Willingness to Pay for an Unwanted Medicine Collection Program: A Double Hurdle Approach

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Abstract

There has been increasing concern about the environmental impact of pharmaceutical accumulation in surface and groundwater over the last two decades. Several states in the U.S. have implemented medicine take-back programs to help mitigate problems associated with unused and unwanted pharmaceuticals in households. States bordering the Great Lakes have particularly been concerned about this issue. This study assessed the value of a pharmaceutical collection program based on the willingness to pay per prescription and willingness to pay per visit of current and potential participants of the program in the Great Lakes area. We found that 60 % of the population is willing to participate in a collection program, while 40 % is willing to pay to participate in the program. The estimated unconditional mean WTP from a Double Hurdle Model is $0.53 per prescription and $1.03 per visit; and with the conditional mean willingness to pay, $1.25 per prescription and $2.33 per visit. Total annual benefits for such programs given the number of households in the area are estimated to be $20.1 million when considering WTP per prescription, and $18.9 million for a single drop-off per year when considering WTP per visit. This information will help better inform program providers, researchers, policymakers, advocates and other interested parties.

1. Introduction

Pharmaceuticals have been used for thousands of years to treat illnesses and diseases. Over the last two decades, concern of the environmental impact of pharmaceutical accumulations in surface and groundwater has increased. Active pharmaceutical ingredients (APIs) have been found in rivers, streams and groundwater in 71 countries across the world (IWW, 2014), and across the U.S. (Benotti, et al., 2009, Kolpin, et al., 2002). The Great Lakes, which provide drinking water, recreation, transportation, and industry to more than 40 million people in the American North Central region and are home to diverse unique basin-wide ecosystems, are no exception to the risks of such accumulations (Blair, et al., 2013). The introduction and accumulation of pharmaceutical compounds in the environment is a growing issue, with latent implications for human health and ecosystems that are still not clearly understood. APIs enter the environment as a result of excretion from humans, pets and livestock, waste waters from the pharmaceuticals industry, and improper disposal of unused and unwanted prescriptions.

Once in the environment, living organisms are exposed to pharmaceutical substances. Given that these metabolites may still contain APIs, they are potentially harmful to the species of each ecosystem. The vast majority of drugs have not been associated with a significant risk from chronic exposure to the concentrations in the environment, but some drugs may still have the potential to affect wildlife (Hester and Harrison, 2015). There is some evidence about the effects on metabolism regulation, reproduction and development, and signal transmission disruption between cells of some APIs, even at very low concentrations (Andersen, et al., 2003, Langston, et al., 2007, Swan, et al., 2006). Links between pharmaceutical exposure and harmful effects have been established in a limited number of different cases (Caldwell, et al., 2008, Hinck, et al., 2008, Vajda, et al., 2008).

Pharmaceuticals have also been found in the drinking water supply. Unlike surface and groundwater, the concentrations found in human water supply are 100-fold below the minimum therapeutic dose of 0.05 μg/L (Jelić, et al., 2012, WHO, 2012). The World Health Organization suggests it is very unlikely humans will suffer any consequence from the current trace exposure (WHO, 2012). Nevertheless, potential effects in the future as a result of chronic exposure to trace contaminants is a latent concern. The increase of water demand could potentially lead to greater incidence of indirect and direct water reuse, and this could result in an increased exposure to higher concentrations (Jones, et al., 2005).

In addition to environmental pollution, pharmaceutical accumulation and unsafe storage in households can also pose a public safety hazard. Medicines are one of the most common poison exposure in the country (Mowry, et al., 2015). When not properly stored, the risk of accidental poisoning with medications of children and pets increases. Prescription drug abuse and its potential health consequences are also a public health problem. According to the National Center for Health Statistics (NCHS), drug overdose death rates have increased five-fold since 1980, becoming the leading cause of accidental deaths in 29 states and Washington D.C., even ahead of heroin (NCHS, 2014). The estimated cost to the nation include lost productivity, medical costs and criminal justice costs, which amounts to $53.4 billion a year (NCHS, 2014).

A number of states and counties across the U.S. have implemented medicine take-back programs to mitigate the environmental problems of improper pharmaceutical disposal and public health risks of accumulation of medicines in households. Medicine take-back programs provide secure collection points and environmentally sound destruction of unwanted medicines. Pharmaceutical take-back programs have been established in different areas, including permanent locations in police departments, pharmacies, hospitals and other health care facilities, special single and multi-day collection events, and mail programs. Regarding pharmaceutical collection schemes, a few studies have looked at the perception of these programs among users and non-users. Thach et al. (2013) suggested both users and non-users viewed such programs as a potentially valuable service. About half of the respondents expressed their willingness to pay (WTP) on a per weight basis. Other studies have evaluated participation rates and the most common medications returned in pilot programs. (Lystlund, et al., 2014, Perry, et al., 2014). These studies have provided useful information that has helped to understand behavior and practices towards prescriptions medications in the U.S.

A common question among program providers and policymakers is the estimated monetary value of the economic benefits provided to society by these programs as a result of properly disposing unwanted household pharmaceuticals, reducing environmental pollution in water sources, preventing adverse effects to organisms in the different ecosystems, and averting public health issues related to accidental poisoning and prescription medication abuse. Available literature suggests that it is very difficult to establish a correlation between the medicines collected and the reduction in pollution in each location given limited market economic data. Thus, to estimate the value of disposal programs, a non-market valuation model needs to be employed. Kotchen, et al. (2009) analyzed the willingness to pay for the establishment of a pharmaceutical program in Santa Barbara, California. An assessment through contingent valuation (CV) concluded individuals are willing to pay, on average, a premium of $1.53 on each prescription bought to fund a pharmacy disposal program. The estimated total annual benefit for the U.S. was $2.9 billion dollars.

The problem of generalizing the findings from this study to the Great Lakes region is the possible biases that could arise as the result of the differences between the representative samples, the number of take-back programs available in the region, the potential costs of environmental pollution in the surface waters, and the realistic realization of the hypothetical case scenario used for contingent valuation in the region. This research intends to estimate the mean willingness to pay for unwanted medication collection programs in the Great Lakes region and calculate the annual value of medicine take-back programs in the region.

2. Data

To analyze the individual's willingness to pay for medicine take-back programs, the responses from an online 23-question survey[1] were used. The survey was designed to gather information regarding presence of unwanted pharmaceuticals within the household, general medicine disposal practices, likelihood to participate in a medication take-back program, willingness to pay for a medicine disposal program (per prescription and per visit), importance of the environment, and a number of demographic variables from individuals at least 18 years of age. The survey covered households living in Indiana, Illinois, Michigan, Minnesota, Ohio and Wisconsin. The survey was administered by Qualtrics during the summer of 2015.

The sample population was randomly selected, and considered both current and potential participants of take-back medication programs. A total of 2,443 people started the survey but 67 were younger than the target population, 15 lived outside the delimited geographical area, and 330 did not complete the survey, which were excluded. This resulted in a total number of respondents of 2,031, from which 378 had previously participated in a medicine take-back program. For this analysis, 1284 observations were considered because 747 observations had missing data.

The survey participants were asked to establish their willingness to pay per prescription (WTPP) and willingness to pay per visit (WTPV). The contingent valuation question was designed assuming a fee had to be paid to drop medications, based on either the number of prescriptions or the number of visits. The hypothetical state was established in the following way:

[1] The complete survey can be retrieved from: https://purdue.qualtrics.com/SE/?SID=SV_em724dM9PhaewHr

> "The presence of pharmaceuticals in surface waters is a growing concern. Let's suppose local authorities are to charge a fee for take-back pharmaceutical programs at local permanent collection sites (e.g. pharmacies, hospitals, other health care centers, police departments, and hazardous waste centers) to address this concern."

Subsequently, respondents were asked about their willingness to participate, average number of prescriptions likely to dispose-off, and WTP based on the number of prescriptions and per visit. Given the limitations of the survey to ensure a response to these questions, ranges were provided for respondents, instead of allowing for an open response. The options provided for WTPP ranged from \$0.00 to \$3.00, with \$1 dollar increments, and \$0.00 to \$6.00 with \$2 dollar increments for the WTPV option.

The variables that were considered relevant as the determinants of WTP were divided into 3 categories: environmental practices of the household (***Env***), pharmaceutical related variables (***Phar***), and demographic variables (***Dem***). The environmental variables included environmental awareness, i.e. important (*e.imp*), neutral (*e.ntrl*) and unimportant (*e.unimp*), and number of environmentally friendly programs a household participates in (*#envp).* The pharmaceutical variables included the presence of unwanted pharmaceutical in the household over the last 12 months (*unmed*), the number of prescriptions (*#Rx*) they would be likely to drop off at a collection point in the future, and a dummy variable to control for respondents that have participated in a medicine collection program before (*part*). The demographic factors included average household income (i.e. \$0.00-\$30,000 (*inc0*), \$30,001-\$45,000 (*inc30*), \$45,001-\$60,000 (*inc45*), \$60,001-\$75,000 (*inc60*), and over \$75,000 (*inc75*), number of people in the household (*#pple*), college education (*educ*), age (i.e. 18-45 years old (*age18*), 46-65 years old (*age46*), and over 65 years old (*age65*)), and gender (*male*).

3. Methodology

A significant number of respondents, accounting for 60% of the sample population, reported zero WTP (both per prescription and per visit). Tobin (1958) was the first to propose a censored regression model, the Tobit model, to analyze such data with significant zero observations.

For the purpose of the analysis, the empirical Tobit model was defined as:

$$y_i^* = \boldsymbol{Env_i}\boldsymbol{\beta_{Env}} + \boldsymbol{Phar_i}\boldsymbol{\beta_{Phar}} + \boldsymbol{Dem_i}\boldsymbol{\beta_{Dem}} + \varepsilon_i, \quad i = 1, \dots, n. \tag{1}$$

where $\boldsymbol{Env_i}$ is the vector set of independent environmental variables including *e.imp*, *e.ntrl* and *#envp;* $\boldsymbol{Phar}$ is the vector set of pharmaceutical related variables including *unmed, part* and *#Rx;* $\boldsymbol{Dem}$ is the vector set of socioeconomic variables including *#pple, inc30, inc45, inc60, inc75, edu, age18, age46,* and *male.* Two different models with different dependent variables (y_i^*) were estimated, *WTPP* and *WTPV*. In the Tobit model, given its parametrization, the factors that determine the probability of consumption are the same factors that affect the level of consumption.

Cragg (1971) proposed a more general and flexible model where the decision of participation and the level of consumption (amount willing to pay) are determined by two different stochastic processes. This model considers the possibility that factors influencing willingness to pay and factors influencing the amount paid may be different. The maximum likelihood estimator in the first stage (decision of participation) can be obtained using a Probit estimator, and the second stage (amount willing to pay) can be estimated from a truncated normal regression model. In the Double Hurdle (DH) Model[2], the estimation vector for each stage consisted of different variables. Just as with the Tobit model, the DH model was estimated

[2] All estimations for this model were done using Stata 13.1 with Burke's (2009) estimation command *craggit*.

twice with *WTPP* and *WTPV* as the dependent variables. The first stage for the probit estimation was defined as:

$$y^*_{i,1st} = \boldsymbol{Env_i \beta_{Env}} + \boldsymbol{Phar_i \beta_{Phar}} + \boldsymbol{Dem_i \beta_{Dem}} + \varepsilon_i, \quad i = 1, \dots, n. \tag{2}$$

where $\boldsymbol{Env_i}$ is the vector set of independent environmental variables including *e.imp*, *e.ntrl* and *#envp;* $\boldsymbol{Phar_i}$ is the vector set of pharmaceutical related variables including *unmed*, *part* and *#Rx;* $\boldsymbol{Dem_i}$ is the vector set of socioeconomic variables including *#pple, inc30, inc45, inc60, inc75, edu*,*age18*,*age46,* and *male.*

For the second stage, the variables related to the level (how much) of willingness to pay were:

$$y^*_{i,2nd} = \boldsymbol{Env_{(res)i} \beta_{Env}} + \boldsymbol{Phar_{(res)i} \beta_{Phar}} + \boldsymbol{Dem_i \beta_{Dem}} + \varepsilon_i, \quad i = 1, \dots, n. \tag{3}$$

where the only environmental variable included in $\boldsymbol{Env_{(res)i}}$ is *#envp*, $\boldsymbol{Phar_{(res)i}}$ includes *part* and *#Rx* and $\boldsymbol{Dem_i}$ which includes the same variables as the first stage.

The conditional value of *y* given *x* and y_i>0, $E(y_i|y_i > 0, x_{2i})$, and the unconditional expected value of *y* given *x*, $E(y_i|x_{2i})$, were calculated the and the following way:

$$E(y_i|y_i > 0, x_{2i}) = x_{2i}\beta + \sigma \times \lambda(x_{2i}\,\beta/\sigma) \tag{4}$$

$$E(y_i|x_{1i}, x_{2i}) = \Phi(x_{1i}\gamma)\{x_{2i}\beta + \sigma \times \lambda(x_{2i}\,\beta/\sigma)\} \tag{5}$$

with $\lambda(c)$ as the inverse Mills ratio $\lambda(c) = \phi(c)/\Phi(c)$ where $\phi(c)$ is the standard normal probability distribution function. From the estimated mean willingness to pay per prescription and per visit, the total annual benefits of an unwanted pharmaceuticals program were estimated.

4. Results and Discussion

Descriptive Statistics

About 60 % of respondents indicated they were not willing to pay to drop off their medications. Table 1 summarizes the percentage of individual's WTP per prescription and Table 2 their WTP per visit. Consistent with economic theory, the trend is that at a higher price, consumers are less willing to pay to take their unwanted medicines to a permanent collection center.

Table 1: Distribution of Responses for Willingness to Pay per Prescription

WTTP [USD]	Frequency [%]
$0.00	60.89
$0.01-$1.00	19.83
$1.01-$2.00	8.43
$2.01-$3.00	6.71
$3.01+	4.14

Table 2: Distribution of Responses for Willingness to Pay per Visit

WTTV [USD]	Frequency [%]
$0.00	59.64
$0.01-$2.00	21.23
$2.01-$4.00	9.21
$4.01-$6.00	7.26
$6.01+	2.65

Environmental awareness was measured in the form of importance of environmental quality to the individual, i.e. important (*e.imp*), neutral (*e.ntrl*) and unimportant (*e.unimp*). From the sample population, only 2% considered the environmental quality as unimportant to them, 15% responded to being neutral, and 84% indicated environmental quality as an important factor. Regarding the participation in environmentally friendly programs (i.e. recycling, composting, water conservation, energy conservation, and use of environmentally friendly products), only 2% responded they are currently not involved in any of these practices. Nineteen percent of the sampled population participates in one of these activities, 19% of the households are engaged in two of these programs, 24% in three programs, 27% in four programs, and 9% in all five activities. The most practiced activity is recycling, followed by energy conservation practices and water conservation practices.

Concerning the pharmaceutical related variables, about 25% of the individuals did not have unused or unwanted pharmaceuticals in their households, while 75% did have. The number of prescriptions (*#Rx*) individuals would likely drop off at a collection point in the future was included as a reference to the potential amount of prescriptions within the household, which on average was 2.03. These two variables were included in the model to help explain the participation behavior based on the existence of unwanted pharmaceuticals in a household. The previous participation in a medicine collection program dummy variable (*part*) captured the proportion of respondents that have participated in a program before. About 350 people have previously participated either in a permanent collection, single day collection program, or mailed back their medicines.

The average size of the surveyed households was between 2 and 3 people per house. Sixty seven percent of respondents had at least a college degree, while 33% had their highest level of education as high-school. In Table 3, the percentage of individuals from each income group for each expressed willingness to pay is shown. In line with the literature, we observe a trend that shows the percentage of people from lower income groups decreases for each bid amount, but the number of individuals from higher income groups increases with bid amounts. The same trend was observed when comparing income with willingness to pay per visit. It is expected that households with a higher income will have a higher willingness to pay both per prescription and per visit because they have more disposable income, assuming all other variables are constant.

Table 3: Proportion of Individual's WTPP Given Annual Household Income

		Willingness to Pay per Prescription [USD]					
	Variable [%]	$0.00	$0.01-$1.00	$1.01-$2.00	$2.01-$3.00	$3.00+	Total
Annual Household Income [MUSD]	$0-$30	29.36	24.80	16.67	10.47	18.87	25.68
	$30.01-$45	18.59	19.29	15.74	11.63	5.66	17.49
	$45.01-$60	17.05	17.32	18.52	15.12	5.66	16.63
	$60.01-$75	11.28	12.60	16.67	31.40	11.32	13.35
	$75.01+	23.72	25.98	32.41	31.40	58.49	26.85

The literature suggests a negative correlation between age and environmentally friendly practices (Kotchen, et al., 2009, Torgler, et al., 2008). The same relationship is observed in the data, as shown in Table 4. The percentage of individuals from the first age group (*age18*) increases as consumers are willing to pay a higher amount. In other words, the proportion of young adults in relation to other age groups increases as the bid amount goes up. The inverse relationship is observed for older citizens. The presumption is that as people grow old, the number of prescriptions in their homes increase, therefore age has a negative effect on how much a person would be willing to pay to drop off their medications. This is logical because economic theory indicates quantity has an inverse relationship with price.

Table 4: Proportion of Individual's WTPP Given Age Group

		Willingness to Pay per Prescription [USD]					
Age [years old]	Variable [%]	$0.00	$0.01- $1.00	$1.01- $2.00	$2.01- $3.00	$3.00+	Total
	18-45	45.38	47.24	71.30	87.21	84.91	52.38
	46-65	37.82	34.32	21.30	9.30	11.32	32.71
	65+	16.79	18.50	7.41	3.49	3.77	14.91

The survey responses also provided information about the reasons for pharmaceuticals accumulation in households and disposal practices. An estimated 61% of the households have had unwanted pharmaceuticals in the past 12 months. The main reasons reported for the accumulation of these substances are: users stopped taking the medication before the supply ran out (33%), not knowing what to do with the expired medicines (32%), and a change in medication (25%).

Regarding disposal practices, about 68% of respondents had disposed of unwanted pharmaceuticals at some point in the past. In line with other studies (Kotchen, et al., 2009, Kuspis and Krenzelok, 1996), the most common disposal method reported is throwing the substances in the trash (44%), followed by flushing them down the toiler or sink (29 %). Most people dispose the pharmaceuticals of their own households, while a few reported doing so for other relatives or their pets.

A total of 350 persons reported they have participated in some kind of take-back program in the past. These programs include single day collection programs, mail back programs, and permanent collection boxes at pharmacies, police departments, hospitals and other health care centers. Three out of 4 users have participated only in one type of program, while 25% have used at least two different types of collection centers. The most popular types of programs are the single-day collection events, followed by the permanent collection boxes at police departments and pharmacies. Mail programs are the least popular, accounting only for 7% of the participation rates. On average, users have been participating for 19 months in these programs, and they travel an average of 12.5 miles to dispose 5-6 different types of prescriptions.

Econometric Model

The estimation of the participant's willingness to pay per prescription using the Tobit and Double Hurdle model are summarized in Table 5 and willingness to pay per visit in Table 6. It is necessary to establish if the individual's decision on the extent of participation (WTP) is the result of a step-wise decision or not. The first decision would consist of determining whether the individual would be willing to pay to participate in a take-back program, and the second is the amount they would be willing to pay, given that the individual is willing to pay. A log-likelihood test was used to determine which model is the most appropriate. The results indicate the data supports the use of a Double Hurdle model is more appropriate for the present study[3].

From Table 5, the decision of WTPP is determined by the number of prescriptions likely to dispose of (*#Rx*), the presence of unwanted pharmaceuticals in the household (*unmed*), annual household income between $60,000 -$75,000 (*inc60*), annual household income above $75,000 (*inc75*), age (*yrs18*), and the number of people living in a household (*#pple*).

[3] With a χ^2 of 53.72 for WTPP χ^2 of 41.81 for WTPV, the null hypothesis that the decision process is only a one step process is rejected, indicating the DH is the most appropriate specification for the study.

The factors that determine the amount households are willing to pay per prescription are the number of environmental programs households are involved in (*#envp*), the number of prescriptions that consumers would get rid of (*#Rx*), age (*age18*), gender (*male*), and income level (*inc60* and *inc75*). Thus, we can conclude that the factors that influence a person's decision to participate in a paid pharmaceutical collection program are different from the factors that determine how much they are willing to pay per prescription. A similar observation applies when individuals are asked for their willingness to pay per visit, as observed in Table 6. The only difference is the independent variables that influence the decision process.

Environmental Practices (***Env***)

The amount consumers are willing to pay per prescription (Table 5) is influenced by the number of environmental programs the household is engaged in (*#envp*). Pro-environmental behavior is associated with higher environmental awareness, thus the expectation was a complementary effect and therefore a positive effect on how much individuals are willing to pay for a drug collection program. However, the results suggest participation in other environmental programs has a negative effect on the consumption level of individuals. The possible explanation is that, participation in other environmental programs involves additional costs (e.g. higher price, participation fees, and transportation time) and therefore there is a possible substitution effect. Individuals may consider the program to have a positive benefit, but the marginal benefits perceived from this specific program in contrast with another environmental programs may be lower. Thus, there may be some trade-off or substitution effect. From Table 6, the number of pro-environmental programs is not statistically significant when determining the WTP and the amount WTP per visit.

Unwanted Pharmaceuticals ***(Phar)***

The willingness to pay per prescription (Table 5) and per visit (Table 6) is influenced positively by the number of prescriptions (*#Rx)*. It may be that the number of medicines a person is likely to dispose-off reflects the number of medicines accumulated in their household. Thus, the utility from using the program is higher as the number of prescriptions increases, and the risks related with improper storage such as accidental poisoning and abuse decrease. The same reasoning applies for the effect of whether the household has had unwanted medicines at the home the past 12 months (*unmed*), when determining participation. Perhaps, it may also explain the findings in Table 6, i.e., the number of prescriptions (*#Rx)* also has a statistically significant positive effect in the level of consumption for both models.

Socio-economic Variables ***(Dem)***

The expectation was that household size (*#pple*) would have a positive effect on the participation decision in WTP as a result of higher risk of accidental poisoning and drug abuse. However, the results suggest there is a statistically significant negative effect in both models. The negative association may result from higher expected expenses in larger households and budget constraints.

Annual household income influences participation decision positively. The effect is statistically significant at the 1% level for *inc60* and at the 5% for *inc75* (Table 5). We expected the income to be a statistically significant factor when determining the amount consumer would potentially pay (Table 6). The model estimations suggest the expectations hold with statistical confidence (5%). The estimated coefficients support findings in the literature of a positive relationship between household income and willingness to pay for an environmental program.

Table 5: WTP per prescription from Tobit and DHM estimations.

	Variable	Tobit	Double Hurdle	
		Coefficients	Participation	Consumption
Env	e.ntrl	-0.168 (0.480)	-0.084 (0.310)	
	e.imp	0.884* (0.460)	0.465 (0.298)	
	#envp	-0.069 (0.050)	0.012 (0.034)	-0.211*** (0.077)
Phar	part	0.296** (0.127)	0.127 (0.086)	0.312 (0.192)
	unmed	0.174 (0.140)	0.185** (0.091)	
	#Rx	0.150*** (0.026)	0.102*** (0.019)	0.060* (0.032)
Dem	#pple	-0.050 (0.045)	-0.052* (0.030)	0.051 (0.069)
	inc30	0.169 (0.179)	0.116 (0.116)	0.103 (0.324)
	inc45	0.203 (0.183)	0.122 (0.120)	0.229 (0.315)
	inc60	0.633*** (0.192)	0.343*** (0.129)	0.727** (0.302)
	inc75	0.531*** (0.169)	0.266** (0.111)	0.670** (0.283)
	edu	0.234* (0.128)	0.138 (0.084)	0.007 (0.225)
	age18	0.940*** (0.186)	0.408*** (0.121)	1.662*** (0.393)
	age46	-0.029 (0.187)	-0.071 (0.120)	0.457 (0.397)
	male	0.291** (0.122)	0.075 (0.082)	0.589*** (0.183)
	_cons	-2.412*** (0.510)	-1.438*** (0.327)	-0.971* (0.567)
	sigma_cons	1.666*** (0.059)		1.315*** (0.086)
	N	1,284		1,284

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

Table 6: WTP per visit from Tobit and DHM estimations.

	Variable	Tobit	Double Hurdle	
		Coefficient	Participation	Consumption
Env	e.ntrl	-0.626 (0.850)	-0.298 (0.300)	
	e.imp	1.429* (0.810)	0.354 (0.287)	
	#envp	-0.070 (0.090)	0.013 (0.034)	-0.200 (0.132)
Phar	part	0.558** (0.228)	0.143* (0.086)	0.485 (0.333)
	unmed	0.646** (0.255)	0.242*** (0.091)	
	#Rx	0.316*** (0.046)	0.111*** (0.020)	0.190*** (0.053)
Dem	#pple	-0.107 (0.081)	-0.068** (0.030)	0.177 (0.126)
	inc30	0.255 (0.324)	0.130 (0.116)	-0.268 (0.600)
	inc45	0.523 (0.328)	0.174 (0.120)	0.610 (0.555)
	inc60	1.157*** (0.346)	0.353*** (0.129)	1.371** (0.545)
	inc75	1.121*** (0.306)	0.261** (0.112)	1.765*** (0.514)
	edu	0.451* (0.232)	0.151* (0.084)	0.107 (0.399)
	age18	1.552*** (0.335)	0.434*** (0.122)	2.032*** (0.626)
	age46	-0.095 (0.335)	-0.040 (0.120)	0.186 (0.647)
	male	0.233 (0.219)	0.053 (0.082)	0.227 (0.321)
	_cons	-4.432*** (0.901)	-1.338*** (0.317)	-1.721* (0.964)
	sigma_cons	3.013*** (0.105)		2.382*** (0.149)
	N	1,284	1,284	

* *p*<0.1; ** *p*<0.05; *** *p*<0.01

People age 18-45 have a statistical positive correlation (1% confidence level) with the participation and consumption decision process in both models. As alluded earlier, on average, younger adults are more willing to pay for a pharmaceutical collection program. Although not statistically significant, we observe a negative correlation between willingness to pay for an environmental program and the older age group.

Studies on environmental program participation have found women are more likely to participate than men (Ferreira and Moro, 2013, Kotchen, et al., 2009). The results from Table 6 for WTPV suggest the amount individuals are willing to pay per visit (2^{nd} stage) is influenced by male gender. The difference with previous studies might be explained by the fact that, although women tend to express more environmental concern than men, this does not necessarily imply they are more likely to actually engage in environmental actions compared to men (Blocker and Eckberg, 1997).

Mean Willingness to Pay and Estimated Annual Benefits

Based on the DH model results presented in Table 5 and Table 6, the mean willingness to pay per prescription and per visit were estimated and are presented in Table 7. The estimated unconditional mean willingness to pay per prescription is $0.53 and the mean willingness to pay for those who have a positive willingness to pay per prescription is $1.25. In the case of WTP per visit, the mean value for all consumers is $1.03, and $2.33 for those who actually indicate an amount.

Table 7: Estimated Mean WTP from DHM.

Dependent Variable	Conditional WTP	Observations	Mean	St. Dev
WTP per Prescription	WTP E(y|y>0)	1293	$1.25	0.43
	WTP E(y)	1287	$0.53	0.40
WTP per Visit	WTP E(y|y>0)	1293	$2.33	0.80
	WTP E(y)	1287	$1.03	0.78

The mean willingness to pay for only respondents that had previously participated in a medicine take-back were also estimated (Table 8). The results suggest that these individuals are willing to pay a slightly higher price per prescription and per visit. For example, the unconditional mean WTP for all respondents per prescription is $0.53, while those that have participated in previous program are willing to pay $0.72 per prescription, $0.17 more. Similarly, the unconditional WTP per visit for all individuals is $1.03 and $1.42 for those that have previously participated in a program; a difference of $0.39. The difference in the mean WTP given a predicted positive participation in the first stage of the model between all individuals and recurrent participants is $0.15 per prescription and $0.31 per visit.

Table 8: Estimated Mean WTP from DHM from previous program participants (*part=1*).

Dependent Variable	Conditional WTP	Mean	St. Dev
WTP per Prescription	WTP E(y|y>0)	$1.40	0.55
	WTP E(y)	$0.72	0.53
WTP per Visit	WTP E(y|y>0)	$2.64	1.01
	WTP E(y)	$1.42	1.03

Assuming that heterogeneity exists among individuals and potentially the states, an alternative approach where the WTP per prescription and per visit varied across states was considered. To obtain the mean willingness to pay per states, state dummies were incorporated into the regression[4]. The estimated values per state are reported in Table 9 and Table 10. Illinois residents are willing to pay the highest amount, unconditional mean WTPP of \$0.70 and mean WTPP of \$1.44 (Table 9). Illinois has one of the highest median income in the Mid-west. (U.S. Bureau, 2014). Income is found to be positively correlated with willingness to pay. In addition, concerns for pharmaceuticals in the drinking water source and the Michigan Lake since the 2000's have led to awareness campaigns and promotion of disposal programs in collaboration with the public and private sector in Illinois.

Indiana is the state with the 2nd highest mean WTPP and WTPV. The geographical proximity with Illinois, support from the Illinois-Indiana Sea Grant to both Indiana and Illinois for the implementation of medicine collection programs, and the high number of deaths from prescription drugs are possible explanations for this finding.

[4] Initially, state dummies were included as variables in the model. Given a non-statistical T-test for any of the States, an F-test was performed to test their joint significance. The results fail to reject the null hypothesis that the model supports the imposed restriction of $\boldsymbol{\beta}_{Geo} = 0$.

Table 9: Mean WTP per prescription per State from DHM

State	WTPP E(y)	St Dev E(y)	WTPP E(y|y>0)	St Dev E(y|y>0)
Indiana	$0.50	0.38	$1.21	0.40
Illinois	$0.70	0.47	$1.44	0.49
Ohio	$0.41	0.32	$1.07	0.36
Michigan	$0.48	0.35	$1.11	0.36
Wisconsin	$0.42	0.26	$1.21	0.38
Minnesota	$0.46	0.28	$1.19	0.36

Table 10: Mean WTP per visit per State from DHM

State	WTPV E(y)	St Dev E(y)	WTPV E(y|y>0)	St Dev E(y|y>0)
Indiana	$1.04	0.85	$2.39	0.85
Illinois	$1.36	0.88	$2.63	0.84
Ohio	$0.78	0.64	$2.02	0.66
Michigan	$0.93	0.73	$2.12	0.69
Wisconsin	$0.81	0.52	$2.15	0.65
Minnesota	$0.79	0.48	$2.02	0.57

The total annual benefits of a pharmaceutical take-back program per state were calculated using the estimated mean willingness to pay for each model. We used the U.S. Census Bureau household data from 2013 in the Great Lakes region and the average number of prescriptions likely to be dispose reported by respondents. The number of households (millions of households) per state are: Indiana 2.5; Illinois 4.8; Ohio 4.6; Michigan 3.8; Wisconsin 2.3; Minnesota 2.1 (U.S. Bureau, 2014) and the average number of prescriptions used from our sample is 2.03. The estimations were performed with the unconditional mean willingness to pay (WTP E(y)), and the conditional willingness to pay (WTP E(y|y>0).

Table 11: Annual Benefits per State calculated ($million).

State	WTPP E(y)	WTPP E(y|y>0	WTPV E(y)	WTPV E(y|y>0
Indiana	$2.5	$2.4	$2.6	$2.4
Illinois	$6.8	$5.4	$6.5	$5.0
Ohio	$3.8	$3.9	$3.6	$3.7
Michigan	$3.7	$3.4	$3.6	$3.2
Wisconsin	$2.0	$2.2	$1.9	$2.0
Minnesota	$2.0	$2.0	$1.7	$1.7
Total	$20.8	$19.3	$19.7	$18.0

Table 11 provides a summary of the estimated total annual benefits per state given the number of households in each state. The benefits using the unconditional mean WTPP add up to $20.8 million and $19.3 from the conditional mean WTPP. For WTPV, the value of the pharmaceutical take-back program is estimated with the unconditional mean willingness to pay;

$19.7 million per year and $18.0 million with the conditional mean willingness to pay. Averaging the estimated total annual benefits under these assumptions, the societal value of medicine collection programs is between $18.9 and $20.1 million. The state with the highest estimated annual benefits is Illinois, and the lowest estimated annual benefits are Minnesota.

The econometric model indicated that the estimated unconditional mean WTP for recurrent participants of pharmaceutical programs is higher than the unconditional average from the entire sample population ($0.53 vs $0.72 for WTPP and $1.03 vs $1.42 for WTPV). The number of prescriptions likely to dispose-off also varied (2.03 vs 4.65). Taking into consideration these differences, we also estimated a hypothetical scenario which assumes awareness campaigns result in widespread participation of households. We consider this value to be the potential average value of pharmaceutical collection programs in the Great Lakes region since this approximation considers a full engagement from society. We assumed the mean WTPP for *part*=1 from Table 8, 4.65 disposed prescriptions and 2 visits per year. The value of the program under this scenario is $67.2 million per year with the unconditional mean willingness to pay per prescription, and $57.0 million with the unconditional mean willingness to pay per visit. The annual benefits per state are summarized in Table 12. Although these assumptions are very unlikely, the estimated benefit provides a potential ceiling, assuming all other factors remain constant, of the monetary value of the program. Additionally, an assessment of the access to take-back medicine programs suggests a limited availability to a large percentage of the population (PSI, 2012). As the public becomes more aware about the risk of improperly disposing their medications, it is very likely the number of programs across the region will continue to grow. Hence, this information can help program providers and policymakers make decisions in the future.

Table 12: Annual Benefits Calculated Assuming Widespread Participation ($million)

State	WTPP	WTPV
Indiana	$8.3	$7.1
Illinois	$16.0	$13.6
Ohio	$15.3	$13.0
Michigan	$12.8	$10.9
Wisconsin	$7.7	$6.5
Minnesota	$7.1	$6.0
Total	$67.2	$57.02

Comparing Benefits to Costs

The estimated monetary value calculated from the DH model provides insight into consumer's preferences by approximating the societal benefits for these programs. On average, annual benefits in the Great Lakes region range between $18.9 and $20.1 million. Costs of existing programs in each state vary by the type of program, size and scope. Some of the incurred costs may include advertising, secure drop boxes, supplies, costs of consolidation of medicines at central collection site, warehousing of medicines prior to disposal, transportation to disposal facility, destruction costs and wages. The specific costs for each program vary given the type of program and the defined scope. The most economic type of medicine collection schemes are single day events. The associated costs for these events are transitory, including planning, advertising, staff, and logistics. Some of the reported total costs for these events include $6,815 plus voluntary hours of staff for a one-day event organized by the Milwaukee Metropolitan Sewerage District, to $90,000 and 1,980 hours of staff time for 59 events organized during a week in 39 locations by the Bay Area Pollution Prevention Group in California (IISG, 2009).

Permanent collection programs have continuing costs associated with the administration, transport and disposal of the medications. Reported costs of these types of programs have been reported to range from $12,000-$15,000 dollars spent annually to operate the La Crosse County disposal program of household medications (La Crosse County, 2016), to $516,800 spent annually in King County, Washington for 1,033 pharmacy drop sites (KingCounty, 2012). Some programs have reported they incurred costs per pound or container disposed. In San Mateo County, the pharmaceutical collection program at three different police stations was estimated to cost $1.57 dollars per pound of collected medicines (Gordon, 2007). The City of Olmsted Falls, Ohio developed a medication disposal program in conjunction with a nearby hospital. To dispose of the medications, they incur a $60 dollar fee per 28-gallon container (IISG, 2009). In Washington State, the estimated cost for a statewide program is $5.60 per pound.

Program providers and policymakers can use the estimated total benefits to perform a cost-benefit analysis when assessing the implementation of new programs. If benefits exceed the costs, the implementation of these programs should be considered as a policy measure to reduce APIs in rivers, lakes, groundwater, drinking water and other ecosystems. Comparing the total costs of implementation of a single collection program (either single day or permanent collection site) suggest a favorable cost-benefit ratio, even with a conservative estimation of the total annual benefits. Moreover, the advertising and awareness campaigns that would likely be implemented with a program, will increase participation rates, suggesting a higher mean WTP as observed in the study when the mean WTP between participants and non-participants was compared. Thus, the societal value of the programs would more likely be higher than initially estimated.

5. Conclusions

Medicine take-back programs have been implemented across the U.S. as a measure to reduce water pollution from pharmaceutical residues in the environment and reduce the risk of prescription abuse and accidental poisoning. These programs have a positive value to society associated by avoiding environmental and public health costs. However, given the data and market limitations, it is not possible to determine the societal value by quantifying avoided costs. A contingent valuation method was used to estimate the mean annual benefits for these programs in the Great Lakes region, associating the amount individuals are willing to pay with the benefits of the program.

The results suggest that the decision to pay for a medicine take-back program and the amount participants are willing to pay are influenced by different factors. Participation is influenced by the presence and number of pharmaceuticals in the household, annual income above $60,000 and age 18-45 years old. The amount participants are willing to pay is influenced by the age and income level and the number of pills consumers are likely to dispose.

The estimated unconditional mean WTP is $0.53 per prescription, and $1.03 per visit. The estimated mean WTP and a conservative assumptions of 1 visit per year per household and 2.03 prescriptions disposed per household per year were used to calculate the annual benefits of these programs. The results provide a range of $18.9 to $20.1 million for the value of the take-back program. From a policy perspective, we suggest a continued support for the maintenance of current programs and the implementation of more collection schemes in the region

An assessment of the access to take-back medicine programs suggests a limited availability to a large percentage of the population. For more programs to be established, and a continuous support to the existing ones, stakeholders (e.g. regulators, legislators, program providers, pharmaceutical industries, tax payers) must recognize that the societal benefits from these programs is higher than the costs sustained.

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