Assessment of Household Disposal of Pharmaceuticalsand its Management in Kozhikode

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ABSTRACT

Pharmaceutical is an extensive group of chemical compounds which when released into the environment has potential adverse effects on human health conditions aquatic systems and marine life. In many developing countries the extent of the problem and the percentage of pharmaceuticals in water bodies are generally unknown. While thousands of tons of pharmaceutical substances are used annually, little information is known about the method used for its disposal after its required usage. They are considered as emerging contaminants because there is no acceptable limit on ther discharge into water bodies.

This report focuses on the management and the methods used for disposal of human-use pharmaceutical wastes in Kozhikode. In this project survey was conducted consisting for around 290 people, the final result revealed that majority of the respondents disposed their unwanted medication through domestic solid waste streamUsing SPSS software, it was found that willingness to participate in the future takeback programs was a function of age, monthly income, education and their views towards awareness and the importance of establishing a collection system of pharmaceutical waste. Ultimately, collaboration and cooperation between concerned stake holders are essential for developing a successful district wide national collection plan.

Keywords Pharmaceutical Waste .Management . Water quality protection .Collection programs .KozhikodeAdministration . Statistical Modelling

I. INTRODUCTION

Over the last fifteen to 30 years, pharmaceuticals have been receiving increasing attention as potential bioactive chemicals in the environment. They are considered as emerging contaminants in water bodies because they are not kept at check and their disposal still remain unregulated, they are currently undergoing a regularization process however the directives and legal frameworks are not set-up by the government yet. Pharmaceuticals are continuously introduced into the environment and are prevalent at small concentrations, which can affect water quality and potentially impact drinking water supplies, ecosystem and human health and marine and aquatic life. Although pharmaceuticals have been present in water for decades, their levels in the environment have only recently begun to be quantified and acknowledged as potentially hazardous to ecosystem

As pharmaceuticals are a necessary part of the health and well-being of an individual it is not feasible to prohibit its use. Since more emphasis was given on the cases ofof poisoning among children due to pharmaceuticals more importance was given to safe use of pharmaceuticals rather than awareness on methods of disposal and management (Musson et al.2007).

Household medications reach the aquatic environment through three main parts, excretion after utilisation, disposal either via the municipal wastes or flushing down the toilet and bathing that causes removal of topical medications (Bound and Voulvoulis 2005; Glassmeyer et al. 2009) (FIG 1). The methods used for disposal of unused medications doesn't contribute much to pollution of aquatic environment when it is compared to that of the direct excretion pathway. However, the disposal route may cause an exponential increase in the concentration as it is disposed in its raw undigested form. The disposal route is said to have the greatest "control potential" which is pretty significant when it comes to a pollution standpoint (Daughton and Ruhoy 2008, 2009; Smith 2014). Household medications reach the aquatic environment through three main parts, excretion after utilisation, disposal either via the municipal wastes or flushing down the toilet and bathing that causes removal of topical medications (Bound and Voulvoulis 2005; Glassmeyer et al. 2009) (FIG 1). The methods used for disposal of unused medications doesn't contribute much to pollution of aquatic environment when it is compared to that of the direct excretion pathway. However, the disposal route may cause an exponential increase in the concentration as it is disposed in its raw undigested

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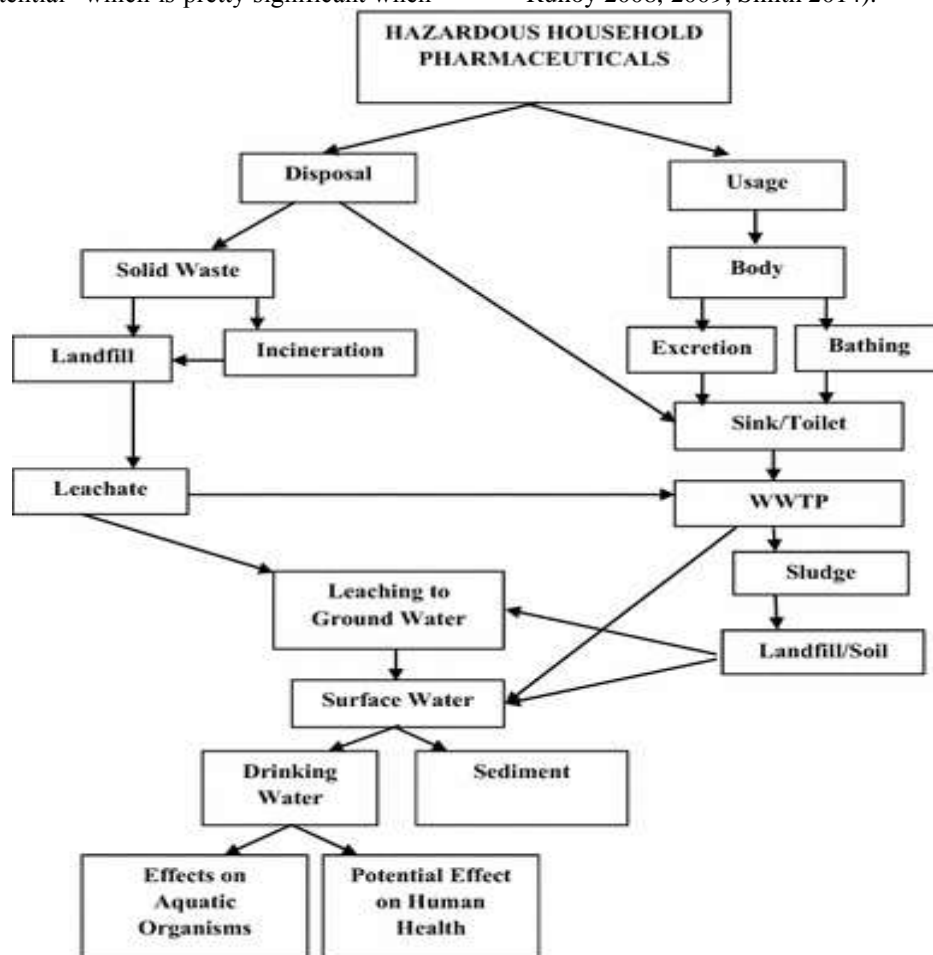

Fig. 1 Pathway of hazardous household pharmaceuticals into the environment (Bound and Voulvoulis2005; Glassmeyer et al. 2009)

To date, there is a lot of data on the occurrence of pharmaceuticals in water bodies e.g. in surface water (Kolpin et al. 2002; Ashton et al. 2004), groundwater (Barnes et al. 2008; Loos et al. 2010), and marine and coastal environment (Gaw et al. 2014). Most of the research has been conducted in North America, Europe and China (Hughes et al. 2013). There is significant proof that wastewater treatment plans have not been entirely successful in completely removing pharmaceutical effluents in its system. (Ashton et al. 2004; Humphreys et al. 2008; Verlicchi et al. 2012). Studies (Jones et al. 2005; Stackelberg et al. 2007; Watkinson et al. 2009; Benotti et al. 2009).

Most countries in the developing world lack a clear and safe pharmaceutical management plan or program for the collection or take-back of unwanted medicinal products. As such, it is expected that pharmaceuticals will pose potential environmental and public health concerns in the near future. Therefore, minimizing the disposal pathway, through adopting a proactive preventative at-source collection, could prove more effective and less costly than post-disposal treatment. This research focuses on developing appropriate strategies and schemes to manage and dispose hazardous pharmaceuticals. The results obtained can provide baseline information for future regulation and local development projects

The project deals with creating a survey and a questionnaire. Respondents of Kozhikode district were requested to answer a questionnaire. The data collected was processed in SPSS software and statistical models were created. graphs and tables regarding demographic details, usage of medicines, disposal methods and willingness to participate were generated depending on the inputs of the respondents

II. METHODOLOGY

Study Area

The study area considered was Kozhikode. The study site was chosen because Kozhikode is an upcoming town with where there has been an exponential increase in hospitals and medical colleges another reason wasthe convenience and accessibility of the region. The survey was predominantly conducted in residential areas and in public transport hub. The initial step of the project was to determine the approximate number of respondents required. This was found by using the formula

$$n = \frac{Z_{0.90}^2 \times p(1-p) \times N}{(N-1) \times m^2 + Z_{0.90}^2 \times p(1-p)}$$

$$= \frac{1.63_{0.90}^2 \times 0.75(1-0.75) \times 131000}{(131000-1) \times 0.05^2 + 1.63_{0.90}^2 \times 0.75(1-0.75)}$$

=206

where n = required sample size; Z = confidence level at 90 % (standard value of 1.63); p = estimated prevalence of the outcome variable of interest; N = the total number of the population; and m = margin of error at 5 % (standard value of 0.05).

The total population was "N" was found to be 1.31 lakhs from Indian census 2011.From the above mention formula the total sample size required was derived and it was about 186 which was approximated to 205 respondents. About 250 questionnaires were created andaround 210 accurate responses were received.The survey was conducted between February 5th – March 10th 2019. The questionnaire was distributed randomly among different age groups, gender and educational background.

The questions were of multiple-choice format and were distributed randomly among respondents across various residential areas and transportation hubs around Kozhikode so as to obtain a result relative to the whole district in the event of a non-response, rejection or inaccessibility an adjacent household or the next respondent was selected. The questionnaire was pre-tested during a pilot survey conducted in Kovaipudur Coimbatore and then data collection began in Kozhikode.

A pre-tested survey questionnaire, in English was developed and used for the acquisition and col-lection of data. It comprised of a set of structured, standardized, closed-ended and coded set of questions. The questionnaire was structured and developed so as to address the following:
1. Most common pharmaceutical types (uses) and estimated quantities consumed by residents at the household level.
2. Residents' most common practices in terms of pharmaceutical waste management (storage and disposal).
3. Residents' knowledge and perceptions of any potential environmental or public health impacts that may result from residential pharmaceutical waste mismanagement.
4. Residents' knowledge or awareness on proper household pharmaceutical waste management practices.
5. The most common incidents/accidents related to or resulting from mismanagement of residential pharmaceutical waste.
6. Residents' willingness to participate in any future pharmaceutical waste disposal or collection or ''take back'' system or program.

Data Management and Statistical Modelling

The data collected from the responses by the public was converted into excel format and a table was formed. The data was then further simplified to binary format so as to input it into the SPSS software. The required models were generated using Binomial logistic regression test. This test predicts the probability that an observation falls into one of two categories of a dichotomous dependent variable based on one or more independent variables that can be either continuous or categorical. Basically, this test helps us to determine the significant parameters that influences the respondent's willingness to take part in take back programs. The first to models were generated using binomial regression as only two options were considered that is either one of yes or no with the question being whether they willing to participate in the take back program. However, the 3rd model deals with the preferred method of future disposal and this has more than two options and therefore multinomial regression is used. From the 210 data collected and analysed 150 responses are analysed using SPSS and the remaining data was analysed using equations in excel so as to validate the responses analysed by the software. The parameters considered were age, household income, health plan, annual expenditure on medicine, level of education, awareness of environmental dangers, do they dispose unused

medications and if they are aware of any laws regulating disposal. The options for preferred choice of disposal were, give to needy, Government run intervention program and public sector run program. A confidence interval (CI) of 90% and a significance level (sig value) of 0.1 was considered. The three models were;

Model 1 It identifies the main predictors expected to be associated with the ''willingness to participate in a future household pharmaceutical waste collection/take-back program''.

Model 2 It establishes the main predictors associated with the ''willingness to participate in a future household pharmaceutical waste collection/take-back program for a fixed fee''.

Model 3 It focuses on exploring the predictors that influenced the ''respondents' preferred choice of a future pharmaceutical waste collection/take-back program''

The models were created by running Multinomial regression and binomial regression

Fig. 2 Map of the study areaKozhikode
(Source:www.mapsofindia.com)

III. RESULTS AND DISCUSSIONS
3.1 Respondents' demographic, socio-monetary and wellbeing attributes

Table 1.**Demographic, socioeconomic and medical background of respondents**

Characteristics	Frequency(%)
Gender :	
Male	127(61.95%)
Female	78(38.04%)
Age, mean (± SD)	38
Education :	
Elementary or less	8(4.7%)
Secondary	60(29.26)
University(and equivalent)	137(66.82%)
Household size, mean (± SD)	4
Currently employed :	
No	88(42.92%)
Yes	117(57.07%)
Monthly household income (in INR) :	
<8000	25(14.70%)
8000-10000	30(14.70%)
>10000	70(34.14%)
>50000	46(22.43%)
>100000	34(16.58%)
Yearly expenditure on medication (INR) :	
>3600	114(55.61%)
<3600	91(44.39%)
Healthcare plan :	
Public coverage	31(15.12%)
Private insurance	78(38.04%)
None	96(46.82%)

Our study does not show any gender bias, the mean age was calculated to be 38 Years (Ranging from 17 – 84),the mean household size was approximately 4 members per household. 77.05% percentage held university degree.

About 57.07 percentage of respondents were employed at the time of survey,most of the unemployed respodents we interviewed were students or   housewifes .More than   34.14 percentage have more than ten thousand rupees monthly income.55.61 percentage of respodents spent more than 3600 rupees annualy on medication.

3.2 Most generally utilized sorts and amount of pharmaceuticals

Out of the population that had a chronic medical condition, 8.2 percentage respondents have hypertension, 13 percentage has diabetes the percentage of cardio-vascular diseases was unknown ,these stats can excepted to show the representative health profile of Kozhikode. It should also be noted that respondents may not be comfortable with revealing they have cancer, Typhoid cardio vascular diseases etc and that is why datas these medical conditions were

negligible. Around 15.54% claimed to suffer from migrane and 7.6% cited influza as their prevailing medical condition. Only 3% of the respondentd suffered from whooping cough.

Out of the total percentage of percentage medication purchased from the counter,.12.3 percentage were bloodsugar regulators,12.5 percentage were blood pressure regulators and 41.7

percentage were antibiotics.The most commonly used OTC medication was anelegesics/painkillers and it was used by 29 percentage of responents followed by antiseptic andantibacterial medications which was about 23.5%.. The season in which the survey was conducted could play a role in prevailing medical condition and the common medication purchased at the reigon.
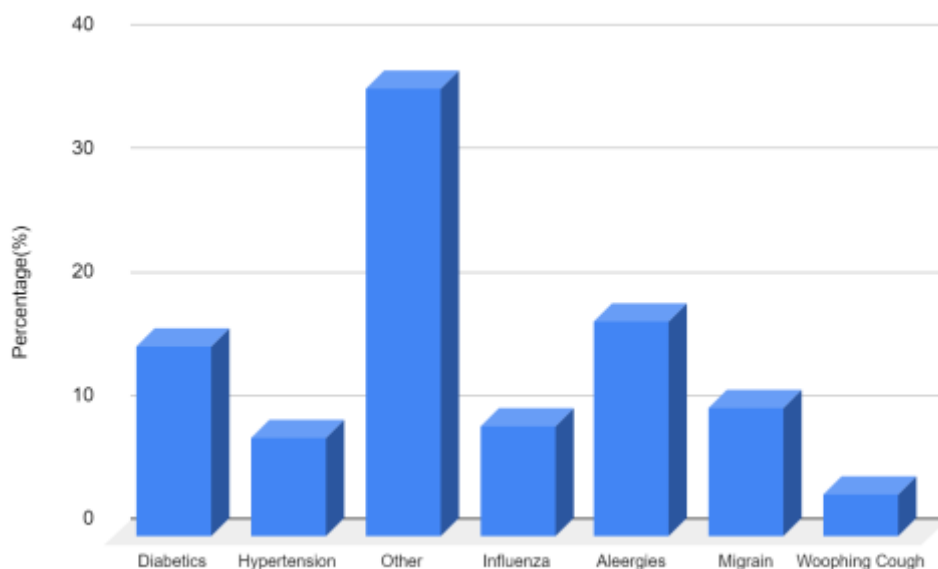
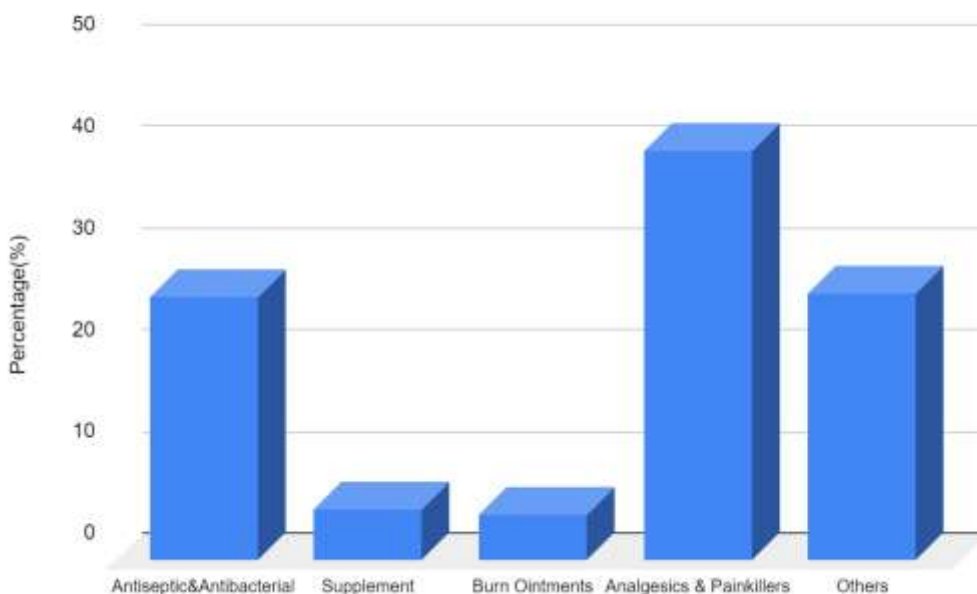**Fig 3: Graph showing prevailing medical condition in the reigon**
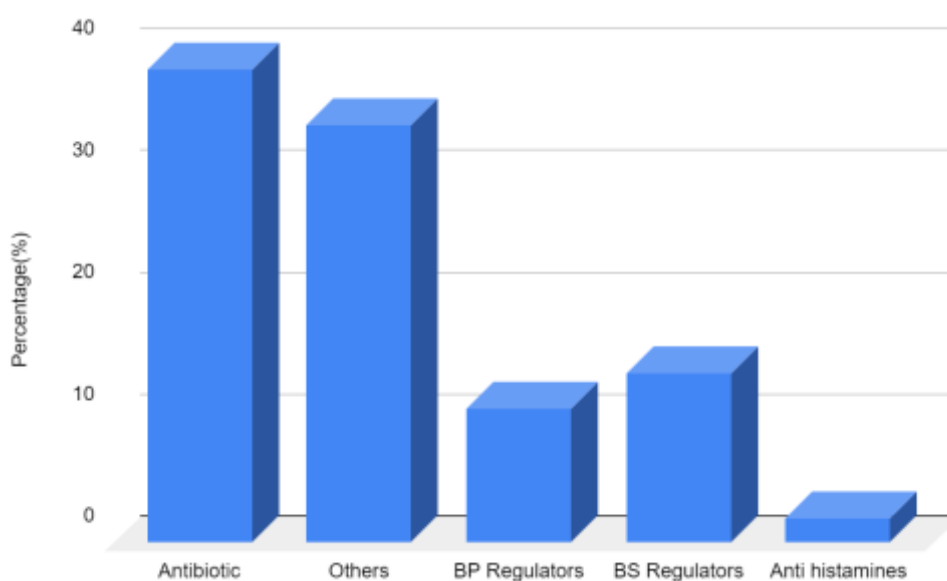
Fig 4 : Graph showing commonly consumed prescription medicines

Fig 5: Most common types of OTC products stored in the household

3.3 Current work on with respect to the administration of family unit pharmaceutical waste
TABLE 2 Respondents practices for the management of unwanted medications at the residential level

Characteristics	Frequency(%)cy
Dispose of unwanted medications	
No	
Yes	98(57.64%)
	72(42.35%)
Reason for disposing of unwanted medications	
Later need	
Side effects	
Excess supply	117(57.075)
Medical condition improved	1(0.4%)
Change of treatment method	29(14.14%)
Others	12(5.85%)
	12(5.85)
Solids	34(16.88%)
Toilet/Sink	
Garbage/Solid Waste Stream	
Return to Pharmacy	12(5.85%)
Take back program	130(63.41%)
Give to nearby dispensary/people in need	25(12.19%)
	12(5.85%)
	26(12.68%)
Liquids	
Toilet/Sink	
Garbage/Solid Waste Stream	

Return to Pharmacy	40(19.51%)
Take back program	109(53.17%)
Give to nearby dispensary/people in need	25(12.19%)
	9(4.39%)
Cream and Ointments	22(10.73%)
Toilet/Sink	
Garbage/Solid Waste Stream	
Return to Pharmacy	
Take back program	0
Give to nearby dispensary/People in need	144(70.24%)
	23(11.21%)
	10(4.87%)
	28(13.65%)

It was noted that 57.4 % of respondent claimed to have had unused medication at home. 42.35% of respondent said yes when asked if they disposed unwanted medication. Out of the respondents who had unused medications with them it was found that 57% of them stored the medication citing the reason that it may be needed later and around 14% had unused medication with them due to excess supply.

The respondents were asked to mention the most common form of disposal of their choice. The questionnaire divided the medication to three common types ie solid form(tablets/capsules).Liquid form (syrups and suspension) and semi solid form i.e. creams , ointment 5.85% of respondents disposed of their solid medicines by tossing them into the toilet/sink and 12.68% gave to needy and the majority of 63.41% dumped it down the trash/Solid waste stream, similarly for liquid waste about 19.51% disposed of their liquid waste into the toilet/sink and 4.39% gave it to take back program initiative and around 10.73% gave to people in need similar to solid waste more than half the respondents ie 53.17% dispose it through the garbage/Solid waste stream. In the case of unwanted creams and ointments which comes in the category of semi-

solid waste about a majority of 70.24% got rid of it through the solid waste stream such as garbage.

These results clearly show that majority of the population dispose of their medication through the domestic waste stream and majority of the population think of it as the most practical and safest method of disposing of the unused medicine. The ever increasing number of solid waste generation has been a growing problem for many developing countries and environmental engineers. India in general and Kozhikode is no exception when it comes to this issue. For an overpopulated country like India refuse generation continues to be of major concern and the government faces a lot of challenging development related issues. In such countries open dumping is commonly used. In such a scenario the practice of disposing unused medicines into the solid waste stream can further aggravate the existing problem and lead to the contamination of water supplies. In such situations the medications could also end up in the hands of scavengers and children and if the waste is openly dumped it could be illegally diverted to the market for resale and reuse which could cause great dangers and problems.

3.4 Learning, familiarity with natural perils and ability to take an interest future mediation program

Table 3 Respondents perception and knowledge on proper management of unwanted medication

Characteristics	Frequency (%)
Have been given awareness/guidance on proper management of unwanted medication	
No	117(57.07%)
Yes	88(42.92%)
Awareness/guidance provided by	
Physician	20(9.75%)
Pharmacist	25(12.19%)
Friend	24(11.17%)
Other	134(65.36%)
There should be awareness/guidance on proper management of unwanted medication	
No	15(7.31%)
Yes	190(92.68%)
Best way for reducing quantity of unwanted medication at the residential level	
Awareness programs Collection/take back systems Accurate prescription of medication	73(35.69%) 72(35.12%)

Have heard of any law/legislation related to management of unwanted medication	
No	182(88.78%)
Yes	23(11%)
There should be law/legislation related to management of unwanted medication	
No	0
Yes	205(100%)
Improper management of unwanted medication poses environmental and public health threats	
No	68(33.17%)
Yes	137(66.82%)
Do you know any collection/take back program for unwanted medication from households	
No	164(80%)
Yes	41(20%)
Willingness to participate in any future household pharmaceutical waste collection/take back program	
No	32(15.60%)
Yes	173(84.39%)
Preferred option of future household pharmaceutical waste collection program (future intervention)	

Return to pharmacy	132(64.39%)
Public sector (governmental) intervention program	51(24.8%)
Give to people in need	22(10.72%)
Willingness to participate in any future household pharmaceutical waste collection/take back program for a fixed fee	
No	53(25.85%)
Yes	152(74.12%)

57.07 % of the respondents claimed they never received any sort of awareness or guidance on appropriate disposal methods of unused medicines. This can be attributed to lack of natural framework, lack of laws and regulations and lack of general awareness of appropriate disposal methods. Majority of respondents agreed that it was necessary to develop proper awareness and guidance on proper disposal methods.

About 66.82% of the respondents perceived the improper disposal of such type of waste as dangerous and might contribute to environmental degradation and potential health impacts (Table 3). It is to be noted that answers to questions involving participant behaviour, attitudes, and perceptions might involve a margin of social desirability that might not be accurately matching to reality, where respondents might tend to provide ''best-answers'' to impress the interviewer. Approximately 74.12 % of respondents thought that there should be collection/take back program for pharmaceutical waste generated by residences. 24.8 percent of respondents who thought there should be a local collection/take back program preferred the Indian government as the prime responsible entity for organizing and steering such a future intervention program. About. Around 64% preferred returning them to the pharmacy, followed by 10.72% who were willing to give them to people they knew in need. Majority of the respondents 84.39% were willing to participate in future collection take back programs. However, the willingness of respondents to take part in a take back program for a fixed fee was reduced to around 74.12%.

5.5 Study Of Factors Influencing Willingness to Participate (WTP) in and Preference of Waste Collection Program

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	**Employment status(1)**	-1.602	0.617	6.737	1	0.009	0.202
	Education			6.203	2	0.045	
	education(1)	-2.671	1.134	5.552	1	0.018	0.069
	education(2)	- 0.941	0.674	1.948	1	0.163	0.390
	Insurance			9.399	2	0.009	
	insurance(1)	-1.237	.859	2.075	1	0.150	0.290

insurance(2)	1.258	1.015	1.537	1	0.215	3.520
Do you dispose medicine(1)	1.629	.608	7.168	1	0.007	5.098
Think take back program required	2.166	1.259	2.960	1	0.085	8.724
Constant	3.231	1.000	10.437	1	0.001	25.299

Table 4: Trimmed down table showing the most significant parameters for willingness to participate in a take back program(Model 1)

$$U_{WTP} = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + \cdots \ldots + a_nx_n$$

$P = \dfrac{1}{1 + e^{U_{WTP}}}$

Several predictor variables were found to be significant for willingness to participate. The various parameters considered while running binomial logistic regression were age, employment status education level, health plan(insurance) whether private or public, household size, household income and whether they were given awareness on proper management methods and if they were aware of a take program in their region.

If the sig value was less than 0.1 then the parameter was said to have a high degree of influence and was considered as a significant parameter. Table 2 shows the significance of the various parameters and from this the result was further trimmed down and generated (Table 3). From table 3 it is clear that the most significant parameters that influenced respondent's willingness to participate was found to be employment status (sig=0.009), Level of education (sig=0.018), and if they knew about any take back program(sig=0.085) and most importantly whether or not they dispose of their unused medication.

From the model it was understood that Employed respondents were 0.202 times more likely to participate. This could be due to the exposure they gain and the extra access to information and awareness they gain in a working environment.

Education was also a influencing parameter when it came to willingness and graduates (sig=0.018, Exp(B)=.069) were 0.69 times more likely to participate than those who discontinued from secondary level.

The two most significant factors were, whether or not the respondent disposes his unused medication (sig=.007, Exp(B)=5.098) and whether they think that there should be a take back program (Sig=0.085, Exp(B)=8.724). Respondents who disposed of their unused medicines were 5 times more likely to participate than the people who don't. Respondents who believed in the requirement of a take back program were on average 8.7 times more likely to participate in a future collection take back program.

This could be attributed to the fact that these respondents were generally more environmentally aware and as such are more willing and better understand the benefits

		B	S.E.	Wald	Df	Sig.	Exp(B)
	Insurance			13.126	2	0.001	
	insurance(1)	-2.438	0.828	8.667	1	0.003	0.087
	insurance(2)	-1.161	0.841	1.905	1	0.168	0.313
	Are you aware of the environmental impact(1)	-0.309	0.403	0.587	1	0.443	0.734
	Age	-0.032	0.014	5.274	1	0.022	0.969
	Any proper guidance on management(1)	-0.890	0.423	4.436	1	0.035	0.411
	Constant	4.392	1.059	17.193	1	0.000	80.789

Table 5: Trimmed down result table showing the top-most significant parameters for   willingness to participate with a fixed fee(Model 2)

Similarly willingness of respondents to participate for a take back program with a fixed fee was analysed. The significant variables were subject to binomial logistic regression. The most significant parameters were found to be age, guidance on proper disposal techniques and insurance plans followed by the respondents.

People who were given guidance from friends, doctors or pharmacists(sig=0.035,Exp(B)=.411) were 0.4 times more willing to participate for a fixed fee.Age (Sig=0.022, Exp(B)=0.969) was also found to be another important parameter. For every 10 year drop in age it was found that respondents were 1.2 times more likely to take part for a fixed fee. The results were surprising as T the study showed that younger people had more favourable perceptions about paying for a take back service when compared to older respondents.

preffered[a]		B	Std. Error	Wald	Df	Sig.	Exp B
return to pharmacy	Intercept	3.877	0.771	25.303	1	0.000	
	Age	-0.051	0.016	9.692	1	0.002	0.951
	[willingness to participate=.00]	-2.148	0.650	10.905	1	0.001	0.117
	[willingness to participate=1.00]	0[b]	.	.	0	.	.
public sector	Intercept	1.870	.799	5.482	1	0.019	
	Age	-0.032	0.017	3.755	1	0.053	0.968
give to people	Intercept	-3.877	0.771	25.303	1	0.000	

in need	Age	0.051	0.016	9.692	1	0.002	1.052
	[willingness to participate=.00]	2.148	0.650	10.905	1	0.001	8.564
	[willingness to participate=1.00]	0^b	.	.	0	.	.

Table 6: Trimmed down result Table of all the significant parameters associated with preference of type of take back program.

The final model analysed the significant parameters associated to the preferred method of pharmaceutical take back program of the respondents the different options provided were, return back to pharmacy, willingness to provide to people in need or to take part in a government led intervention program. Majority of the respondents nearly 64% favoured to return their medication to the pharmacy.

The option of giving unused medication to the needy ranked low this could be because absence of supervision and lack of approval of physician could be the reason as to why people were apprehensive of this method of management. Age, Education level and willingness to participate were significant factors.

"Age" was found to be a significant predictor of peoples choice (sig=0.002, Exp(B)=1.052). The study showed that higher the age of the respondent more likely were they willing to regift their unused medication to the needy. Possible reasons of giving their medication to people in need could be out of their personal concerns and preferences in the humanitarian aspect of managing medications rather than the environmental and safety implications of proper management. Older respondents may also prefer bypassing official channels or programs because of their fear that the products may be manipulated or illicitly resold.

Overall, age was found to be a quite significant predictor of willingness to participate in a waste management program irrespective of associated costs. Younger respondents were more willing to take part and this could be attributed to the fact that they may have been more informed and well aware of the environmental concerns improper disposal causes. Surprisingly factors like gender and income do not have much significance in people's choices. Preference of take back program was found to vary as a function of age and education.

IV. CONCLUSIONS AND RECOMMENDATIONS:

The survey revealed that majority of the respondents disposed of their medication through the domestic solid waste stream irrespective of the type of medicine. Predominant reasons for having unused medications included If they were needed later and excess supply therefore it can be suggested that proper prescription can help reduce the number of unwanted medicines. Along with physician accurate prescription awareness programs were also considered. Respondents who were aware of environmental impacts of improper waste management and those who obtained proper guidance were more likely to participate in a take back program for fixed fee. Younger participants were on average found to be more willing than older respondents in average. On another note older respondents preferred to give their unused medications to the needy compared to that of the younger people who preferred to return the medications to pharmacy or to a government led intervention program.

Overall The respondents preferred to give back their unused medications to the pharmacy. This was found to be more advantageous as such a scheme can reduce the burden on the government and the community as well as allow producers to take responsibility of the environmental impacts of their products and bear the cost of environmental management and gain trust from consumers.

The various significant factors that have been identified in this study to influence consumers' behaviour, attitudes, and perceptions on the management of household pharmaceuticals should be considered, While identifying the steps needed to develop a nationally-applicable collection program. Awareness and guidance programs should be delivered to the largest audience. Factors that have shown to influence individuals willingness to participate in a future program should be considered as potential key factors when planning for future interventions.

A collaboration and coordination between the responsible entities namely government the

stake holders and pharmaceutical manufacturing companies is crucial for developing national or local collection programs steered by public sector. Physicians and pharmacists should focus on measures to reduce over prescribing of medications and emphasise on the need for patient compliance, in order to minimise the the quantities of pharma waste. All this is hard to follow due to a lack of proper regulations imposed by the government in regard to proper disposal of pharmaceutical waste.

Overall proper awareness is a key component in a proper take back program and a well-tailored future take back program should be pilot tested for its accuracy, feasibility, accessibility, acceptability and practicality so as to confirm and ensure its success in the real world scenario.

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