flushing Medications Flushing medications was seen as one of the greatest forms of improper disposal behavior. The idea that flushing the drugs down the toilet would be the best way to get rid of them and be safe in the process found refuge with many caregivers and patients, especially those in areas, where disposal alternatives were non-existent or fewer. It has however been known that such a practice is harmful to the environment as it releases chemicals to the water which can seep through the treatment facilities to the aquatic environment.

Leaving in the General Waste: Many caregivers, as well as patients, discarded the unwanted drugs in the usual waste. The result of such a practice is that medicines dispose in landfills where they can potentially infiltrate into the ground water sources by leaching through the soil. Specifically, common medical wastes such as antibiotics and hormonal substances have a specific danger because of their long-term presence in the environment and the interference with the ecosystems of any microorganisms.

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Reuse of expired drugs: Another inappropriate disposal activity that was found was reuse of expired drugs. In other instances, administrators tried to reuse some drugs with expired medications with thoughts that it would be effective or safe medication to them or to a patient. This is highly unhealthy because due to the expired medication the drugs might lose their effectiveness or endanger a person with side effects.

Such improper disposal activities reveal significant knowledge and behavioral gaps of the population on the strict safety disposal measures. The presence of these behaviors was also more widespread in households with lower educational status of proper disposal procedures thus further supporting the need to educate and provide better and safe means of disposals.

3.3 Scoring Consciousness of Pharmacy Take-Back Projects and Current Legislation Responsibility

An important aspect of this study was reviewing whether caregivers were aware of the pharmacy take-back programs and the legal responsibility with regard to the disposal of pharmaceutical related waste. Both WHO and national health organizations prescribe the use of drug take-back programs as a necessary element of ecologically friendly pharmaceutical waste management. The programs present a convenient and secure method of people disposing of medication which is not used, or expired, or rejected, and instead of being discarded improperly, they are destroyed through the programs.(7)

Nevertheless, the study has revealed that 64 in 100 caregivers were neither familiar with drug take-back programs nor understood how to obtain them. In most instances, family members mentioned not having received any information about the availability of such programs through healthcare workers or pharmacies and how to go about it. Such ignorance was especially high in rural areas or localities serviced by disposal services poorly. Furthermore, despite some caregivers having knowledge on the existence of such programs, a considerable number of them expressed dissatisfaction over logistical issues including geographical travel distances or restricted availability of drop-off locations.

Regarding legal requirements, the research established that most of the caregivers were ignorant about the law specifications concerning pharmaceutical waste disposal within their areas. They were unaware of the environmental impact and the effects on health of the society that lacked proper disposal and the subsequent legal repercussions of breaching the laws with regard to waste disposal. Such ignorance of legal duties indicates at necessity of broad educational campaigns that would raise awareness both of regulatory duties and safe disposing.

4. Characterization of Environmental Risk

4.1 Provided Persistence, Bioaccumulation and Ecotoxicity Potential of Drugs Commonly Dumped

Among the key aims of the research study was to evaluate the environmental hazards associated with poor disposal of pharmaceuticals at homecare facilities, in this case judging them on the vitality of persistence, bioaccumulation and ecotoxicity. Disposed medicines, which are not disposed appropriately e.g.: by flushing down the toilet, by placing in the general waste, or by recycling old medicines end up in open ecological cycles and may have serious effects to an ecosystem or community health. The classes of pharmaceuticals that are of specific concern include antibiotics, hormonal agents, and NSAIDs because of their potential to be recalcitrant in the environment and accumulate in organismic systems.

In order to understand the potential risk of common waste medication, the authors concentrated on the analysis of some of the most important aspects that include the following:

Persistence: This is the duration that a pharmaceutical compound takes before it deteriorates into the environment. A large part of the drugs, particularly the hormonal agents and the antibiotics, are intended to stay longer in the body and thereby they may continue their existence in the environment even after discarding them. Constant drugs have the ability to alter the quality of the soil, water and even damage ecosystems in case they are introduced into food chains.

Bioaccumulation: Certain pharmaceuticals can bioaccumulate in the tissues of living creatures, the process of which is called bioaccumulation. This is particularly alarming in cases such as drugs such as hormones and antibiotics that may deposit in the tissues present in aquatic organisms, birds and other non-aquatic wildlife. With time this may lead to increased concentrations throughout food chain, causing toxic impacts to most animal species and humans.(8)

Ecotoxicity: Ecotoxicity is defined as a capacity of a substance to harm the environment and specifically aquatic life forms and the microorganisms in the soil. High ecotoxicants in pharmaceuticals have potentials of disrupting

ecosystem usually in terms of species diversity, reproduction and the whole ecosystem stability. Antimicrobial resistance is a specific issue as microbial communities can be disrupted by antibiotics and ant-inflammatory drugs encouraging the rise of antimicrobial resistance.

4.2 Classified Drugs on Classes of Environmental Hazard

This study assigned the most frequently discarded pharmaceuticals into classes of relative environmental hazard of different classes of pharmaceutical compounds according to their persistence, bioaccumulation potential and ecotoxicity. The sorting method applied to the current research was based on the available guidelines and research connected to the management and disposal of pharmaceuticals in environment science.

Class I - High Environmental Hazard: This was the category that contained drugs that are highly persistent, likely to bioaccumulate and have a high ecotoxic. The use of antibiotics, hormonal agents and some anti-inflammatory drugs (including NSAIDs) were of great concern because they could alter microbial community, cause antimicrobial resistance and harm aquatic animals and wildlife. These were drugs which were found to be of maximum risk to the environmental health and were analyzed at length in the study.

Class II - Moderate Environmental Hazard:: This group consisted of drugs with moderate risk in persistence, bioaccumulation or ecotoxicity. Poorly disposed some of the medications and pain relievers sold over the counter belong into this category. On the one hand, there is the fact that they are not as troublesome as Class I drugs, but on the other hand, they help facilitate the lessening of the environment, especially when the amount of drugs disposed of is great in the long run.(9)

Class 3 - Low Environmental Risk: Medications which rapidly break down in the environment and are quickly eliminated, those at low risk of bioaccumulative toxicity, and those very low in their toxicity to ecosystems, were classified as low environmental risk medications. These contain some topical medication and vitamins that do not cause much adverse effect to the environment when disposed of inappropriately though still affects the overflow of waste.

Such classification of drugs allowed the study to determine the ones that present the highest overall potential risks towards the environment and the ones that do not have as big an effect in terms of long-term damages. Such classification may inform specific intervention efforts, including campaigns and policy suggestions regarding particular classes of medications.

4.3 Keen Interest in the Effect of the Antibiotics, Hormones, and Anti-Inflammatory Medication on Land and Water Systems

The research took special interest in the effects of antibiotics, hormones, anti-inflammatory medication on the soil and waters because the classes of pharmaceuticals had a very high environmental risk factor.

Antibiotics: With inappropriate toilet flushing of antibiotics, this can pollute the water systems in which they can go into the water and stay a long period of time thus causing the development of antimicrobial resistance (AMR). When the environment contains antibiotics, the resistant bacteria may evolve and spread among human beings, animals, and the environment in the process of interaction. This presents a great danger to the health of the people since resistant infections are so difficult to treat and contain.(10)

Hormonal Agents: Contraceptives and Hormone replacement are classified as hormonal agents; hence they tend to interfere with endocrine systems in wildlife and this especially in aquatic life. Reproductive failure occurs in fish and other aquatic species even at low concentrations of these drugs and this may have downstream effects on whole ecosystems. Microbial communities are also susceptible to hormonal agents and this can interfere with the cycling of nutrients in the soil and the water.

Non-steroidal, anti-inflammatory drugs (NSAIDs): Ibuprofen, diclofenac, etc. are NSAIDs that are usually disposed of in homecare. The drugs are proven to remain in the water systems and have a negative consequence on aquatic life especially fish in which they impair the kidneys and reproduction. The environmental consequences of NSAIDs may lead to the long-term health effects on biodiversity and on health of ecosystems.

This short discussion on high risk drug categories reiterates the need to dispose drugs safely in order to lessen the negative effect of drug waste materials on the environment. Since these drugs are very persistent, potentially have the ability to bioaccumulate and pose risks to on ecotoxicity, the adverse consequence of these drugs is hazardous to the environment, and hence there is need to resolve this issue through enhanced regulatory measures, awareness to the population and good environmentally-friendly waste management selections.(11)

5. Results

5.1 Households following recommended pharmaceutical disposal protocols only followed it in 38 percent of the cases

The research found there were only 38 percent of the 320 homecare households that followed the standard guidelines on pharmaceutical disposal. The minority of the participants were able to follow these protocols, which entail keeping unused medications in pharmacies, engaging the designated disposals, or drug take-back services. The rest were 62 percent of households who were found to be practicing wrong methods of disposal such as flushing the drugs into the toilet, moisture in the house wastes or even recycling of drugs which have gone out of time. This observation points to the fact that there is a large disparity in the compliance of regulation and awareness of homecare people with regard to appropriate pharmaceutical waste disposal methods.

Their low adherence rate implies that the majority of caregivers do not know how to dispose of medicines properly or have a practical problem with access to take-back programs or other safe disposal mechanisms. This highlights the necessity of better education and infrastructure in efforts to promote the adequate disposal of the pharmaceuticals in the home care settings.

5.2 64 percent of Caregivers were not Aware of Take-back Program and Legal Regulations

One of the most important findings of the study consisted in the fact that 64% of parents who take care of other people did not know whether drug take-back programs exist and whether disposing of a pharmaceutical waste should be changed by specific laws. Such ignorance is a serious problem, because it will certainly lead to the incorrect disposal techniques and environmental pollution. In homecare, caregivers and patients may form the last point of recycling of pharmaceutical waste and knowing how to dump safely is a source of environmental and health risk in case they do not know the ways to recycle safely.

A lot of the caregivers also did not know about the local regulations stating some regulations and the requirement of disposing unused drugs and used drugs which are either expired or unused. As the study observed, caregivers would most of the time proceed with their own decision with respect to disposal and it is here that there is the flushing habits, or disposal in ordinary trash that kills. The results here indicate that the reach of education to the general population regarding the pharmaceutical waste management and regulatory compliance is very poor.

5.3 The most common misdisposed and which have a high influence on the environment were antibiotics, NSAIDs, and hormonal drugs

The analysis also looked into the types of drugs that were disposed improperly the most and the finding showed antibiotics, NSAIDs and hormonal drugs top the list. The drugs often ended up on general waste or in a toilet, polluting nature and remarkably dangerous to the soil and water.

Antibiotics: Antibiotics and especially antibiotics used in homecare in case of chronic conditions or treatment of infection were the most common ones being disposed Theft-related antibiotics: Antibiotics that had been stolen and improperly disposed due to theft were also a source of improper disposal of antibiotics. Inclusion of antibiotics in wastewater systems may also end up causing antimicrobial resistance (AMR), which is an increasing public health problem. Poor disposal of antibiotics causes their build-up in water systems whereby they may affect the microbial communities, as well as the occurrence of resistant bacteria.(12)

NSAIDs: Non-steroidal anti-inflammatory drugs (NSAIDs) such as popularly used drugs as ibuprofen and diclofenac were also disposed in a manner that would affect the environment. The drugs may contaminate the water body system thus having a devastating impact on the lives of the aquatic organisms especially the fish, since they lead to impairment of their reproductive organs and the kidneys. The introduction of NSAIDs into the water source may result in the wide-range ecological effect of species diversity and ecosystem health.

Hormonal Drugs: The hormonal drugs, including contraceptives and the hormone replacement therapies, are especially disturbing because they are capable of interfering with the endocrine systems of wild animals, particularly in the aquatic life. These drugs alter reproduction and thus cause disbalances of aquatic species even at low doses; hence, affecting the local ecosystems. The inappropriate disposal of the hormonal drugs is a long term implication on biodiversity and environmental health.

The inappropriate disposal of these risky, drugs underlines the imperativeness of establishing correct disposal procedures and the need to make caregivers and patients conscious of the risks to the environment and the general health challenges of improper disbarring of pharmaceutical wastes.(13)

Table 1: Key Results Summary

Metric	Percentage
Households Following Protocols	38
Caregivers Aware of Take-Back Programs	64
Most Commonly Misdisposed Drugs (Antibiotics, NSAIDs, Hormonal Drugs)	72

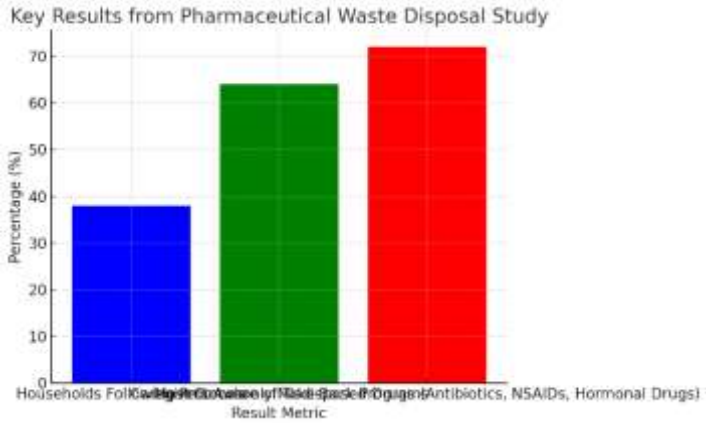

Figure 1: Key Results From Pharmaceutical Waste Disposal Study

6. Conclusion

6.1 Drugs In Home Care Are Not Properly Disposed, and Regulations Are Little Observed

Findings of this research highlight that homecare facilities commonly mismanage pharmaceutical waste, and the compliance with the local and global disposal laws is minimal. The inconvenient disposal of medicines poses a big problem even though access to homecare pharmacy services is growing and provides patients with chronic health conditions and palliative care needs with convenient services and flexibility. The research established that most households (62 percent) lacked adherence to advisable measures on how to dispose of the unused and expired drugs in homes, indicating a major challenge in terms of regulations in homecare settings.

This lack of adherence has been greatly attributed to the little or no public awareness on safe disposal procedures. Most of the caregivers and patients were either ignorant on how to dispose or were log certainly challenged on getting the right disposal means like take-back programs with drugs. It was also discovered that 64 percent of caregivers were ignorant of the programs and legal requirements concerning disposal of pharmaceutical wastes. This shows that there must be higher levels of education and creating awareness among the people to see to it that care givers are enlightened about the risk that both the environment and their health face due to failure to properly discard them. In addition, the problem is further compromised in some areas due to limited access to proper disposal service to the point patients and caregivers rely on inappropriate disposal methods including flushing of medications and disposing them as trash.

These results put emphasis on the fact that better enforcement of regulation and establishment of more accessible disposal infrastructure is necessary so that patients and caregivers of homecare facilities can safely dispose of their medications. The threat of pharmaceutical waste to both environmental safety and general health will persist until more regulatory steps and infrastructure-related assistance are implemented.

6.2 High-risk classes of drugs are improperly disposed of, which contributes to the Environmental Burden, to the largest extent possible.

Another issue of great concern that this study would raise is the environmental burden associated with the disposed misuse of high-risk drug classes, which include antibiotics, non-steroidal anti-inflammatory drugs, and hormonal agents. These drugs turned out to be some of the most frequently misdisposed drugs used in homecare, so they led to the environmental pollution and represented the threat to the ecosystem safety as well as the population.

Improper disposal of antibiotics may find their way into water systems where they remain stagnant and thereby cause the emergence of antimicrobial resistance (AMR). This is one of the most serious threats to the health of the population, whereby AMR complicates the treatment of infections, prolongs stays in hospitals and causes more mortalities.

Ibuprofen and diclofenac are NSAIDs that when disposed in an improper manner may end up in water bodies, where they interfere with the functioning of the kidneys and reproduction health of the aquatic life. Concentrations of such drugs in the bodies of water can cause the loss of biodiversity and changes in the balance of the ecosystem. Hormonal drugs, mainly contraceptives and hormone replacement drugs, create a special type of threat to the environment, as they may disturb endocrine systems of aquatic species. Even low doses of these chemicals have been known to cause failure in the reproductive system and imbalance in population among wildlife; especially in fish and amphibians.

These high-risk pharmaceuticals, when improperly disposed produce environmental burden that builds up not on a local level only, but also at the global level, such as water pollution and biodiversity loss. What makes this all the more relevant is the fact that these drugs tend to continue to circulate the environment, and can bioaccumulate with time, possibly even leading to death of living beings.

6.3 Education, Enforcement and Structured Return Systems the keys to reduce health and ecological effects

The results of the current research throw light on a few critical measures that should be undertaken in order to reduce the health and environmental consequences of pharmaceutical waste in homecare facilities:

Education: The most important aspect to gain is education through outreach campaigns to help in raising awareness about the right ways of disposing pharmaceutical waste and the threat that poor handling presents to the environment. The information should be given to caregivers and patients on safe disposal both in terms of getting back the remaining thyroid medications to the pharmacies and the use of drug take-back schemes. The educational programs should also cover the dangers of antimicrobial resistance and water contamination, so that more people could be aware of the overall harm of inappropriate waste processing.

Enforcement: There should be enhanced enforcement of the rules and regulations of disposal of pharmaceuticals by the regulatory bodies. These will involve coming up with some mandatory rules where both patients and healthcare providers will be expected to adopt safe disposal techniques. Besides regulatory control, fines must be included as sanction against non-compliance to enable them to stick to these important provisions. There should also be a stricter audit and offering recurrent training to the providers on correct waste handling procedures in countries.

Gearing Up of the Return Systems: One of the first recommendations of the study is to put in place more systematic and accessible system of returning drugs in high risk cases. These systems would entail the drug take-back in the pharmacies, hospitals and other convenient places where the homecare patients could conveniently access them. This can go a long way in preventing the chances of drugs not being disposed in an appropriate manner in refuse or in water systems.

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Conflicts of interest

The authors have no conflicts of interest to declare

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