Journal of Environmental Management 90 (2009) 1476–1482

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Pharmaceuticals in wastewater: Behavior, preferences, and willingness to pay for a disposal program

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ARTICLE INFO

Article history:
Received 7 August 2007
Received in revised form
12 September 2008
Accepted 7 October 2008
Available online 25 November 2008

Keywords:
Pharmaceutical disposal
Contingent valuation
Willingness to pay
Wastewater

ABSTRACT

The presence of pharmaceutical compounds in treated wastewater and in surface waters is a growing environmental concern. This paper provides information about general awareness of the issue, disposal practices, willingness to pay for a disposal program, and willingness to participate in a disposal program. The results are based on a telephone survey of 1005 residents in southern California. Less than half of the respondents are aware of the issue. While disposal of unused medications through the trash and toilet/sink is the most common practices, respondents that are aware of the issue are more likely to return pharmaceuticals to a pharmacy or drop them off at a hazardous waste center. The results of a contingent valuation question indicate a substantial willingness to pay a surcharge on prescriptions to support the establishment of a pharmaceutical disposal program. The more conservative estimate of mean willingness to pay is $1.53 per prescription, which translates into an average annual willingness to pay of approximately $14. A benefit-cost comparison suggests ample scope for establishing a pharmaceutical disposal program that would yield positive net social benefits, even if the surcharge was applied to only one prescription per year. We also find that respondents are likely to participate in a disposal program. Assuming that the program is based on drop-off locations at local pharmacies, approximately 70 percent of the respondents would be very likely to return their unwanted or expired medicines.

1. Introduction

The introduction and accumulation of pharmaceutical compounds in the environment are growing environmental concerns. As methods for detection have improved (Ternes et al., 2004), scientists have established pharmaceuticals as nearly ubiquitous pollutants in both ground and surface waters (Halling-Sørensen et al., 1998; Kolpin et al., 2002; Roberts and Thomas, 2006; Sacher et al., 2001; Weigel et al., 2004). While concentrations ranging from the parts per trillion (ppt) to low parts per billion (ppb) have been found in wastewater effluent (see Fent et al., 2006 for an excellent review of pharmaceutical occurrence research), pharmaceuticals have also been discovered in drinking water supplies (Stackelberg et al., 2004; Webb et al., 2003; Webb, 2004). Beyond the presence of pharmaceutical compounds in the environment, concern is growing because relatively little is known about the implications for human health and ecosystems, especially concerning chronic toxicity from continuous exposure to multiple compounds (Daughton, 2003a). Currently, there are no regulations regarding acceptable levels of pharmaceuticals in drinking water or wastewater effluent (Snyder et al., 2003).

Treated wastewater is the primary mechanism by which pharmaceuticals are introduced to the environment. When people take medication, only a fraction is completely absorbed by the body, and the excess is excreted as unchanged compounds or processed metabolites. With septic systems, pharmaceutical compounds leach directly into ground water. With municipal sewage, the compounds make their way to sewage treatment facilities that are not equipped to degrade medicinal substances. The result is wastewater effluent that contains various degrees of pharmaceutical waste, much of which goes undetected because water districts and sewage treatment facilities are not required to test for pharmaceuticals (NACWA, 2005). The disposal of unwanted or expired drugs is another way that pharmaceuticals enter the wastewater stream. When people dispose of medications, it is common to pour them down the sink or flush them down the toilet. It is also common for people to dispose of pharmaceuticals by throwing them in the trash, in which case they end up in landfills and may eventually enter waterways through leachate.

A number of states and localities across the United States have begun to experiment with programs to mitigate the problem of pharmaceuticals in the environment. These initiatives focus

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doi:10.1016/j.jenvman.2008.10.002

primarily on disposal practices and include the establishment of permanent pharmaceutical take-back locations, special collection events, and education and awareness programs. Along with the growing momentum for such policies, there is an increased demand for research that addresses several related questions: What are current practices within households for pharmaceutical disposal? What is the level of awareness about the presence of pharmaceuticals in waterways? How likely are people to participate in voluntary disposal programs? What is the demand for such programs? And how might the benefits of such programs compare with the costs?

A limited number of surveys have been conducted to understand household disposal practices. Typical reasons for disposal are that the medication has expired, it is no longer needed because the condition has been resolved, or house-cleaning has prompted the disposal of medications that were being stored (BAPPG, 2006; Morgan, 2001). Some studies have attempted to quantify the amount of pharmaceuticals that households store (Seehusen and Edwards, 2006; WCRC, 2006), while another study shows that the amount of medication for disposal depends highly on the pharmaceutical type (Bound and Voulvoulis, 2005). The most common means of disposal are the sink, toilet, and trash (BAPPG, 2006; Boivin, 1997; Kuspis and Krenzelok, 1996; Seehusen and Edwards, 2006; WCRC, 2006), and the specific choice appears to depend on age, whereby older respondents choose disposal through the sink or toilet, and younger respondents choose disposal through the trash (WCRC, 2006). Although it occurs far less frequently, there is evidence that some people return unused medication to pharmacies, physicians, or other health-care providers (Boivin, 1997; Bound and Voulvoulis, 2005; Kuspis and Krenzelok, 1996; Seehusen and Edwards, 2006; WCRC, 2006).

While many of these studies provide useful information, the extent to which the results can be generalized is limited because many are based on samples of convenience, ranging from callers to a regional poison information center (Kuspis and Krenzelok, 1996), participants in a local collection event (BAPPG, 2006), customers at an outpatient pharmacy (Seehusen and Edwards, 2006), and members of a retirement community (Morgan, 2001). The studies by Boivin (1997) and Bound and Voulvoulis (2005) are based on random samples and occurred in Ontario, Canada, and Southeastern England, respectively. The study conducted by the Washington Citizens for Resource Conservation (WCRC, 2006), which took place in King County, Washington, is the only study based on a random sample that has occurred in the United States. In addition to questions about disposal practices, the WCRC study asked respondents about their willingness to participate in a pharmaceutical disposal program. The study reports that 80 percent of the respondents would likely return their unused or expired medicines to a drop box at their local pharmacy.

In this paper, we report the results of a telephone survey of 1005 randomly selected households on the central coast of California. We asked questions about general awareness of pharmaceutical pollution, disposal practices, and willingness to participate in a disposal program. Many of the results are comparable to those of existing studies. But the main contribution of our research comes from the results of a contingent valuation (CV) question about willingness to pay (WTP) to establish a pharmaceutical disposal program. Based on econometric analysis of a referendum format CV question, we estimate the economic benefits that would arise with the establishment of a national pharmaceutical disposal program. We find that WTP varies with socioeconomic characteristics in both plausible and statistically significant ways. When compared to the costs of existing programs, we find much potential for the benefits of a disposal program to exceed implementation costs. We are unaware of any existing study that estimates the economic benefits associated with drug disposal programs. Hence the results reported here should be of interest to researchers, policymakers, and advocates looking for ways to mitigate the introduction of pharmaceutical compounds in the environment.

2. Survey design and data collection

Data were collected as part of the Central Coast Survey (CCS), an annual telephone survey conducted by the Social Science Survey Center at the University of California, Santa Barbara. The CCS covers Santa Barbara and Ventura counties and consists of questions on a variety of social issues that vary from year to year. We included a set of questions in the survey that was conducted on weeknights between January 8 and February 26, 2007. Telephone numbers were generated from a list of all prefixes in Santa Barbara and Ventura counties. Randomly selected four-digit numbers were then added to the prefixes, ensuring that both listed and unlisted numbers had an equal chance of being selected. Interviews were conducted in both English and Spanish and averaged 14 min in length. All survey respondents were at least 18 years of age and were the individuals that answered the call. In total, 1657 households were contacted and 1005 interviews were completed, yielding a cooperation rate of 61 percent.[1]

The survey questions were designed to learn about pharmaceutical disposal practices, general awareness of pharmaceutical pollution, willingness to pay for a disposal program, and willingness to participate in a disposal program. In addition to the questions tailored to each of these objectives, our statistical analysis takes advantage of the typical suite of socioeconomic questions, including age, gender, income, education, and political party affiliation.[2]

The questions pertaining to disposal practices and awareness were relatively straightforward. We asked respondents, "How do you typically get rid of unwanted or expired prescription or over-the-counter medications in your household?" Response categories, from which they could choose one, included "trash", "toilet/sink", "pharmacy", "hazardous waste center", "store at home", or "other". We then asked, "Are you aware that medical compounds have been found in treated wastewater and surface water?" To this question, respondents could answer "yes" or "no".

We constructed the contingent valuation (CV) question to reflect an actual policy recommendation for establishing a pharmaceutical disposal program (Gressitt and Kaye, 2006). Part of the recommendation, which was drafted by members of the Maine Benzodiazepine Study Group and of the Unused Drug Disposal Group and submitted to federal agencies, is to establish a nationwide drop-off program that permits residents to return unused pharmaceuticals in a secure and environmentally sound manner. To ensure that the program remains self-funded and reduces the burden on local jurisdictions, it is also recommended that a nominal 25-cent fee be assessed on each filled prescription. This proposal provides the basis for our dichotomous choice, referendum format CV question:

> "The presence of medicines in surface waters is a growing environmental concern. To address this concern, there is currently a proposal to add a surcharge to prescription medication to fund a national disposal program. To implement this program, would you be willing to pay $_____ per prescription you purchase?"

[1] As is standard practice, the cooperation rate is defined as the number of eligible respondents who complete the survey, divided by the total number of households reached.

[2] The survey instrument itself can be found in Appendix C of an initial report, "Pharmaceuticals in Wastewater Streams: Disposal Practices and Policy Options in Santa Barbara", which is available online at the following url: http://www.bren.ucsb.edu/research/documents/PharmaceuticalsFinalReport.pdf.

Respondents were then asked to answer "yes" or "no." The dollar amounts were randomly assigned from the following distribution: $0.05, $0.10, $0.25, $0.50, $1.00, $1.50, $2.00, $2.50.[3]

The willingness to participate question builds on the CV scenario, as individuals may be willing to participate in a disposal program even if they are unwilling to pay for it. We asked, "If a disposal program were implemented at local pharmacies, how likely would you be to return unwanted or expired medicines to your pharmacy for disposal?" For this question, response categories were based on a 5-point Likert scale, including "very likely", "somewhat likely", "neutral", "somewhat unlikely", and "very unlikely".

3. Statistical and econometric analysis

Table 1 reports descriptive statistics for the socioeconomic variables. Respondents, who are the individuals in the household that answered the call, are split almost evenly between males and females. The average age is about 50 years. Twenty-five percent have annual household incomes below $35,000, and almost the same percentage have incomes above $100,000. High school is the highest level of education completed for 27 percent of the respondents, while more than 42 percent have at least a college degree. Thirty-nine percent of the respondents consider their political leanings as most in line with the Democratic Party. The socioeconomic characteristics of the sample are reasonably representative of Santa Barbara and Ventura Counties.[4] Compared to national averages, the sample is somewhat older, has greater income, and is more highly educated.

We find that 43 percent of the respondents are aware (i.e., *Awareness* in Table 1) that medical compounds have been found in treated wastewater and in surface waters. Table 2 shows how this awareness affects disposal practices. We first report the percentage frequencies for each disposal method for all respondents. In line with the findings of previous studies, trash and toilet/sink are the most common. We do find, however, that trash is substantially more common (with 45 percent) than toilet/sink (with 28 percent). Five percent of the respondents return their unused medications to their pharmacy, another 5 percent drop them off at a hazardous waste center, and 12 percent indicate that they simply store them at home. The last two columns of Table 2 report the frequencies separately for those who are not aware or aware that medical compounds have been found in treated wastewater and in surface waters. A test of similarity between the distribution of responses for the two groups reveals statistically significant differences (Pearson's $\chi^2 = 48.3$, $p < .001$). Respondents that are aware of the issue are less likely to dispose of unused medications in the trash or sink/toilet, and they are more than three times as likely to either return pharmaceuticals to the pharmacy or drop them off at a hazardous waste center.

Table 1
Descriptive statistics of socioeconomic variables.

Variable	Mean	Std. Dev.
Gender (male = 1)	0.475	0.500
Age (years)	49.507	16.554
Income (household annual before taxes)		
Lower (<$35,000)	0.254	0.435
Middle ($35,000–100,000)	0.476	0.500
High (>$100,000)	0.271	0.445
Education (highest level completed)		
High school	0.269	0.444
Some beyond high school	0.305	0.461
College or graduate degree	0.426	0.495
Democrat (1 = yes)	0.387	0.487
Awareness (1 = yes)	0.434	0.496

Although not reported in the table, we also conducted tests to determine whether the choice of disposal method differs by age. Following the WCRC (2006) report, we split the sample between those younger than 55 and those 55 and older. We again find statistically significant differences (Pearson's $\chi^2 = 19.0$, $p = .002$). Consistent with the WCRC report, older respondents are more likely than younger respondents to choose disposal through the toilet/sink (31 vs. 26 percent). Older respondents are also more than twice as likely to return unused medications to the pharmacy (9 vs. 4 percent). Contrary to the WCRC report, however, we find that both age groups remain more likely to choose trash as the most common disposal method, with 38 and 49 percent for the older and younger groups, respectively.

Table 3 lists the distribution of bid amounts for the contingent valuation (CV) question, and we report the percentage of "yes" responses for each amount. As one would expect, the trend is that respondents are more likely to respond "yes" at the lower bid amounts. To further analyze the CV responses, we estimate logit models to explain the probability of "yes" responses as a function of several covariates, including the randomly assigned bid amount, age, gender, democrat, awareness, and income. Table 4 reports results of the full specification as Model 1. In addition to the estimated coefficients and standard errors, we report the marginal effects evaluated at the mean of the corresponding explanatory variable. All coefficients are statistically significant, with the exception of those for income. The negative coefficient on *Bid Amount* is consistent with economic theory, as higher bid amounts decrease the probability of a "yes" response. The corresponding marginal effect implies that, starting from the mean bid amount of $1.07, a 10-cent increase in the bid decreases the probability of a "yes" response by 0.01. We find that older respondents are less likely to support the policy proposal. This is not surprising because older people take more prescriptions on average, so for any given surcharge the policy would cost them more. The finding that males are less likely to respond "yes" is consistent with a substantial economics literature showing that females are more willing to

Table 2
Pharmaceutical disposal practices for all respondents and split by awareness.

Disposal method	All respondents	Not aware	Aware
Trash	45.2	49.5	38.7
Toilet/Sink	28.0	31.3	23.2
Pharmacy	5.9	3.1	10.1
Hazardous waste Center	5.1	2.3	9.5
Store at home	11.8	10.5	13.7
Other	4.0	3.3	4.9

Notes: "Not Aware" and "Aware" indicate awareness that medical compounds have been found in treated wastewater and in surface waters. Columns may not sum to 100 due to rounding. A test for differences between the distribution in the last two columns is statistically significant with Pearson's $\chi^2 = 48.3$ and $p < .001$.

[3] We began with values that ranged from $0.05 to $1.50, but after reviewing the first two weeks of data, which included a majority of "yes" responses, the lowest two values were dropped and the highest two values were added. This change in bid design does not pose any problems for the analysis, as bid distributions are typically chosen somewhat ad hoc in CV studies, and it does not bias the results. The important feature of the design is that the values cover a wide enough range to guarantee variation in the "yes" and "no" responses.

[4] US Census data for Santa Barbara and Ventura counties reports estimates of 2006 household incomes in the following proportions: lower = .26, middle = .45, high = .30. The most comparable census estimates for education are those for ages 25 and older, while those in Table 1 are for those ages 18 and older. Nevertheless, for purposes of comparison, the 2006 census estimates are the following: high school = .40, some beyond high school = .30, college or graduate degree = .30. Further details about the socioeconomic characteristics of the sample can be found in the detailed report of the Central Coast Survey, available at http://www.survey.ucsb.edu/central-coast-survey.

Table 3
Distribution of bid amounts and percentage of "yes" responses.

Bid Amount	Frequency	Percent "yes"
$0.05	66	71.4
$0.10	57	67.9
$0.25	151	60.8
$0.50	165	54.5
$1.00	149	59.1
$1.50	193	53.2
$2.00	112	42.2
$2.50	112	39.5

voluntarily provide public goods (e.g., List, 2004; Kotchen and Moore, 2007). In particular, we find that, controlling for other factors in the model, females are 9 percent more likely to respond "yes". Respondents identifying themselves as Democrats are also more likely to respond "yes", which may not be surprising given that Democrats tend to be more supportive of government programs. Compared to other political parties, Democrats are 13 percent more likely to support the proposed pharmaceutical disposal program.

Perhaps more surprising is the negative and statistically significant coefficient on *Awareness*, which implies that respondents are less likely (7.5 percent) to respond "yes" if they are aware that medical compounds have been found in treated wastewaters and in surface waters. Although we cannot explain this result definitively, we conjecture two possibilities. Respondents that are aware of the issue may also be aware of other environmental issues and consider pharmaceutical pollution a relatively low priority. Another possibility is that aware respondents may also believe that excretion of pharmaceutical compounds is the primary problem and are therefore skeptical about whether a disposal program will have an appreciable effect.

We find no statistically significant effect of income, although the signs on the coefficients on middle- and high-income are negative relative to the omitted category of lower-income.[5] It is worth noting that if we replace the income variables with education variables, the results change very little. We also estimate the specification that does not include the income variables, reported as Model 2. Economic theory based on the random-utility model implies that income should not be included in the logit model (Hanemann, 1984), we estimate Model 2 without income for this reason, in addition to testing robustness. The income variable is associated with a relatively high degree of non-response (approximately 12 percent), which is typical in survey research. Model 2 therefore includes more observations, 861 compared to 773. Nevertheless, the results do not change very much between the two specifications. Coefficient magnitudes are very similar, and the only qualitative difference is that *Awareness* is no longer statistically significant.

The final model that we estimate includes only *Bid Amount* as an explanatory variable. Reported as Model 3, this specification includes even more observations, 952, because of missing data for the other variables in Model 2. The coefficient estimate on *Bid Amount* is still negative, highly statistically significant, and has a very similar magnitude.

We derive estimates of mean willingness to pay (WTP) based on Model 3 because it includes the most data and estimates the coefficient on *Bid Amount* with the most precision. We employ two commonly used methods. The first method truncates the cumulative distribution function at zero, while the second does not. Hence the second method provides a more conservative estimate of mean WTP. Hanemann (1989) provides the formulas for both methods:

Method 1: $E(WTP) = \ln(1 + \exp(\alpha))/\beta$

Method 2: $E(WTP) = \alpha/\beta$.

For our application, the term α is the constant in Model 3, and β is the absolute value of the coefficient on *Bid Amount*. The point estimates are reported in the first row of Table 5. Method 1 produces an estimate of $2.56, while method 2 produces the more conservative estimate of $1.53. These values represent the mean WTP for a surcharge per prescription to establish a national disposal program. In order to estimate the precision of these estimates, we derive 90- and 95-percent confidence intervals using Park et al. (1991) adaptation of the Krinsky and Robb (1986) technique for calculating confidence intervals for elasticities. The 95-percent confidence interval ranges from $1.67 to $5.60 for Method 1 and from $1.09 to $2.97 for Method 2. An important finding for Method 2, which allows the possibility for negative values of WTP, is that the estimate for mean WTP differs from zero with a high level of statistical significance.

Regardless of how much individuals are willing to pay for a drug disposal program, they may be willing to participate in one. The WCRC (2006) study determined that the most convenient location for a pharmaceutical return program was at pharmacies. As a follow up, we find that respondents in Santa Barbara and Ventura counties are quite willing to participate in such a pharmacy-based program. When asked how likely they would be to return unwanted or expired medicines to their pharmacy, 68 percent of the respondents answered "very likely". The response percentage distribution for other categories is approximately 11 percent for "somewhat likely", 9 percent for "neutral", 3 percent for "somewhat unlikely", and 10 percent for "very unlikely". To investigate the relationship between these responses and socioeconomic characteristics, we estimated correlations between likeliness to participate and the variables in Table 1. Although the specific results are not reported here, we found two significant correlations: older respondents and female respondents are both more likely to state a willingness to participate.

4. Discussion

The results of our contingent valuation question indicate a substantial willingness to pay (WTP) to establish a pharmaceutical disposal program. For purposes of discussing the policy implications, we focus on the more conservative estimates from Method 1. The point estimate of $1.53 – which is the mean WTP a premium per prescription to establish a program – can be used to infer the economic benefits that would arise if a disposal program were put in place. Hence the estimated WTP can be used to make broad comparisons between the benefits and costs of potential pharmaceutical disposal programs.

The Medical Expenditure Panel Survey (DHHS, 2004) provides the most recent data for US residents on the number of annual prescriptions filled and expenditures on prescription drugs. In 2004, the mean number of prescriptions was 9.22 and the median was 1. The positive skew is not surprising because prescriptions tend to increase with age. Table 6 reports the descriptive statistics for different age cohorts. Note that the mean number of prescriptions per year is nearly 30 for those 65 years of age or older, while it is less than 3 for those under 25 years of age. Table 6 also shows the out-of-pocket pharmaceutical expenditures for each cohort, and these range from less than $65 per year for those under 25 to approximate $930 per year for those 65 and older.

A simple way to estimate the annual benefits of establishing a pharmaceutical disposal program is to multiply the estimated mean WTP of $1.53 by the average number of prescriptions per year of 9.22. This yields a benefit of $14.11 per year. When summed over

[5] Although not reported, we also estimated a specification in which income was coded as a numeric variable, and the coefficient estimate remained statistically insignificant.

Table 4
Logit models for the dichotomous choice contingent valuation responses.

Variable	Model 1		Model 2		Model 3	
	Coefficient (Std. Err.)	Marginal effect	Coefficient (Std. Err.)	Marginal effect	Coefficient (Std. Err.)	Marginal effect
Bid Amount	−0.484*** (0.097)	−0.118	−0.509*** (0.092)	−0.125	−0.415*** (0.083)	−0.103
Age	−0.020*** (0.005)	−0.005	−0.020*** (0.005)	−0.005	–	–
Gender	−0.375** (0.154)	−0.091	−0.354** (0.145)	−0.087	–	–
Democrat	0.535*** (0.161)	0.129	0.545*** (0.151)	0.132	–	–
Awareness	−0.306* (0.156)	−0.075	−0.231 (0.148)	−0.057	–	–
Middle income	−0.119 (0.196)	−0.029	–	–	–	–
High income	−0.151 (0.217)	−0.037	–	–	–	–
Constant	1.981*** (0.337)	–	1.839*** (0.286)	–	0.636*** (0.111)	–
Observations	773		861		952	
Log likelihood	−493.4		−552.9		−642.8	
Psuedo R^2	0.07		0.07		0.02	

Notes: Observations with missing data are not included in the estimation. One, two, and three asterisks indicate significance at the 90-, 95-, and 99-percent levels, respectively. Marginal effects are evaluated at the means of the corresponding explanatory variable. Marginal effects for dummy variables are calculated for the discrete change from 0 to 1.

populations 18 years of age or older, this method yields estimates of aggregate WTP that are substantial. Considering Santa Barbara and Ventura counties, the area in which we conducted our survey, the approach implies an annual benefit of nearly $12.6 million per year. When extrapolated to the nation as a whole, the annual benefits are in excess of $2.9 billion.

While these numbers are suggestive of substantial benefits that could arise with the establishment of a pharmaceutical disposal program, there are several reasons why they should be interpreted with caution. As described in detail by Mitchell and Carson (1989), contingent valuation surveys are susceptible to sources of bias that can result in overestimates. An obvious source of bias is "yeah-saying", which implies that respondents simply provide the answer to a hypothetical question that they assume researchers are looking for.[6] It is also likely that extrapolation may be biased because WTP would certainly differ in other parts of the country. Another potential source of bias that may be important in our study is that respondents did not account for how many prescriptions that they actually fill and that would be subject to the surcharge. Yet, we know from the data reported in Table 6 that this number can be highly variable and therefore imply different costs for different individuals. Finally, we do not have data on health insurance coverage of respondents, and this could be a source of bias, as there may be a perception that insurers would cover the additional cost. Future research should seek to account for health insurance coverage when eliciting preferences for pharmaceutical surcharges.

To address the potential source of bias in which respondents did not adequately consider how many prescriptions they fill per year, we consider a more conservative approach for estimating the overall benefits of establishing a pharmaceutical disposal program. We assume that the estimated mean WTP of $1.53 applies for only *one* prescription per individual per year.[7] This assumption implies an aggregate benefit of $1.36 million per year for Santa Barbara and Ventura counties and $320 million for the nation as a whole. Even with this far more conservative approach, the estimated benefits remain substantial and suggest ample scope for establishing a disposal program. Another potential reason for considering the surcharge for only one prescription per year has to do with the distributional effects if the revenue were to actually be raised with a surcharge. Imposing a surcharge on every prescription would place a disproportionate burden on older residents and senior citizens. For example, it would cost an average of $45.62 per year for those 65 or older, compared to the average of $14.11 per year for all individuals. Hence, if the goal is to implement a surcharge to raise revenue in support of a pharmaceutical disposal program, imposing the surcharge on only one prescription per year for each individual would raise substantial revenue and affect the population more equitably.

How do the benefits, and therefore the potential to raise revenue, compare with the costs of existing pharmaceutical disposal programs? While the costs of implementing a program vary depending on location and type of program, we report here some basic information that we collected about existing programs. Some municipalities have experimented with special collection events. They are often the simplest type of program to initiate, both in terms of time and financial resources. Setting up a temporary collection event involves transitory costs for planning, staff, and logistics, which include arrangements for the transport and final disposal of collected drugs. The Northeast Recycling Council has held several collection events for which the total cost of each event, including outreach, staff time, disposal, and transport, ranged from $1576 to $4190 (Rubinstein, 2006). On a larger scale, the BAPPG (2006) recently held a widely advertised regional 2-day collection event at 39 pharmacies, and the program cost $3645 for disposal of the collected pharmaceuticals, $86,360 for advertising, and 1980 in staff hours.

Permanent disposal programs may result in increased participation, as residents are likely to prefer to dispose of medications at times that they deem most convenient. Setting up a permanent disposal program entails not only initial planning and infrastructure costs, but continuing costs for program administration as well as transport and disposal of collected drugs. A pilot program in Washington state was established to collect pharmaceuticals at eight pharmacies in five different counties. In its first two years, the program has required funding of $251,000 to cover all costs, including one-time planning and infrastructure costs, plus labor

[6] Further details on and empirical estimates of hypothetical bias can be found in Murphy et al. (2005). Future studies that employ CV to estimate WTP for a pharmaceutical disposal program would benefit from a research design that enables comparisons between stated and revealed preferences for purposes of calibration. Aadland and Caplan (2006) provide an example in the context of curbside recycling.

[7] Another possibility would be to correct for hypothetical bias, but we do not have information on revealed preferences against which to calibrate our results. We could, however, use the estimate in Murphy et al. (2005) for the ratio between hypothetical and actual values of 1.35. This procedure implies a mean annual WTP of $10.45 and overall benefits to Santa Barbara and Ventura counties of $9.3 million per year. Even with the calibration, these numbers remain substantially higher than assuming the WTP of $1.53 for *only* the first prescription. Our policy analysis should therefore be considered very conservative in terms of the benefits of establishing a disposal program.

Table 5
Estimates of mean WTP and confidence intervals.

	Method 1	Method 2
Mean WTP	$2.56	$1.53
90-percent confidence interval	$1.78–$4.77	$1.14–$2.63
95-percent confidence interval	$1.67–$5.60	$1.09–$2.97

Table 6
Prescriptions and out-of-pocket pharmaceutical expenditures for 2004.

Age cohort	Prescriptions per year		Out-of-pocket
	Mean	Median	Expenditures
0–17	2.28	0.0	$31.69
18–24	2.71	0.0	$63.26
25–44	5.45	1.0	$134.91
45–64	16.33	6.0	$397.88
65 and older	29.82	21.0	$929.90
Overall	9.22	1.0	$239.61

Source: Medical Expenditure Panel Survey (2004).

equivalent to one to two full-time employees. An alternative way to structure a permanent disposal program, which has been employed in San Mateo County, California, is to set up drop boxes at police stations. The San Mateo County program takes place at three different police stations and costs $1.57 per pound, for a total of less than $1900 in six months of collection (Gordon, 2007). The only direct cost this collection program incurs is for disposal, as police officers service the boxes and the U.S. Postal Service donated the collection containers. Finally, pharmaceutical disposal could be based on a permanent mail-back program. The state of Maine recently allocated one-time funding of $150,000 for the Maine Drug Enforcement Agency to establish a mail-back program.

Outside of the United States, the Return Unwanted Medications (RUM) Project in Australia, established in 1998 by the Commonwealth Department of Health, allows consumers to take unwanted and out-of-date medications to community pharmacies (Appel, 2007). The program is operated by a national nonprofit company and funded by the Australian government. In 1998 the program received $3 million (Australian dollars) for three years, and in 2005 it received $6 million for an additional four years. Community pharmacies collect the medicines at no cost, and pharmaceutical wholesalers provide discounts for delivery and collection of RUM Project containers to pharmacies. Each month an average of over 30 metric tons (30,000 kg) of unwanted medicines are collected across Australia and ultimately destroyed by high temperature incineration. Several programs are also in operation throughout Canada, but we were unable to find data on the costs of these programs.

Our brief review of the costs associated with pharmaceutical disposal programs suggests much scope for these programs to satisfy the benefit-cost criteria, even with the most conservative benefit estimates. We must recognize, however, that a requisite component of all the aforementioned disposal programs is a marketing or advertising campaign. Such efforts will help raise awareness of the issue and will influence people's disposal behavior toward more environmentally preferred disposal habits. We found in our survey, for example, that people who are aware of the presence of pharmaceuticals in the environment are less likely to dispose of drugs via the trash or drain.

In addition to preventing pharmaceuticals from entering the environment, disposal programs will also encourage people to dispose of their unwanted medications instead of keeping them around the house, where there is an increasing risk of misuse. Abuse of prescription medication has risen in recent years, and prescription drugs have surpassed marijuana as the most common illicit drug used by first-time drug users (DHHS, 2006). This concern prompted the Office of National Drug Control Policy to make recommendations for disposing of pharmaceuticals via the trash (ONDCP, 2007).

Finally, we should mention one challenge that must often be addressed when attempting to implement a pharmaceutical disposal program. The Drug Enforcement Agency classifies some medications as controlled substances due to their potential for abuse or misuse. The regulations stipulate that once controlled substances have been dispensed to the end-user, they can only be handled by law enforcement personnel (ODC, 2007). This rule means that many collection programs must exclude controlled substances, and this creates confusion among the public because most people do not know the regulations and/or are unaware of which substances are controlled. While some programs have sought waivers in order collect both uncontrolled and controlled medications, it is important to acknowledge that this issue has been and continues to be an important obstacle when it comes to establishing pharmaceutical disposal programs.

5. Conclusion

The presence of pharmaceutical compounds in treated wastewater and in surface waters is a growing environmental concern. While little is known about the relative importance of excretion vs. disposal as an avenue for introducing the compounds to the environment (Daughton, 2003b), managers have focused attention on the establishment of disposal programs, which are thought to provide a straightforward mechanism to help address the problem. Based on a telephone survey of 1005 residents in southern California, this paper provides information about general awareness of the issue, disposal practices, willingness to pay for a disposal program, and willingness to participate in a disposal program.

Less than half of the respondents are aware that medical compounds have been found in treated wastewater and in surface waters, and awareness affects disposal practices. While disposal of unused medications through the trash and toilet/sink are the most common practices, respondents that are aware of the issue are less likely to use these disposal routes and more likely to return pharmaceuticals to the pharmacy or drop them off at hazardous waste centers. It appears, therefore, that one implication of efforts to increase awareness will be to affect disposal practices in environmentally beneficial ways.

The results of our contingent valuation question indicate a substantial willingness to pay a surcharge on prescriptions to support the establishment of a pharmaceutical disposal program. The more conservative estimate of mean willingness to pay is $1.53 per prescription. For the average individual, with 9.22 prescriptions per year, this translates into an annual willingness to pay of approximately $14. When multiplied by corresponding populations, i.e., Santa Barbara and Ventura counties or the nation as a whole, these results imply substantial benefits that easily outweigh what would be the costs of establishing disposal programs. Indeed, even if the surcharge were applied to only one prescription per year, the comparison of benefits and costs suggest ample scope for establishing pharmaceutical disposal programs that would yield positive net social benefits. From a policy perspective, applying the surcharge to only one prescription per year also has the advantage of not placing a disproportionate burden on senior citizens, who require more prescriptions per year.

Beyond evidence on willingness to pay, we find that respondents are also likely to participate in a disposal program if one were established. Assuming that the program was based on drop-off locations at local pharmacies, 68 percent of the respondents answered that they would be very likely to return their unwanted or expired medicines. Collecting pharmaceuticals in this way would help to reduce the amount of pharmaceutical compounds that enter the wastewater stream through residential disposal. Advocates of disposal programs of this type also point to the potential benefits of avoiding the abuse of prescription drugs that might otherwise be stored within the household.

Acknowledgements

We gratefully acknowledge financial support from the National Marine Sanctuaries Foundation and the Shoreline Preservation

Fund. We are grateful for helpful comments and discussions we received from Jenny Phillips, Leslie Robinson, Trish Holden, Hunter Lenihan, Kira Schmidt, William Lee, Paolo Gardinali, and especially three anonymous reviewers. Any errors or omissions are solely our responsibility.

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