

A Threat to the Environment from Practice of Drug Disposal in Thailand

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Abstract

Medicine contains active pharmaceutical ingredients which may do harm to the environment when dispersed into the environment. Once people have leftover medicines, if they discard them incorrectly, these medicines will contaminate the environment. This study determined how Thai villagers stored and disposed their medicines. A survey study of 331 subjects was conducted in 4 villages of Khon Kaen suburb by interviewing about what medications they stored, how they stored and how they managed their leftover medicines. The study showed that 89.4% of people kept some kind of drugs in their houses. Neuromuscular drugs were the most common group. The study revealed that there were leftover medicines at homes and they discarded them when unwanted. The most common method of discard was trashing in to rubbish bin. This method accounted for 81.4%, 64.6% and 66.6% of solid dosage form, liquid dosage form and external use drugs respectively. Liquid dosage forms were also put into the drainage system (7.4%). These disposal methods are discussed as non environmental friendly methods as the active pharmaceutical ingredients could eventually get into surface water and then may unconsciously get back to people through tap water and drinking water. This study alerts the concern for more appropriate means of drug disposal in Thailand.

Keywords : drug disposal; leftover drug; pharmaceutical in wastewater; waste

1. Introduction

Medicines involve, more or less, everybody in daily life. Medicines contain active pharmaceutical ingredients which may be toxic to the environment if they, intentionally or unintentionally, reach the environment. The active pharmaceutical compounds can leak into the environment in every step of a drug's life cycle: manufacturing, distribution to the consumer, consumption by consumer and discarding of the leftover or unused medicine by consumer. With the strict legislation of good manufacturing practice (GMP) and good delivery practice (GDP), very little of active pharmaceutical ingredient should leak into the environment (Velagaleti *et al.*, 2002). However when consumers do not finish their medications, disposal of these leftover medicines may result in pollutants in the environment (Ruhoy and Daughton, 2007). A review of disposal practices for unused medicines around the world by Tong *et al.* (2011) revealed that the most popular method for household drug disposal was by trashing into garbage (ranging from 24% to 89%) or rinsing down a toilet or sink (ranging from 2% to 55%). Solid dosage forms were more likely to be put into rubbish and liquid dosage forms were more likely to be poured into drainage (Tong *et al.*, 2011). Eventually, if not degraded by sewage treatment processing, the active pharmaceutical

ingredients from these two disposal methods may finally enter the environment. Although in some countries, the sewage is treated before re-entering the environment, the active pharmaceutical constituents may not be removed because the conventional sewage treatment is designed to improve only the bulk properties such as color, odor, total level of suspended solids, biological oxygen demand and pH that is acceptable for discharging. Conventional sewage treatment facilities are generally not designed to deal with pharmaceutical compounds due to their highly variable physical and chemical properties, (Jones *et al.*, 2005; Fent *et al.*, 2006). In Sweden, where there is high public awareness concerning disposal of unused medicine into garbage or sewage, Persson *et al.* (2009), found in a survey that 42% of the respondents returned the unused medicines to a pharmacy for proper disposal, 55% kept them at home. There was only about 2% put the unwanted medicines into trash. More interesting, 42% compared to 26% of the respondents said that they were worried about environmental pollution caused by the medications in the 2007 and 2004 survey studies respectively. (Persson *et al.*, 2009). Similarly, in a Dutch survey, up to 80% of people returned the unwanted medicines to pharmacy or to chemical waste facility because they were concerned about the environmental toxicity caused by unwanted medicines.

In Thailand, a country which has about 65 million population and where medicine consumption is about one third of total health expenditure or about 2% of GDP, there is no data about how people manage their unwanted drugs. This study was, therefore, conducted to determine what Thai people do with their unwanted medicines and considered in aspects of impact that might have on the environment.

2. Methodology

This study was conducted in Ban Ped sub-district, Khon Kaen City, Thailand. This area is a suburb of Khon Kaen City. The study was carried out during November 2009 till March 2010. The area of study was composed of 1,307 houses in 4 villages. The sample size for study was calculated by

$$N = \text{population size} / [1 + \text{population size} (e)^2]$$

where e was a level of precision and was set to 0.05 (Yamane, 1967). Three hundred and thirty one study samples were grouped into 4 clusters according to the villages and random sampling was conducted in proportion to the population of each cluster. Structured interviews were used in this study. Study participants were, mainly, asked about what medicines they had, how they stored their medicines and how they managed their unwanted medicines. The interviewer also asked for a permission to observe and to identify the stored items as well as to record the data. If a solid dosage form of medicine or external use medicine had changed from

its original appearance, it was defined as deteriorated. Deterioration of a liquid dosage form was accounted if its color changed or it precipitated or it appeared to have non-homogeneous texture after shaking. Recorded data were analyzed. Descriptive statistic was used to analyze data into percentage of practice and Chi-square was tested to determine the difference between groups.

3. Results

Table 1 showed the demographic data of the study samples. Of this 311 study samples, 278 subjects had kept some kind of drugs in their houses (89.4%). There were 1,428 items of medicines found in this survey. Drug for neuromuscular disorders was the most common stored item (Fig. 1). The medications were kept in various conditions as shown in Fig. 2. Some medications were observed deteriorated by physical appearance (Table 2). From the interview, it was found that people did dispose the unused medicines when they did not want them as a general behavior. Reasons for disposal of medicine are shown in Fig. 3. Trashing unwanted medicines into rubbish bin was the most common method of disposal for all dosage forms (Table 3). Although there were more female than male in this study, there were no significant differences of storage and disposal practices between genders. Neither was any significant differences found with regarding to education, career and income versus practice of storage and disposal.

Table 1. Demographic data of the 311 study samples

Character	Description	No. (%)
Gender	Male	108 (34.7%)
	Female	203 (65.3%)
Education	No education or lower than primary school	40 (12.9%)
	Primary school	140 (45.0%)
	Secondary and high school	70 (22.5%)
	Vocational school	11 (3.5%)
	University level	50 (16.1%)
Career	Unemployed	85 (27.3%)
	Employee	88 (28.3%)
	Farmer - Agriculture	53 (17.0%)
	Government service	35 (11.3%)
	Own business	28 (9.0%)
	Student	12 (3.9%)
	Retired	10 (3.2%)
Income	≤ 4,000 Baht/month (≤ 135 \$/ month)	117 (37.6%)
	4,000 - < 6,000 Baht/ month (133 - < 200 \$/ month)	63 (20.2%)
	6,000 - < 8,000 Baht/ month (200 - < 266 \$/ month)	27 (8.7%)
	8,000 - < 10,000 Baht/ month (266 - < 333 \$/ month)	31 (10.0%)
	≥ 10,000 Baht/ month (≥ 333 \$/ month)	73 (23.5%)

Table 2. Number and percentage of drug observed deteriorated.

Dosage form	No. observed deteriorated	% observed deteriorated
Liquid dosage form	14/216	6.5%
Solid dosage form	35/996	3.5%
External use drug	13/216	6.0%

Table 3. Practice actions to unwanted medicines of the study samples

Drug Dosage Form	Practice for unwanted medicine				
	Returned to Pharmacy	Trashed to rubbish bin	Put into drainage system	Land filled	Never discarded
Liquid dosage form	0	201 (64.6%)	23 (7.4%)	0	87 (28.0%)
Solid dosage form	3 (1%)	253 (81.4%)	0	5 (1.6%)	50 (16.0%)
External use drug	0	207 (66.6%)	0	2 (0.6%)	102 (32.8%)

4. Discussion

This study showed that nearly 90% of people stored some type of medicines at home. Most of the study participants had experience of medication disposal. The most common method of medication dispose was trashing into a rubbish bin, no matter which dosage form it was (64.6% for liquid dosage form, 66.6% for external use drug and 81.4% for solid dosage form). Previous studies of several groups revealed similar results that the most common method of drug disposal was trashing into garbage; 97% in Kuwait (Abahussain *et al.*, 2007), 89% in Lithuania (Krupiene and Dvarioniene, 2007), 63% in the United Kingdom (Bound and Voulvoulis,

2005), 51% in New Zealand (Braund *et al.*, 2009) and 45% in the United States (Kotchen *et al.*, 2009). Trashing unwanted drugs into garbage will finally end up with active pharmaceutical ingredients widely spread into the environment. Neuromuscular drugs were the most common group stored in houses from this survey (Fig. 1) then, when unwanted they would be discarded. This finding was in accordance with previous studies which found that neuromuscular drugs like diclofenac, ibuprofen, and mefenamic acid were often found in effluent of sewage treatment plants; 86%, 84% and 81% of sample water respectively (Thomas and Hilton, 2004; Ashton *et al.*, 2004). Drug storage places in Fig. 2 showed that medicines were kept in inappropriate places

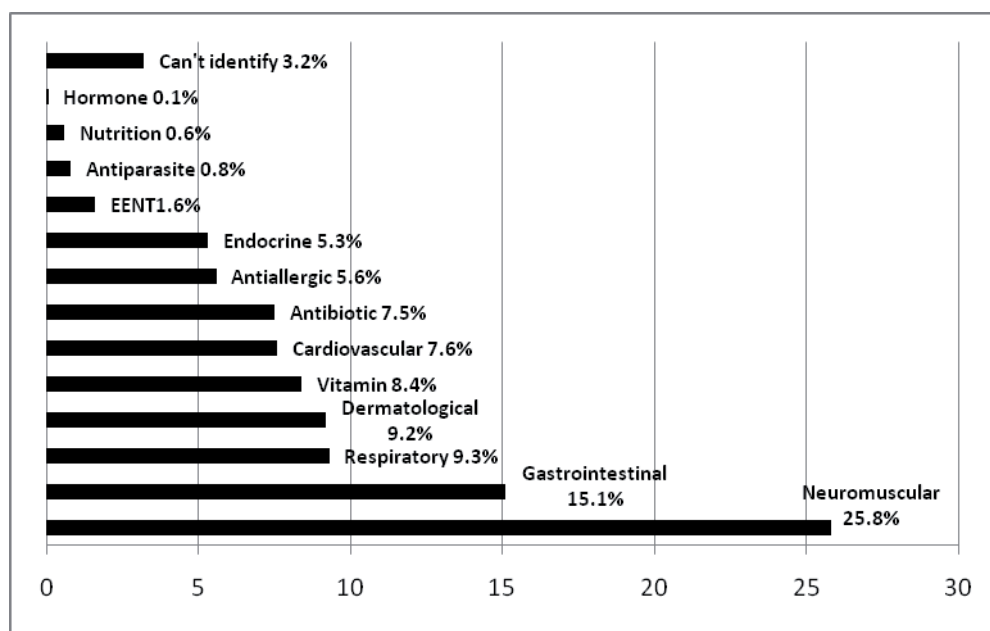


Figure 1. Percentage of medicine kept in a house classified by drug group (EENT =Eye, Ear, Nose, Throat)

more than in appropriate places. This might accelerate the degradation process then deteriorated the medicines and they would be discarded. However, Fig. 3 revealed that there were several reasons people disposing their unwanted medicines. No matter which reason of drug disposal, the pharmaceutical active ingredients would get into environment inevitably. Bound *et al.* (2006) investigated the link between perception of risk to environment and drug disposal behavior. They found no link between perception of risk to environment and disposal methods.

Pal *et al.* (2010) summarized in a review article that antibiotics, analgesic and anti-inflammatory drugs, anti-epileptics, beta blockers, hormones and lipid lowering agents were detected in effluent of wastewater treatment plants/ sewage treatment plants and in fresh water /river/ canals in regions of North America, Europe, Asia and Australia. The presence of active pharmaceutical ingredients in the aquatic system brings up a concern that these pharmaceutical compounds may get into drinking water. Therefore, water soluble residual active pharmaceutical compounds may remain in the tap water and drinking water. Indeed, Mompelat *et al.* (2009) reported that 17 pharmaceutical products and 5 pharmaceutical by-products were found in drinking water with concentration between 1.4 ng/L and 1,250 ng/L. Non steroidal anti-inflammatory drugs (NSAIDs), carbamazepine and iodine were among the highest concentration of detected substances (Mompelat *et al.*, 2009). Safholm *et al.* (2012) demonstrated that hormone pollutants might pose a threat to reproduction in wild amphibian populations.

Although presence of active pharmaceutical compounds in aquatic systems resulted from various

routes i.e., drug excreted from human usage, disposal of domestic sewage, effluents and runoff from animal farms, effluents from hospitals, it cannot be denied that individual household disposal of unwanted drugs adds up the toxic substances to the environment. Even a seemingly insignificant amount discarded compared to the huge volume of natural water resources, discarding of each individuals waste every day may accumulate active pharmaceutical compounds to toxic levels eventually. At present, toxic concentrations of each active pharmaceutical substance were not well established, but Lin *et al.* (2008) introduced the term 'lowest predicted no effect concentration (lowest PNEC)' to describe this toxic level. Lowest PNEC is described as the minimal inhibitory concentration or lowest observational concentration or toxicity threshold for the most sensitive species in that environment (Lin *et al.*, 2008). The lowest PNEC of various active pharmaceutical compounds has been summarized in a review article written by Pal *et al.* (2010). Some pharmaceutical substances in waste water of some regions have already been reported as higher than the lowest PNEC (Pal *et al.*, 2010).

More appropriate management of unwanted medicines has been an issue of campaign in some developed countries in the last two decades. In 1996, Canada launched the 'ENVIRx Disposal Program'. They allowed consumers to return all unused medications to pharmacies for incineration (Gagnon, 2009). Australia initiated the 'Return Unwanted Medicines' Project, since 1998. In this project, patients are asked to bring unwanted or expired medicines to any pharmacy, where the pharmacist collects them in a special bin for correct disposal (The RUM project). European Union Directive

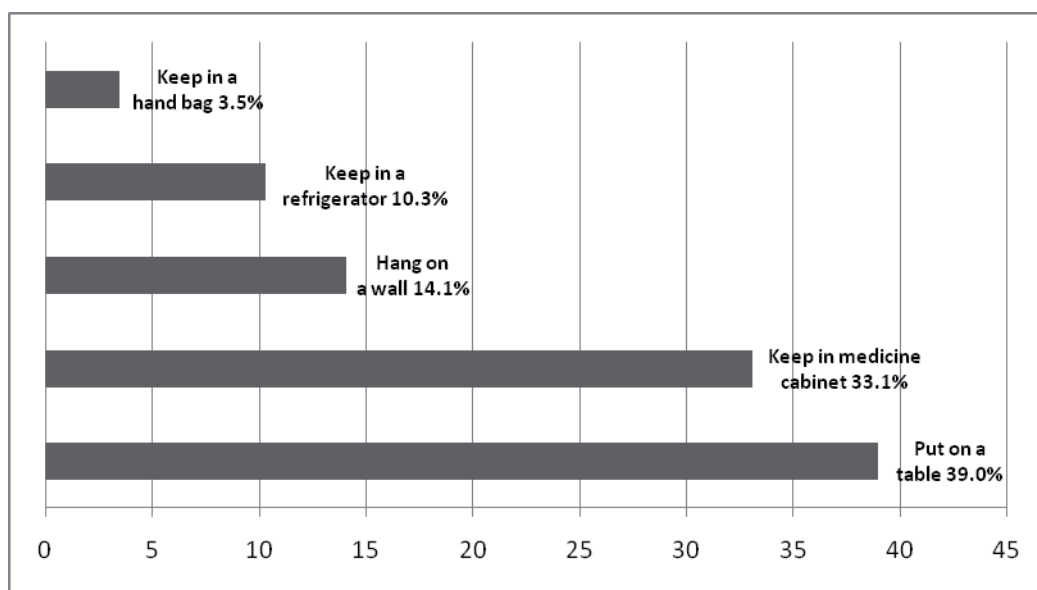


Figure 2. Percentage of medicine storage place

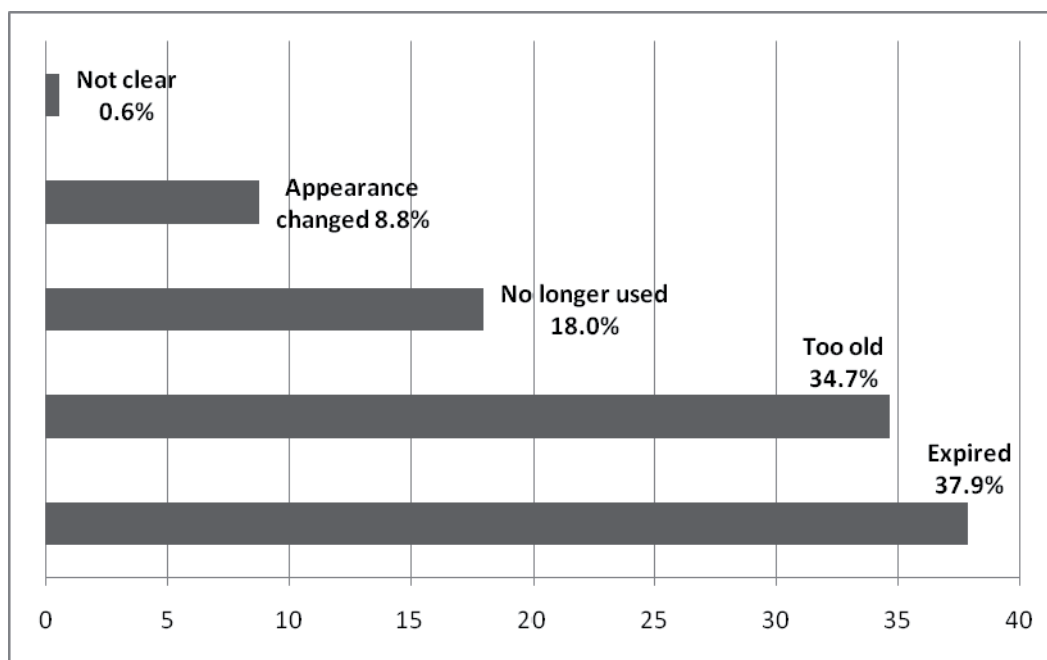


Figure 3. Percentage of reason to dispose medicines

2004/27/EC (2004) required that member states should ensure appropriate collection systems for unused or expired medicinal products. Pharmacy-based collection system to manage with unwanted medicines is a common system of the member states. The US issued federal guidance for consumer drug disposal in 2007 (Office of National Drug Control Policy; ONDCP) and SMARxT Disposal program in 2008 (SMARxT Disposal). These two programs suggested people not to flush medications down the toilet. However, the ONDCP guidance still recommended flushing down thirteen drugs with high potential for abuse or those acutely toxic in order not to get available to other people accidentally. In Thailand, concern about environmental toxicity from disposal of unwanted medicines in the general public is low. The community pharmacy association ran 'Return Your Unwanted Medicines to Pharmacy' program to promote a more appropriate disposal of unwanted medicines, but this project was just one week event. It was not a continuous program and, therefore, it was not strong enough to build up public concern about this aspect. In 2012, the Ministry of Public Health launched a project called 'Exchange Old Unused Medicines for Eggs' in order to estimate the volume and value of unused medicines. Again, this project was just one week event and the amount and value of returned medicines have not yet been revealed to public (Old Medicines for Eggs, 2012).

Retention and disposal of unused medication is a problem not only as a threat to the environment but also a risk to harm to other people accidentally and problem of financial loss too. Daughton and Ruhoy (2008) introduced a new term 'PharmEcovigilance' to alert peo-

ple that (1) Leftover drugs, when disposed improperly represent a diverse source of potential chemical toxicity to the environment, (2) Leftover drugs reflect wasted healthcare resources, (3) Leftover drugs represent a potential for accidental poisoning and improper or abusive usage. The goal of a pharmEcovigilance program is to continually lower the incidence of leftover drug and the ultimate goal is to eliminate them altogether (Daughton and Ruhoy, 2008). This new concept is waiting to be accepted and practiced.

This present study used a simple survey study to determine the storage and disposal of medicines by Thai villagers. The outcomes of the study signal that it is time for us to concern about more appropriate ways of managing the leftover medicines. The model of return the unwanted medicines to pharmacy for more appropriate disposal which is practiced in Canada, Europe and Australia should be considered. This study had a limitation that the type and amount of drug disposed were not determined and the survey was conducted only in one area. Future research should study into amount and categories of environmental toxicity of the disposed medicines in wider areas.

5. Conclusion

The study revealed that Thai villagers stored some kind of medicines in their houses and often they did not finish them all. The leftover medicines were thrown away into garbage when unwanted no matter which dosage form it was. This can potentially do harm to the environment.

Acknowledgment

We would like to thank Dr. Jeff Roy Johns, Faculty of Pharmaceutical Sciences, Khon Kaen University, for his comments and editing of this manuscript.

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Received 30 September 2013

Accepted 15 October 2013

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