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Assessment of Household Disposal of Pharmaceuticals in Lebanon: Management Options to Protect Water Quality and Public Health

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Abstract Pharmaceuticals comprise an extensive group of compounds whose release into the environment has potential adverse impacts on human health and aquatic ecosystems. In many developing countries the extent of the problem and the occurrence of pharmaceuticals in water bodies are generally unknown. While thousands of tons of pharmaceutical substances are used annually, little information is known about their final fate after their intended use. This paper focuses on better understanding the management of human-use pharmaceutical wastes generated at the residential level within the Administrative Beirut Area. A survey encompassing 300 households was conducted. Results revealed that the majority of respondents were found to dispose of their unwanted medications, mainly through the domestic solid waste stream. Willingness to participate in a future collection program was found to be a function of age, medical expenditure, and the respondents' views towards awareness and the importance of establishing a collection system for pharmaceutical wastes. Respondents who stated a willingness to participate in a collection program and/or those who believed in the need for awareness programs on the dangers of improper medical waste disposal tended to favor more collection programs managed by the government as compared to a program run by pharmacies or to the act of re-gifting medication to people in need. Ultimately, collaboration and coordination between concerned stakeholders are essential for developing a successful national collection plan.

Keywords Pharmaceutical waste · Management · Water quality protection · Collection programs · Administrative Beirut

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Introduction

Pharmaceuticals were primarily identified in the environment 30 years ago (Garrison et al. 1976; Hignite and Azarnoff 1977). They comprise a large wide group of organic compounds having the tendency to affect human health and aquatic ecosystems (Jones et al. 2001; Kolpin et al. 2002). The use of pharmaceuticals is expected to increase as the population grows and ages as well as our reliance on drug treatment increases. Considering that pharmaceuticals are necessary for the health and well-being of individuals, it is not feasible to prohibit their use (Jones et al. 2005). Over the past decades, concerns revolved around accidental poisoning of children from improper storage of pharmaceuticals. As a result, regulations have focused on the safe use of pharmaceuticals rather than on the methods for disposal and management (Musson et al. 2007).

Household pharmaceuticals reach the aquatic environment via three main paths: excretion after utilization, disposal either via the municipal wastes or flushing down the toilet to sewer and septic systems and bathing causing the

removal of topical medications (Bound and Voulvoulis 2005; Glassmeyer et al. 2009) (Fig. 1). The disposal of unwanted/unused medications does not contribute substantially to the overall environmental loadings when compared to the direct excretion pathway. However, the disposal route may lead to sporadic spikes in concentrations which could be greater than the concentrations resulting from direct excretion. Moreover, the disposal route has the greatest "control potential" and is considered significant from a pollution prevention standpoint (Daughton and Ruhoy 2008, 2009; Smith 2014). To date, an extensive amount of data has been published 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). Measured concentrations of pharmaceuticals in the influents and effluents of wastewater treatment plants have revealed that these systems insufficiently remove some pharmaceuticals (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) have shown the presence of pharmaceuticals and pharmaceutical metabolites at ng/l concentrations in several potable water systems indicating incomplete elimination. In many developing countries, the extent of the problem is generally unknown (Kookana et al. 2014).

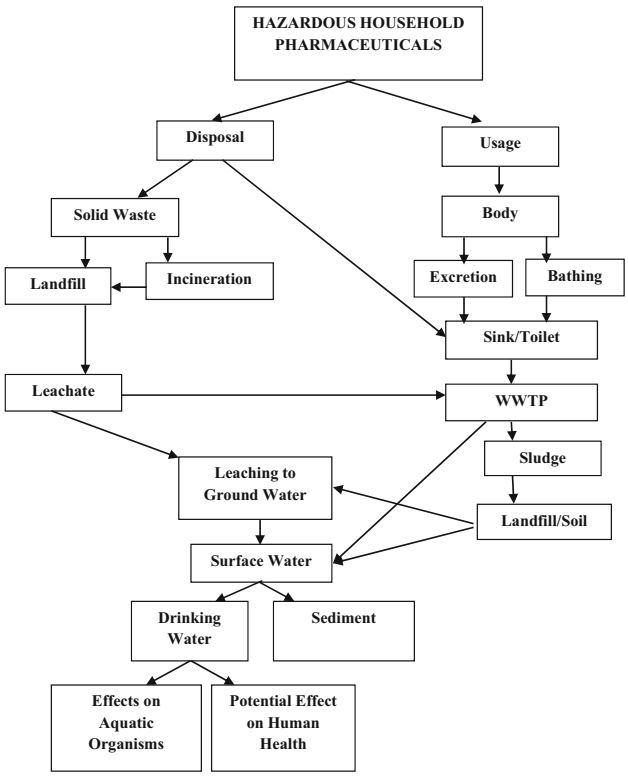

Fig. 1 Pathway of hazardous household pharmaceuticals into the environment (Bound and Voulvoulis 2005; Glassmeyer et al. 2009)

Castensson and Ekedahl (2010) and Tong et al. (2011) surveyed the peer reviewed literature to investigate the attitudes towards disposal of medications and the most popular methods of pharmaceutical disposal employed in a number of countries throughout the world. With the exception of studies conducted in the US, the most predominant method of disposal reported was disposal of medications to the solid waste stream (garbage) followed by home storage (Castensson and Ekedahl 2010; Tong et al. 2011). On the other hand, for countries where take-back programs exist (such as most of the European Countries) return of medications to pharmacists was the most popular method of disposal (Persson et al. 2009). It is worth noting that nationwide pharmacy based "take-back programs" exist in the majority of European countries, while community based take back programs exist in several locations in the US and Australia (Taylor and Poulmaire 2008; Vollmer 2010; Lubick 2010; Thach et al. 2013). The most common disposal method in some parts of the US was through the liquid waste stream, where medications were "poured in the sink" or "flushed down the toilet" (Seehusen and Edwards 2006; Glassmeyer et al. 2009; Tong et al. 2011), while in other parts of the US disposal to garbage was more common (Kuspi and Krenzelok 1996). The method of disposal of pharmaceuticals was influenced by a number of factors such as the dosage form of the medication (suspension/liquid or capsules/tablets or ointment), the type of medication (e.g. cough medicine or antibiotic or painkiller) and availability of "a well-run disposal" system and environmental awareness (Persson et al. 2009; Tong et al. 2011). More recently several new studies have appeared in the open literature where surveys were conducted in Ghana (Sasu et al. 2012), Ireland (Vellinga et al. 2014), Malta and Ireland (Fenech et al. 2013), Qatar (Kheir et al. 2011), Serbia (Kusturica et al. 2012), and the US (Wieczorkiewicz et al. 2013; Law et al. 2015). The results were very similar to those reported in the earlier review papers, where the dominant method of disposal for all countries, including the US, was "throwing medications in the trash".

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, measures, policy reforms and incentive schemes needed to manage household hazardous waste. Moreover, this research study will present a first attempt to tackle the management of pharmaceuticals at the household level in Lebanon, which is expected to provide baseline information needed for future regulatory and developmental national and local projects. Accordingly, the main objectives are to determine the pathway of hazardous household pharmaceuticals to the aquatic environment, investigate the most widely used types and the proportion of unused medications that are disposed, examine residents' willingness-to-participate in any future collection or "take-back" programs of residential pharmaceutical waste and identify steps needed to develop a nationally-applicable collection or "take-back" program of pharmaceutical waste generated at the residential level.

Methodology

Study Area

The study site is the Administrative Beirut Area (ABA) in Lebanon which was chosen based on its representativeness, accessibility and convenience. The ABA is divided into thirteen (13) zones of which three are nonresidential and were excluded given that the research study targets the management of pharmaceutical waste at a residential level. Figure 2 shows a map of the ABA with the cadastral limits of each of its zones.

Study Design

The unit of analysis (study subject) of the study at hand was the household member (interviewee). The sampling units that made up the study sample were the residential households in ABA. The ABA houses a population of approximately 400,000 inhabitants (CAS 2007). In order to estimate the representative number of surveys needed to describe the study area, Eq. 1 was used (Krejcie and Morgan 1970):

$$n = \frac{Z_{0.95}^2 \times p(1-p) \times N}{(N-1) \times m^2 + Z_{0.95}^2 \times p(1-p)}, \quad (1)$$

where n = required sample size; Z = confidence level at 95 % (standard value of 1.96); 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).

Given the absence of any national or local pharmaceutical waste collection or "take-back" program and lack of general awareness among household residents and the findings of several regional studies on pharmaceutical waste management at the residential level (which might be considered culturally comparable), the expected prevalence of disposal of unwanted pharmaceuticals at the residential level in the urban context of the ABA was initially expected to be 75 %. As such, the study sample size was estimated to be equal to 287, which were rounded up to 300 households units. In total 380 questionnaires were eventually distributed to account for the 26.7 % non-response rate. Household questionnaires were conducted between February and April 2014.

The questionnaires were distributed to randomly selected houses in each residential zone, relative to the zone's total population. Only residential buildings (apartments and standalone houses) were included in the random sample selection process; commercial buildings were excluded from the study sample. Random samples of digitized and geo-referenced residential buildings were taken from each zone to choose the targeted buildings. Household units, within each randomly chosen residential building, were then randomly selected. In the event of a non-response, rejection, and inaccessibility, an adjacent building or household unit was selected.

A pre-tested survey questionnaire, in English and Arabic, was developed and used for the acquisition and collection 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 Modeling

Data was coded and entered for subsequent analysis. Data processing and analysis was carried out with the use of two software environments for statistical computing: SPSS®

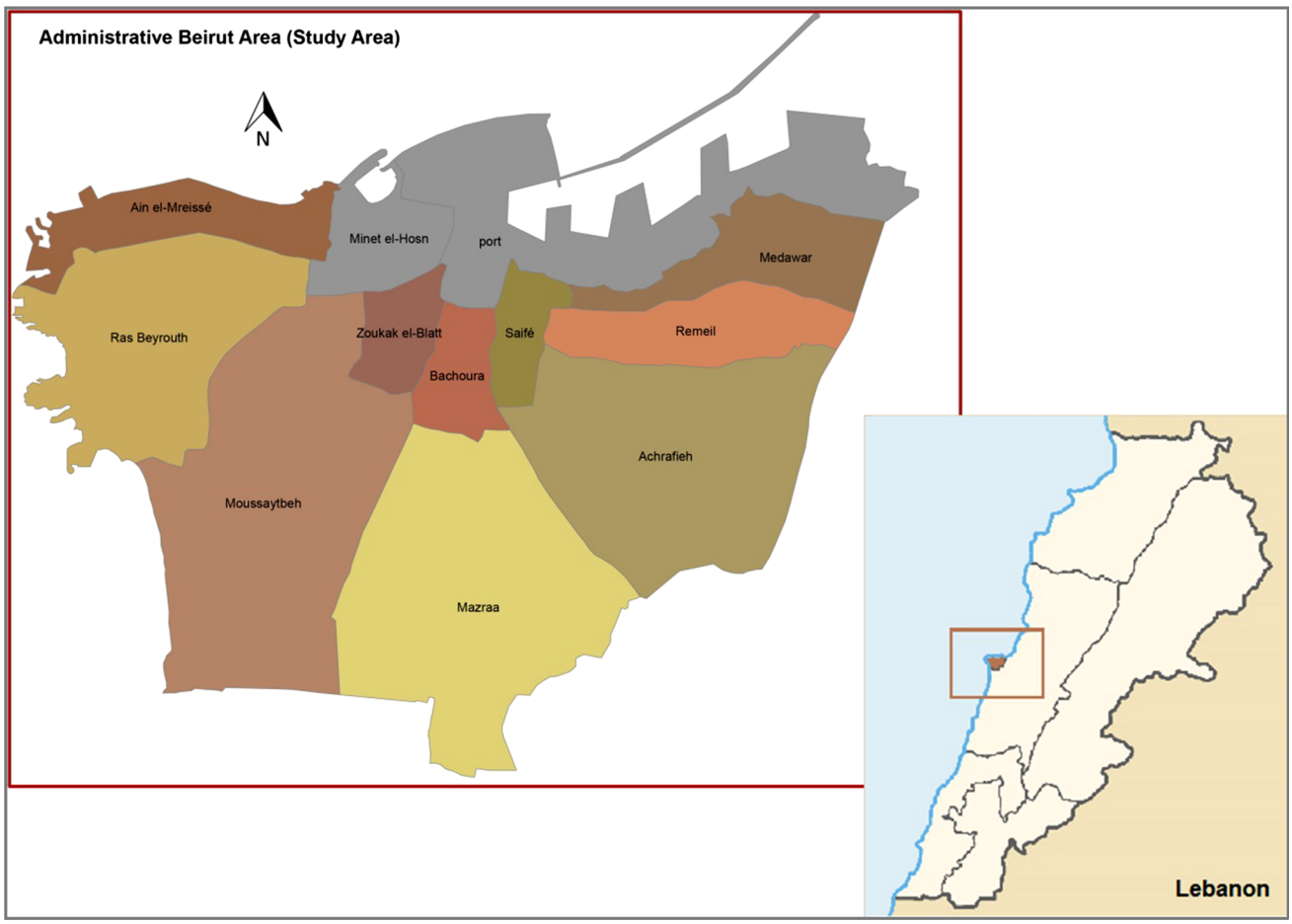

Fig. 2 Map of the study area

(Venables and Ripley 2002) and the nnet® package in R® (R Core Team 2013). Descriptive statistics were carried out to present the frequency distribution of different variables. Continuous variables (age, quantities of consumed prescription pills) were reported in terms of mean and standard deviation. After identifying the main outcomes to be explored by the study and the potentially associated predictors, three statistical models were developed.

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".

A cut-off point for statistical significance was taken at $\alpha = 0.1$, where a P value less than 0.1 indicates a statistically significant association at the 90 % level. Logistic regression models were developed for Model 1 and 2. Final models were selected based on conducting a backward model selection technique on the full model that was initially constructed by including all significant predictors identified earlier from an initial assessment based on univariate model development. Model pruning was based on finding the most parsimonious model, with the lowest Akaike Information Criterion (AIC) score.

$$\ln\left(\frac{P}{1-P}\right) = \log\,(\text{odds}) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon, \quad (2)$$

where P is the probability of the event of the dependent variable Y, α is the intercept parameter, β_i are the slope parameters, X_i are the predictor independent variables, and ε is the error term (Rosburg 2010).

For Model 3, a nominal outcome variable was modeled using a multinomial logistic regression, whereby the odds (or log odds) of a choice were modeled as a linear combination of the tested predictor variables (Bruin 2006; Hasan et al. 2014). The multinomial logistic regression model was used to find the predictors that explained the respondent's preference towards a given future household pharmaceutical waste collection program.

Results and Discussion

Respondents' Demographic, Socio-economic, and Health Characteristics

The sample did not show any gender bias (Table 1). The mean age of the surveyed sample was around 49 years (age ranging from 17 to 88 years). The mean household size (in terms of occupants) was approximately two members per household. Half (50 %) of the respondents held a university degree or its equivalent; note that the high educational level is reflective of ABA and not of Lebanon.

Table 1 Demographic, socioeconomic and medical background of respondents

Characteristics	Frequency (%)
Gender	
Male	148 (49.3)
Female	152 (50.7)
Age, mean (± SD)	48.86 (± 15.815)
Education	
Elementary or less	38 (12.7)
Secondary	112 (37.3)
University (and equivalent)	150 (50.0)
Household size, mean (± SD)	2.47 (± 0.976)
Currently employed	
No	114 (38.0)
Yes	186 (62.0)
Monthly household income (in USD)	
<1000	95 (36.1)
1000–3000	120 (45.6)
>3000	48 (18.3)
Yearly expenditure on medication (USD)	
<1000	185 (64.0)
>1000	104 (36.0)
Healthcare plan	
Public coverage	148 (51.0)
Private insurance	76 (25.0)
None	76 (24.0)

About 60 % of interviewed respondents were employed at the time of the survey. Most of the respondents that were not employed were full-time homemakers, university students, or retirees. More than 60 % of surveyed households had a monthly household income exceeding 1000 USD; the incomes were significantly higher than the 450 USD national minimum monthly wage. Yearly household expenditure on medication exceeded 1000 USD for 36 % of respondents.

Most Commonly Used Types and Quantities of Pharmaceuticals

Forty-six percent (46 %; $n = 137$) of the interviewed respondents had an existing chronic medical condition, similar to the findings of a study conducted by Abou-Auda (2003) in Saudi Arabia, which revealed that 44, 32, and 49 % of household residents with different nationalities, Saudi, non-Saudi, and other Gulf countries, respectively, had at least one chronic disease. Out of the 46 % of respondents who reported having a medical condition, 32 % had hypertension, 21 % diabetes mellitus, and 16 % cardiovascular disorders (Fig. 3). These findings are expected to be somehow representative of the national health profile of Lebanon, where non-communicable chronic diseases prevail among the Lebanese population and are considered the main determinants of morbidity, having 77 % of all reported deaths in year 2002 related to chronic diseases (WHO 2012).

Out of the total number (202) of reported prescription medications, approximately 35 % were blood pressure regulators, 14 % lipid regulators, 8 % blood sugar regulators, and 8 % antihistamines. The most commonly used pharmaceuticals in the blood pressure regulating category were Diltiazem followed by Atenolol and Propranolol. On the other hand, Gemfibrozil, followed by Atorvastatin and Fenofibrate were the most commonly dispensed lipid regulators. Metformin, a blood sugar regulator, Ibuprofen and Acetylsalicylic acid, both anti-inflammatory drugs, were amongst the top five most dispensed medications. Diclofenac and Tiaprofenic acid were the two most commonly prescribed anti-rheumatics.

The average quantity of prescription medication consumed by respondents was approximately 67 dosage units (in the form of pills) per month. According to Abdollahias et al. (2011), drug consumption per capita in Lebanon exceeded 200 per year (measured in Standard Unit, which is a single dosage unit of medication), the second highest after the United Arab Emirates (Abdollahias et al. 2011).

Out of the total reported over-the-counter (OTC) medications stored in the surveyed households, analgesics and pain relievers constituted approximately 55 %. Other reported common OTC products were antiseptics and anti-

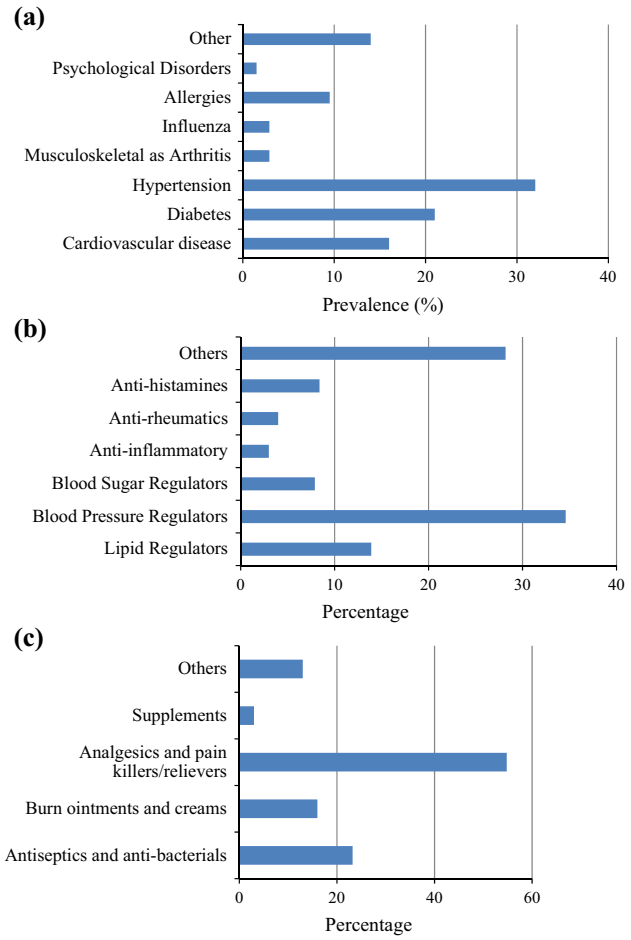

Fig. 3 Prevalence of medical conditions and the consumption of medication among respondents. **a** Type of medical condition; **b** types of consumed prescription medication (total of 202 reported medications); **c** most common types of OTC products stored in household (total of 469 reported medications)

bacterial (23 %), and burn treatment ointments and creams (16 %). More than half of surveyed respondents said that OTC medications were provided upon consultation with a pharmacist without the need for a physician prescription.

The absence of a considerable fraction of antibiotics reported from total consumed medications is considered a peculiar finding compared to the body of literature which provides rather substantial information (around 35 studies) on the most common types and concentrations of antibiotics from human and veterinary sources (Mompelat et al. 2009; Bottoni et al. 2010). Worldwide, antibiotic concentrations in tested tap water were found to be the second highest (Mompelat et al. 2009). Some of the possible reasons that might be linked to this finding may be related to the season during which the survey was conducted, where consumption of antibiotics due to influenza or bacterial infections is expected to be less during summer compared to the cold winter season. Influenza cases made up only 3 % of total reported medical conditions. Another possible reason for low prevalence of reported consumed antibiotics may be related to the short medicinal course as compared to medications needed for chronic illnesses taken for prolonged and even life-long durations. On the other hand, leftovers of antibiotic regimens is not expected to be likely because such medications need to be taken as full course for desired treatment efficacy.

Current Practices Regarding the Management of Household Pharmaceutical Waste

About 20 % of respondents reported that they had remaining medications at home by the time of the survey (Table 2). Ninety-four percent (94 %) of respondents disposed of their unwanted medications, with 67 % disposing them due to medication expiry, followed by 27 % due to completion of treatment. This is comparable to results obtained from a pilot study conducted in Alachua County Florida, where the main reason for throwing away unwanted medication was

Table 2 Respondents practices for the management of unwanted medications at the residential level

Characteristics	Frequency (%)
Dispose of unwanted medications ($N = 300$)	
No	18 (6.0)
Yes	281 (94.0)
Reason for disposing of unwanted medications ($n = 281$)	
Completion of treatment	77 (27.4)
Expiry of medication	188 (66.9)
Other	16 (5.7)
Disposal methods of unwanted medications	
Solids ($n = 281$)	
Toilet/sink	17 (6.0)
Garbage/solid waste stream	220 (78.3)
Return to pharmacy	10 (3.6)
Give to nearby dispensary/people in need	24 (8.5)
Other	10 (3.6)
Liquids ($n = 270$)	
Toilet/sink	46 (17.0)
Garbage/solid waste stream	196 (72.6)
Return to pharmacy	4 (1.5)
Give to nearby dispensary/people in need	12 (4.4)
Other	12 (4.4)
Creams/ointments ($n = 275$)	
Toilet/sink	15 (5.5)
Garbage/solid waste stream	239 (86.9)
Return to pharmacy	2 (0.7)
Give to nearby dispensary/people in need	7 (2.5)
Other	12 (4.4)

due to the expiry of the medicinal product (Musson et al. 2007).

Interviewees who disposed of their unwanted medications were asked to specify the most common method of disposal of common forms of medication (solid form: tablets, capsules; liquid form: syrups and suspensions; and semi-solid form: creams/ointments). Respondents who reported disposing of their unwanted solid medications did so primarily through the municipal solid waste stream (78 %) (Table 3). Sixty-nine percent (69 %) of respondents who reported disposing of unwanted medications consider their method of disposal the best.

Seventy-three percent (73 %) of respondents who disposed of their liquid medications threw them out with the household solid wastes, followed by 17 % who emptied leftover bottles into the drain, and 4.4 % who gave them to a nearby dispensary or to people in need. About 71 % of respondents considered that their method of disposing of leftover liquid medication was appropriate. As for the disposal of unwanted creams and ointments (semi-solid medications), the vast majority (87 %) of respondents got rid of them through the solid waste stream (Table 2). The majority of respondents (72 %) considered their practiced method of disposal of semi-solid unwanted medications (creams and ointments) the best method for disposal.

The results clearly show that the primary disposal method is through the solid waste stream (garbage), which is considered by the majority of respondents as the most practical and the safest method. Considering that there is no organized pharmaceutical waste collection and disposal schemes in Lebanon, discarding of unwanted medications in the solid waste stream may appear to be the most acceptable and practical means of disposal at the residential level as reported in earlier (Kuspi and Krenzelok 1996; Abahussain and Ball 2007) and more recent studies (Kusturica et al. 2012; Law et al. 2015). Although the findings of this study showed that disposal in the domestic solid waste stream was the predominant method practiced at households irrespective of the product form (solid, liquid or cream), some studies have shown differences in disposal preferences depending on the form of disposed medication. For instance, a study conducted in New Zealand in 2009 showed that most respondents preference towards the disposal of unwanted medications varied by the product form (Braund et al. 2009).

The ever-increasing amount of solid waste generation has created disposal problems for many developing countries and Lebanon is no exception. Refuse generation continues to increase with population and economic growth rendering waste management as one of a host of challenging development related issues that the governments in developing countries are facing. Open dumping is commonly practiced in these countries, thus the disposal of unwanted medications in the solid waste stream may aggravate the problem and lead to the contamination of water supplies. Moreover, medications may end in the hands of scavengers and children if the waste is open dumped or may be diverted to the market for resale and misuse.

Knowledge, Perception of Risk and Willingness to Participate in Future Intervention Programs

Ninety-five percent (95 %) of respondents did not receive any kind of awareness or guidance on the proper disposal methods for pharmaceuticals (Table 3). The lack of an informed public and the absence of any awareness or guidance programs might be attributed to the lack of a national framework, program, or guidelines related to the management of pharmaceutical waste generated at the residential level. The majority of interviewees agreed that awareness and guidance on the proper and safe disposal of unwanted household pharmaceutical products was necessary, and agreed that quantities of generated pharmaceutical waste can be reduced mainly through introducing awareness programs to the end users and through accurate prescription of medication by physicians.

About 85 % 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 behavior, 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 87 % of respondents thought that there should be a collection/take back program for pharmaceutical waste generated by residences. Seventy-five percent (75 %) of respondents who thought there should be a local collection/take back program favored the Lebanese Ministry of Public Health (MoPH) as the prime responsible entity for organizing and steering such a future intervention program. About 70 % of the respondents favored the option of a public sector intervention program, whereby 42 % were in favor of storing unwanted medications in separate bags and disposing of them in public pre-defined drop-off points and around 30 % preferred storing them in separate bags to be collected by the municipality. Around 17 % preferred returning them to the pharmacy, followed by 12 % who were willing to give them to people they knew in need or to a nearby dispensary (Table 3). Note that the lower preference of respondents towards the option of returning to a pharmacy as compared to a public sector intervention program might be attributed to their greater faith in a

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	280 (94.6)
Yes	16 (5.4)
Awareness/guidance provided by	
Physician	1 (6.3)
Pharmacist	2 (12.5)
Friend	3 (18.7)
Other	10 (62.5)
There should be awareness/guidance on proper management of unwanted medication	
No	24 (8.3)
Yes	266 (91.7)
Best way for reducing quantity of unwanted medication at the residential level	
Awareness programs	135 (45.9)
Collection/take back systems	56 (19.1)
Accurate prescription of medication	83 (28.2)
Other	20 (6.8)
Have heard of any law/legislation related to management of unwanted medication	
No	278 (92.7)
Yes	22 (7.3)
There should be law/legislation related to management of unwanted medication	
No	60 (21.4)
Yes	221 (78.6)
Improper management of unwanted medication poses environmental and public health threats	
No	35 (13.0)
Yes	234 (87.0)
There should be a collection/take back program for unwanted medication from households	
No	38 (13.3)
Yes	248 (86.7)
Responsible entity for collection of unwanted medication from households	
Ministry of public health	203 (74.9)
Others	68 (25.1)
Willingness to participate in any future household pharmaceutical waste collection/take back program	
No	27 (9.6)
Yes	253 (90.4)
Preferred option of future household pharmaceutical waste collection program (future intervention)	
Return to pharmacy	48 (16.8)
Public sector (governmental) intervention program	205 (71.6)
Give to people in need	33 (11.6)
Willingness to participate in any future household pharmaceutical waste collection/take back program for a fixed fee	
No	72 (28.3)
Yes	182 (71.7)

government-led program versus any other program or their preconceptions related to the possibility of pharmacies illicitly re-selling returned medications. Respondents' preferences for a drop-off points collection program in this study converges with the findings of another study conducted in Kuwait (Abahussain and Ball 2007), where more than half of the participants believed that returning unwanted household medications to drop-off boxes in assigned pharmacies was the most preferred option, followed by 21 % who voted for the option of secured drop-off bin points in shopping malls made available to the public.

The majority of respondents (90 %) reported that they were willing to participate in any future collection or take-back program related to pharmaceutical waste generated at the residential level. This may be attributed to their environmental and health risks perception associated with the currently practiced disposal methods. Nevertheless, the proportion of those willing to participate decreased to 72 %, when asked if they were willing to participate for a fee.

Factors Influencing Willingness to Participate in and Preference of Waste Collection Programs

Several predictor variables for willingness to participate were found to be significant when conducting the univariate logistic regression analysis. These included "*Age*", "*Need for a collection/take-back program", "Preferred responsible entity for any future collection program*", "*Need for awareness/guidance programs on the proper management of household unwanted medication*", "*Perception of danger*", "*Perception of environmental and health risks*", and the "Ne*ed for a law/legislation related to the management of unwanted medication at the residential level*". These predictors were then subjected to a multivariate logistic regression analysis (Table 4). As previously mentioned, backward model selection was carried out on the full model to obtain a parsimonious model with the lowest (AIC) score.

"Age" was found to be a significant predictor of willingness to participate on the multivariate level (OR = 0.967, $P = 0.050$), where with every 10 year decrease in age, respondents were, on average, 1.4 times more likely to participate in future collection programs as compared to younger participants. This may be attributed to younger individuals being more proactive with regards to environmental issues. This finding appears to disagree with one of the significant correlations drawn by a study conducted by Kotchen et al. (2009), where elderly individuals were more likely to demonstrate willingness to participate. Another pilot study carried out by Braund et al. (2008) in New Zealand showed that the majority of those who participated in returning their unwanted medications to one of the two assigned collection points were aged between 61 and 80 years old.

"Household yearly expenditure on medication" was another significant factor for predicting willingness to participate in a future household pharmaceutical waste management program (OR = 3.413, $P = 0.038$). Respondents who reported that their household spends more than 1000 USD yearly on medications were, on average, 3.4 times more likely to be willing to participate in future collection program as compared to households who spent less than that.

Respondents who believed in the necessity of a collection/take back program for unwanted pharmaceutical waste at the residential level were on average 6.3 times more likely to participate in any future relevant program than respondents who did not. This could be attributed to the fact that these individuals are generally more environmentally aware and as such can better appreciate the benefits of establishing such programs for the proper management of pharmaceutical waste.

Similar to the above analysis, the main factors influencing respondents' willingness to participate for a fixed fee were screened. Univariate logistic regression analysis was conducted to find significant predictors. The significant predictors included *"Age", "Need for awareness on proper management of unwanted medication at the residential level", "Need for a law/legislation related to the management of unwanted medication at the residential level", "Need for a collection/take-back program for unwanted pharmaceutical waste at the residential level",* and "*Willingness to participate in a future household pharmaceutical waste collection program*". Significant predictor variables resulting from the univariate logistic regression analysis were then subjected to multivariate logistic regression analysis (Table 5).

Table 4 Multivariate logistic regression (Model 1) of significant variables associated with respondents' willingness to participate in future household pharmaceutical waste collection program

Variable	*B*	S.E.	Exp (*B*)/adjusted odds ratio (OR)	90 % CI	*P*-value
Intercept	2.266	1.002	9.640	–	–
Age	−0.034	0.017	0.967	(0.940–0.995)	0.050
Yearly household expenditure on medication (USD)					
<11,000[a]					
>1000	1.228	0.593	3.413	(1.288–9.046)	0.038
Think there should be a collection/take back program for unwanted medication from households					
No[a]					
Yes	1.834	0.515	6.259	(2.684–14.593)	<0.001

S.E. standard error; *CI* confidence interval of OR

[a] Integrated with the intercept

Table 5 Multivariate logistic regression (Model 2) of significant variables associated with respondents' willingness to participate in future collection program for a fixed fee

Variable	*B*	S.E.	E xp (*B*)/adjusted odds ratio (OR)	90 % CI	*P*-value
Intercept	−0.392	0.775	0.676	–	–
Age	−0.023	0.011	0.978	(0.96–1.00)	0.032
Think there should be law/legislation related to management of unwanted medication at the residential level					0.002
No[a]					
Yes	1.080	0.357	2.944	(1.64–5.30)	
Willing to participate in future household pharmaceutical waste collection program					0.002
No[a]					
Yes	1.791	0.570	5.995	(2.35–15.32)	

S.E. standard error; *CI* confidence interval of OR

[a] Integrated with the intercept

The *"need for a law/legislation related to the management of unwanted medication at the residential level"* was found to be a strong significant predictor of willingness to participate for a fixed fee (OR = 2.944, $P = 0.002$) (Table 5). Respondents who favored the presence of a law were, on average, 2.9 times more likely to participate in a household pharmaceutical waste collection program for a fee as compared to those who did not believe there was a need for regulation.

Similarly, the "*willingness to participate in a future household pharmaceutical waste collection program*" was a strong predictor influencing respondents' willingness to participate with a fixed fee (OR = 5.995, $P = 0.002$). Respondents, who stated a willingness to participate, were on average, 6 times more likely to participate even when a fixed fee was introduced as compared to those who did not demonstrate a willingness to participate in the first place. "Age" (OR = 0.978, $P = 0.032$) was found to be a significant predictor variable of willingness to participate for a fixed fee, where with every 10 year drop in age, respondents were, on average, 1.3 times more likely to participate in a collection program for a fixed fee. This contrasts to the findings of Thach et al. (2013), where it was reported that older participants had more favorable perceptions about paying for a take-back service.

An assessment of the main factors influencing people's preference towards different waste collection program was conducted. Respondents who saw that there was a "need for awareness" were less likely to approve of the option of "return to pharmacy" as compared to the option of a "public sector intervention program" (OR = 0.346, $P = 0.077$ significant at 90 % CI; Table 6). On the other hand, the importance of awareness was not a statistically significant factor to distinguish between respondents' preference towards giving their unwanted medication to people in need and the option of a taking part in a public intervention collection program. This indicates that respondents who see a need for awareness programs believe in a bigger governmental role in regulating the sector.

Respondents that indicated their "willingness to participate in future household pharmaceutical waste collection program," were less likely to opt for giving their extra medications to people in need as compared to the option of a "Public sector intervention program"; the OR was 0.234 (Table 6). According to these results, individuals who have stated a willingness to participate in a future program would probably prefer managing their unwanted medication in an official framework of a collection program organized by a public sector entity, for instance the MoPH. Their preference could be due to their higher faith and trust in a program organized and managed by the government as compared to the private sector. The option of gifting medication to people in need ranked low due to the fact that in the absence of a supervision and approval of a medical physician, liability might be a concern.

"Age" proved to be a significant predictor of people's choices of pharmaceutical waste management. A 10-year decrease in respondents' age was associated with a drop in the odds of giving unwanted medication to disadvantaged people (people in need) versus favoring a public sector intervention program (OR = 1.034, $P = 0.022$ significant at 95 % CI). Possible reasons that may be attributed to older respondents' inclination for re-gifting their unwanted medications to people in need might be out of their personal concerns and preferences in the humanitarian aspect of managing unwanted pharmaceuticals rather than the environmental or safety implications of proper management. Older respondents might also prefer bypassing official channels or programs for pharmaceutical waste collection probably because of their fear that these products might be

Table 6 Multinomial logistic regression of significant variables associated with respondents' preference of future household pharmaceutical waste management program

Preferred choice of future household pharmaceutical waste collection program	Predictor variable	*B*	S.E.	Exp (*B*)/ adjusted odds ratio (OR)	90 % CI	*P*-value
Return to pharmacy	Intercept	−1.226	1.279	0.293	–	–
	Willing to participate in future household pharmaceutical waste collection program	1.253	1.056	3.501	(1.764–5.238)	0.235
	Think there should be awareness on proper management of unwanted medication at the residential level	−1.061	0.600	0.346	(0.641–1.333)	0.077
	Age	−0.008	0.011	0.991	(0.973–1.009)	0.444
Give to people in need	Intercept	−1.487	1.112	0.226	–	–
	Willing to participate in future household pharmaceutical waste collection program	−1.451	0.540	0.234	(0.654–1.122)	0.007
	Think there should be awareness on proper management of unwanted medication at the residential level	−1.020	0.735	0.360	(0.849–1.569)	0.165
	Age	0.033	0.014	1.034	(1.011–1.057)	0.022

Reference group: public sector intervention which includes: (1) store in separate bags to be collected by municipality and (2) store in separate bags and dispose of in pre-defined drop-off points

S.E. standard error; *CI* Confidence interval

manipulated or illicitly re-sold. Moreover, they might have a wider and a more diverse social circle than younger people that would enable them to better identify individuals in need of their unwanted medications. On the other hand, younger respondents might tend to avoid liability associated with "gifting" remaining medications, especially if not examined or approved by a physician. Age was not a significant predictor when it came to choosing between a pharmacy based collection system as compared to one managed by the public sector.

Overall, age was found to be consistently a significant good predictor of willingness to participate in a pharmaceutical waste management program irrespective of the associated costs. Younger respondents were found to be on average more supportive of a pharmaceutical waste management program than their older counterparts. Surprisingly, educational level, gender, and income did not prove to be significant factors affecting people choices. Preference towards future household pharmaceutical waste management program was also found to vary as a function of age, highlighting the large differences between the age group consuming the largest quantity of drugs on one hand and the most environmentally affirmative age group on the other.

Conclusions and Recommendations

Results revealed that the majority of respondents dispose of their unwanted medications, mainly through the domestic solid waste stream, irrespective of the product. Predominantly, pharmaceuticals were disposed due to product expiry and the completion of treatment. Awareness programs and physician accurate prescription were considered to be the best ways for reducing the quantities of unwanted leftover medications. Household yearly expenditure on medications and respondents' belief in the need for pharmaceutical waste collection program increased the odds of respondents' willingness to participate in a future collection program. Respondents who stated a willingness to participate and those who thought there was a need for a legislation to regulate and organize the management of household pharmaceutical waste were more likely to participate in a future collection program for a fixed fee as compared to those who thought otherwise. Younger participants were found to have a higher willingness to participate and willingness to participate for a fixed fee compared to older participants. On another note, younger respondents were less likely to prefer a future collection program with the option of "Give to people in need" as compared to the option of a "public sector intervention program."

While there was an overall preference towards governmental intervention, product stewardship and the shared responsibility that the manufacturers of the pharmaceuticals have with the government should be taken into consideration in any public/government intervention program or scheme. 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, bear the costs of environmental management, and gain trust from their consumers.

The factors that have been identified in this study to influence consumers' behavior, attitudes, and perceptions on the management of household pharmaceuticals should be considered, while identifying the steps needed to develop a nationally-applicable collection program. In order to stir and develop the understanding, knowledge and perception among consumers, awareness and guidance programs should be planned and delivered to the largest possible audience on the possible risks associated with improper domestic pharmaceutical waste management and the potential environmental and public health benefits from proper storage, collection and disposal practices. 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.

Common to any local or nationwide planning, coordination and collaboration among all concerned entities, namely the Ministry of Public Health, Environment, and Industry, and the Lebanese Orders of Physicians and Pharmacists, in addition to the pharmaceutical manufacturing sector, are crucial for developing national or local collection programs steered by the public sector. Physicians and pharmacists should focus on measures to reduce over-prescribing and over-dispensing of medications and emphasize on the need for patient compliance, in order to minimize the quantities of generated household pharmaceutical waste (source reduction). This, however, is specifically challenging given the absence of any regulatory text that regulates and monitors physicians' prescriptions of medication. National pharmaceutical manufacturers are also advised to consider producing and packaging a list of common medications that are prescribed in different treatment regimens (dosages or dosage units). Most importantly, a well-tailored future intervention program should be pilot tested for feasibility, accessibility, acceptability and practicality to its beneficiaries to ensure its success and sustainability.

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