



Full length article

# Household informedness and policy analytics for the collection and recycling of household hazardous waste in California

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## ABSTRACT

Collection and recycling of *household hazardous waste* (HHW) can vary due to differences in household incomes, demographics, material recyclability, and HHW collection programs. We evaluate the role of *household informedness*, the degree to which households have the necessary information to make utility-maximizing decisions about the handling of their waste. Household informedness seems to be influenced by HHW public education and environmental quality information. We assess the effects of household informedness on HHW collection and recycling using panel data, community surveys, drinking water compliance reports, and census data in California from 2004 to 2012. The results enable the calculation of the responsiveness or *elasticity of the output quantities* of HHW collected and recycled for differences in household informedness at the county level. There are three main findings: (1) provision of HHW public education has a positive effect on the amount of HHW collected and recycled, but may have a negative effect on HHW collected in some circumstances; (2) environmental quality information about contaminant violations in drinking water has a negative association with the amount of HHW collected; and (3) when information is sent directly via mail to households, an increase in the number of *contaminant level* (MCL) violations is positively related to the amount of HHW collected. Understanding how these effects work in California can help waste management policy-makers and practitioners in other locations to plan appropriate information policies and programs to maximize household participation in HHW collection and recycling based on household informedness and demographic characteristics.

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## 1. Introduction

*Household hazardous waste* (HHW) is defined as leftover household products that contain corrosive, toxic, ignitable, or reactive ingredients, such as paints, cleaners, oils, batteries, and pesticides (U.S. Environmental Protection Agency, 2014). Often this waste is disposed of improperly, for example, by pouring it down a household drain, onto the ground, into storm sewers, or simply disposing of them together with the regular trash. If this happens, the waste materials can contaminate the land and infiltrate the ground water, and consequently create adverse effects on the environment and people's health (U.S. EPA, 2015). Due to these damaging effects, improving HHW management is essential.

A 2015 review of HHW management performance reported that the amount of HHW collected was only about 0.12% to 1.88%

of *municipal solid waste* (MSW) or general trash (Inglezakis and Moustakas, 2015).<sup>1</sup> This amount may not include HHW that is mixed in general trash or disposed of improperly. The diversion of HHW from general trash can be enhanced through various HHW collection programs. The success of these programs depends on household participation in identifying, segregating, storing and transferring HHW to the collection system.

Besides the convenience and effectiveness of HHW collection programs, household informedness is an essential aspect that can encourage household participation. In this study, we define *household informedness*, a construct we first proposed in an earlier conference presentation (Lim-Wavde et al., 2016), as the degree to which households have the necessary information to make utility-maximizing decisions about the handling of their waste. We focus on household informedness for waste management, though it also is applicable in other disciplines, such as Information Systems,

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Marketing, Economics, Environmental Management, and Social Science. Research related to informedness has been conducted in other disciplines as well. For example, [Shimshack et al. \(2007\)](#) reported on consumers who received mercury advisories from the U.S. Food and Drug Administration, and then reduced their canned fish consumption. [Li et al. \(2014\)](#) also showed that informedness about prices and products determined the choices they made. And [Byrne et al. \(2016\)](#) performed an experiment to understand the impacts of different levels of informedness for electricity use related to decision-making for household-level utility maximization. The theories used in these studies are applicable for information policy and waste management for hazardous waste collection, recycling and environmental sustainability.

Household informedness can be influenced through the provision of environmental quality information and public education. Information in the form of notification or alerts about environmental quality can impact household perceptions about the quality of the environment they live in. In HHW public education, people receive information about what types of household materials are hazardous, what alternative non-hazardous products can replace them, and how to properly dispose of hazardous waste ([Lund, 2001](#)). This may reduce the generation of hazardous waste, and increase household participation in HHW programs that are provided.

Our study focuses on the effect of household informedness. These effects can be assessed by observing changes in the amount of HHW collected and recycled in the presence of different county and demographic characteristics. However, quantifying the causal effects of household informedness on HHW recycling and collection is not a simple task. The field of waste management has been largely *opaque* because of the complexity of the issues, the diversity of practices among people, firms and local institutions, and the difficulty to observe people's behavior toward their waste ([Wijen, 2014](#)). Properly managing waste involves managing heterogeneous stakeholders (households, firms, waste facilities, and local and federal government), as well as other factors (socioeconomic and environmental awareness). Waste reduction relies heavily on people's willingness to participate in reducing, reusing, and recycling their waste, but given the heterogeneity of the stakeholders and variety of factors, there is diversity in behavior and practices.

We selected California for this empirical research because it has diverse county characteristics and accessible annual reporting on HHW collection, disposition, programs, and grant awards. We use data published by California's Department of Resources Recycling and Recovery (CalRecycle), the Annual Compliance Report for Public Water Systems by the California Department of Public Health (CDPH), the American Community Survey, and U.S. census data from 2004 to 2012 for our analysis. Although causal evidence is ideally generated using randomized experiments, randomization is often not feasible in social science settings such as HHW waste management. So causal effect estimates may be hard to establish.<sup>2</sup>

Our study is based on utility maximization theory. It focuses on waste management decisions at the household level. Previous studies by [Kinnaman and Fullerton \(2000\)](#) and [Callan and Thomas \(2006\)](#) used a similar theory; they also considered disposal unit pricing levels as discussed by [Hong \(1999\)](#), however, these studies were based on cross-sectional data analysis at the community-level. [Sidique et al. \(2010\)](#) used county-level panel data analysis

and also discussed the effects of recycling education on the general recycling rate. They also mentioned that the environmental quality which the household perceives may influence the household's utility function. However, this factor was specified as a function of the amount of waste disposed, the amount of waste recycled, and demographic characteristics. They did not consider that recycling would also be affected by the environmental quality information that a household receives from local governments and environmental agencies. Our study considers information about how violations with respect to the *maximum contaminant level* (MCL) in drinking water may affect HHW collection and recycling.

There are a few empirical studies about the generation of solid waste and recycling by households, particularly involving empirical analyses that have examined household waste behavior responses to trash price changes and regulation ([van den Bergh, 2008](#)). [Jenkins et al. \(2003\)](#) analyzed the effectiveness of two waste programs – *curbside pick-up* and *waste drop-off* – on the rate of recycling of five different waste materials: glass bottles, plastic bottles, aluminum, newspaper, and yard waste. In a mail survey of California households, [Saphores \(2006\)](#) found that gender, education, convenience, and environmental beliefs were the key factors which influenced the willingness of households to drop off electronic waste at recycling centers. There also are empirical studies on the factors which affect recycling rates that leverage county-level panel data. For example, [Sidique et al. \(2010\)](#) found that variable pricing of waste disposal increased the rate of recycling in counties in the state of Minnesota, and [Abbott et al. \(2011\)](#) found that the methods chosen for recycling collection are determinants of the observed recycling rates. In addition, a proper infrastructure of recycling facilities is critical ([Bartelings and Sterner, 1999](#)).

While previous empirical studies investigated the influence of socioeconomic factors, the effectiveness of waste collection programs, environmental attitudes and activism, and various waste management policies, our research evaluates the role of household informedness in the context of a special kind of waste, HHW. Household informedness is rarely discussed in the waste management literature perhaps because it is difficult to obtain data to measure the degree to which households have the necessary information to make the best decisions in managing their waste.

A few studies assessed the influence of information on recycling behavior and household recycling decisions. [Martinez and Scicchitano \(1998\)](#) showed that public media programs had positive effects on recycling and these effects were greater for households with higher levels of education. [Nixon and Saphores \(2009\)](#) found that sharing recycling information via family or friends, and at school or at work were the most effective in influencing household decisions to recycle. [Largo-Wight et al. \(2012\)](#) recommended educational campaigns to promote recycling behavior among college students should emphasize positive attitudes towards recycling, behavioral facilitation of recycling (e.g., convenience to recycle), the moral obligations involved, and social norms for prosocial recycling. However, these studies were mainly based on survey data and did not examine the influence of information on the amount of waste recycled. The household informedness construct in this study emphasizes how informedness influences the outcomes that are observed, especially the amount of HHW collected and recycled.

Our research represents the first empirical study to our knowledge to measure and quantify the effect of household informedness on HHW collection and recycling using county-level waste collection data. Our research contributes insights related to impact assessment of household informedness and the quantification of household informedness elasticity on HHW collection and recycling output.

An increase in HHW collection will lead to less hazardous waste being disposed of improperly so there is less polluted water and

<sup>2</sup> Public education about HHW also may suffer from a possible *policy-related endogeneity* issue. The decision of local government to provide HHW public education may be a purposeful action to meet certain waste collection targets. From our data, we observed that grant awards used for HHW public education programs seemed to be fewer in number when the amount of HHW collected increased. For this problem, we applied an instrumental variable to see if it were possible to address this bias.

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