International Journal of Environmental Protection and Policy
2019; 7(1): 1-8
http://www.sciencepublishinggroup.com/j/ijepp
doi: 10.11648/j.ijepp.20190701.11
ISSN: 2330-7528 (Print); ISSN: 2330-7536 (Online)

Artisans' Willingness-to-Pay for Safe Collection and Recycling of Used Automobile Lead-Acid Batteries in Kumasi, Ghana

Evelyn Delali Ahiale[1], Emmanuel Dartey[2, *], Isaac Abunyuwah[1]

[1]Department of Agricultural Economics and Extension Education, University of Education, Winneba, Mampong, Ghana

[2]Faculty of Science and Environment Education, University of Education, Winneba, Mampong, Ghana

Email address:

emmldartey@yahoo.co.uk (E. Dartey)

[*]Corresponding author

To cite this article:

Evelyn Delali Ahiale, Emmanuel Dartey, Isaac Abunyuwah. Artisans' Willingness-to-Pay for Safe Collection and Recycling of Used Automobile Lead-Acid Batteries in Kumasi, Ghana. *International Journal of Environmental Protection and Policy*. Vol. 7, No. 1, 2019, pp. 1-8. doi: 10.11648/j.ijepp.20190701.11

Received: October 5, 2018; **Accepted**: January 25, 2019; **Published**: February 22, 2019

Abstract: Growing demand for automobiles has logically led to the generation of huge quantities of used Lead-Acid Battery (LAB) which are usually found stockpiling in and around car-repair shops all over Ghana. The reclamation and recycling of spent LABs in the country is mainly unregulated and informal and therefore not done in a sustainable and eco-friendly manner. This paper estimates artisans' willingness to pay (WTP) for the safe collection and recycling of used lead-acid batteries (LABs) with data collected through the contingent valuation method (CVM) from 102 artisans in the Kumasi Metropolis of Ghana. Artisans' WTP and its determinants were estimated using Bayesian estimation of the interval data regression model. An estimated mean WTP of GH¢16.06 (US$3.87) was obtained for the safe removal and recycling of any one (1) spent LAB. Important artisan characteristics influencing willingness to pay positively are age and monthly income whereas experience influences willingness-to-pay negatively. Training received, awareness of risk of LABs to personal health, wearing of protective clothing, and other safety measures are significant awareness, knowledge and safety factors affecting WTP in a positive way. Sensitization on the health and environmental effects of LABs as well as the importance of taking safety measures should be given to artisans and should be mainly targeted at younger artisans.

Keywords: Used Lead-acid Battery, Recycle, Contingent-Valuation-Method (CVM), Interval-Data Regression Model, Willingness-to-Pay (WTP)

1. Introduction

Lead-acid batteries (known as LABs) are extensively used worldwide on a large scale. Approximately 85% of the total world-wide consumption of lead is for the manufacture of LABs [1]. LABs are mainly used in vehicles for starting, lighting, and ignition purposes, but are also used in photovoltaic solar installations and telecommunications systems to store energy. In developing countries where the power supplies are often erratic, LABs are regularly used to power a wide-range of appliances and equipment used in homes and by businesses when outages occur [1-3]. The vast majority of LABs are automobile starter batteries for vehicles and trucks. All automobile batteries and 95 percent of industrial batteries are lead-acid secondary cells. The increase in the development and use of renewable energy sources and its associated need for storage batteries, along with the growing demand for automobiles as countries advance economically will therefore lead to the demand for LABs increasing continuously in many African countries including Ghana.

LABs usually contain high levels of lead, a highly toxic heavy metal, and sulfuric acid, an extremely corrosive electrolyte solution. Averagely, each automobile produced contains approximately 12 kilograms of lead, about 96% of which is used in the common lead-acid battery and the rest 4% for wheel balance weights, protective coatings and vibration dampers [4]. The health (particularly in children) and environmental consequences of exposure to lead is widely known and documented [see e.g., 5, 6-10]. In the developing world, over 3 million die annually owing to lead contamination from processing of spent LABs, with the regions most affected being South America, South Asia, and Africa [4]. The recycling of spent LABs is thus of public health concern.

Occupational and environmental lead exposure in developing countries arguably may have a more profound effect than in developed countries. Poor nutrition, common in developing countries, increases lead absorption through the gastrointestinal tract. Lead poisoning imposes a range of hidden costs on developing countries. One study estimated that a 50% decrease in childhood blood lead levels in Nigeria could save the country $1 billion annually; the health care cost of lead exposure for adults is estimated to total $7 billion [11-13]. Lead-induced decrements to health status may further decrease productivity, which will lead to less investment and the continuation of the cycle of poverty [14].

The high lead-content of LABs make them economically attractive for recycling. However, due to the toxicity of lead, once LABs have reached their end-of-life, it is essential that they are safely collected and recycled in an eco-friendly manner. In Ghana, however, the reclamation and recycling of spent LABs is mainly unregulated and informal and therefore not well done. Traders and recycling companies are supplied with spent LABs by offering cash-money mainly to car and battery repairers (i.e., mechanics). Consequently, numerous small and medium size companies and individuals engage in the collection and sale of spent lead-acid batteries [15]. It is therefore not uncommon to find spent LABs stockpiling in and around car-repair shops and clusters which are finally sold to small-scale scrap metal collectors [15].

Figure 1. *A stockpile of spent LABs at one of the workshops.*

Once LABs have been collected they undergo different treatments. Some are reconditioned into functioning second hand batteries for the local market, some others are acid-drained (i.e., acid is drained from the batteries) before transportation and are then broken and lead scrap extracted. The recovered lead is mainly melted into raw lead ingots. The lead extraction process also yields empty plastic cases. Because all these activities are done with little or no knowledge of the toxicity of lead, under poor conditions of safety, health and environmental controls, unregulated and informal recycling is most likely to cause environmental contamination and human exposure [3, 16, 17] due to huge releases of lead, lead-particles, lead-dust and residual acid. Particles containing predominantly Pb in the metallic form, such as PbO, PbO_2 or as $PbSO_4$, contaminate the workroom atmosphere and soil. Reports by UNEP [18]; Kumar et al. [19]; Minozzo et al. [20]; Peter [21] and recently Dartey et al. [22, 23] indicate that workers at storage battery manufacture and repair workshops are particularly at risk because industrial hygiene is poor. In fact, Dartey et al. [23] in particular have reported of elevated mean levels of Blood – Pb, Serum-Pb and Urine – Pb among small scale LABs repair workers in Suame Magazine and Asafo Fitam in the Kumasi metropolis of Ghana. High levels of soil Pb in small scale battery workshops at Suame Magazine and Asafo Fitam have also been reported [24].

The reported elevated mean levels of lead in battery repair workers and the soils surrounding repair shops shows that there are health and environmental problems associated with the way spent LABs are generally dealt with in Ghana presently (e.g. stockpiling, disposal in open dumps, etc.). Therefore, a safe and sustainable collection and recycling of spent batteries is needed to prevent the possible negative consequences associated with unsustainable recycling. To achieve this, it is imperative that the present ineffective and unsustainable way of collecting and recycling spent LABs in Ghana is replaced with effective control measures to protect the health of individuals in the disposal and recycling chain as well as to prevent pollution of the environment. Formulating appropriate policies on spent LABs and establishing specialized spent LABs recycling facilities in Ghana is thus necessary. This could ensure that the collection and subsequent recycling of spent LABs is done according to best practices by individuals and business entities knowledgeable in recycling LABs in an eco-friendly manner.

The establishment of eco-friendly and sustainable spent LABS collection process and recycling facilities in Ghana must be grounded on consumers' behavior. The appropriate compensation (price) level for a spent LAB must be known. Fees must be set at an appropriate level. If the price is too low, eco-friendly collection and recycling may not be sustainable as artisans may refuse to sell to them and rather continue their existing practice of stockpiling spent LAB at their workshops and sale to small-scale crop metal collectors who do not practice eco-friendly recycling. When the prices of spent LABs are too high, eco-friendly recycling may not be economically viable and recycling rates may decrease.

Though presently, battery repair workers are offered money for spent batteries, the current study estimates WTP and not WTA (willingness-to-accept). This is because although theoretically, WTP and WTA measures should give similar amounts, empirical evidence has however, shown that large differences between the two measures have systematically been observed with WTA being two to four times and even more greater than WTP [25, 26]. More importantly, as it applies in the context of this study and Knetsch [27] argues, measuring individuals' WTP is more realistic if avoiding, for example, health problems due to pollution if individuals deem such health problems resulting from pollution as "normal or the reference state", and that "relief (the change being considered) is in the realm of gains".

This study estimates WTP and analyses the socio-economic, knowledge, awareness and safety determinants of battery repair workers' WTP for sustainable collection and recycling of spent automobile LABs in the Kumasi Metropolis using data collected through the CVM. The CV elicitation format used here allows for uncertain responses and hence an interval regression model which has been adapted to allow for uncertain responses is employed to estimate WTP and determine the factors influencing it. This paper is novel in using stated preference to estimate WTP for sustainable collection and recycling of spent automobile LABs in a developing country. The findings of this study provide important policy implications for LABs handling and recycling in Ghana and possibly other developing countries with similar socio-economic characteristics, particularly in Africa.

The paper proceeds by presenting the model specification and estimation in section 2. Field survey, data and variables are described in section 3. Section 4 presents the results and discusses their implications. The main conclusions are summarized in section 5.

2. Econometric Model Specification and Estimation

The contingent valuation (CV) is a popular method used to elicit the willingness to pay (WTP) or accept (WTA) for a change in the quantity or quality of some environmental services or of an environmental policy. CV surveys employ diverse question formats to ask respondents to indicate the monetary value they place on these changes. The assumption underlying the CV method is that respondents are able to answer valuation questions with certainty. However, the issue of uncertainty bias in CV surveys arising out of respondents' inability to state their actual preferences with certainty is well known. Preference uncertainty which results from answering valuation questions on goods/services that are either unknown, little known or hypothetical has received considerable attention in the CV literature over the last two decades or more.

Different approaches have therefore been developed and applied in the CV literature to reduce or eliminate uncertainty bias in CV surveys. One such approach is the multiple-bounded uncertainty choice (MBUC) format which was developed by [28] and have since been employed in various surveys [29-36].[1] This is the elicitation format used in the current paper. It permits respondents to state if they would pay an amount with certainty or with some level of uncertainty when presented with a "payment card" with possible range of amounts. Data of each individual thus obtained from the MBUC format falls within a range and therefore cannot be analyzed with the methods commonly used to model WTP.

The interval-data model is employed where the dependent variable is not just a single WTP amount but falls within a range as is obtained from the MBUC. Empirical studies assessing the efficiency of the interval-data model exists. For example, Hanemann et al. [37] found the interval-data model to be more statistically efficient in estimating WTP by reducing the variance and point estimates of WTP models compared to single-bound models. Alberini [31] also assessed the efficiency and biases of the estimates got from both the bivariate probit and interval-data models and observed more robust estimates for mean/median WTP obtained from interval-data model. She thus concludes that when perfect correlation as is the case in many CV studies is absent, the interval-data model might be suitable. The

1 The MBUC format is referred to under various names in the literature. These include: the multiple-bounded, polychotomous-choice format or multiple-bounded format with uncertain response options [38] and the multiple-bounded format [34].

interval-data model works under the assumption that responses of individuals to both initial and follow-up dichotomous choice payment questions are driven by single WTP/WTA amounts [31]. The model uses data with lower and upper bounds.

To transform MBUC answers to a form which allows the statistical models usually used to model stated-preference answers to be employed, the researcher must interpret these answers under certain assumptions. Several researchers have converted MBUC CV data to easily estimable forms using varied rules [33, 34, 36, 38, 39]. Intervals are obtained by assigning, $LB < y_j^* < UB$ given the responses, where LB and UB are the lower and upper bounds respectively. In the current study, the expansion approach of Broberg and Brännlund [33] which includes uncertainty without neglecting the most dependable information about each respondent's WTP, the "definitely" responses is used to obtain the LB and UB. This approach is more intuitive, fits the data better, estimates mean and median WTP with more accuracy, is less sensitive to distributional assumptions, and is more appropriate for policy analysis than other approaches [33].

If utility is unobserved and indicated by the latent variable y_j^*, and WTP_j is the WTP of the jth individual, then the utility is usually expressed as:

$$WTP_j = y_j^* = \beta' x_j + \varepsilon_{j;}\ \varepsilon_j \sim N(0, h) \quad (1)$$

where x_j is a vector of explanatory variables affecting respondents' WTP, β' is the parameter vector related with x_j and ε_j is the error term assumed to be normally distributed with zero mean and standard deviation h.

Per Broberg and Brännlund [40] approach, the highest "definitely yes" and the lowest "definitely no" responses form lower and upper bounds of the interval. Accounting for uncertainties in the model gives the uncertainty interval model which this study employs. The WTP interval for the jth individual is a function of his responses with the LB and UB constructed based on the following assumptions:

1. A 'Y': bid forms WTP_{lower}
2. A 'N': bid forms WTP_{upper}
3. A 'PY': bid forms WTP_{lower}, with a fixed probability, τ
4. A 'PN': bid forms WTP_{upper}, with a fixed probability, τ

Where τ is a probability value of truncation which falls between 0 and 1, and specified by the authors at 0.75; Y is definitely yes, PY is probably yes, DK is don't know, PN is probably no, and N is definitely no.

Subsequently the latent variable y_j^* clearly represents a person's WTP. Equation (1) would hence give an estimate of the mean WTP.

The priors for β and h are specified to be normal $N(.,.)$ and inverse gamma $IG(.,.)$ respectively for a Bayesian estimation and inference:

$$\beta \sim N(\underline{b}, \underline{V}) \\ h \sim IG(n, s) \quad (2)$$

For the latent variable y^*, the likelihood is given by:

$$p(y^*|x, \beta, h) = (2\pi)^{-\frac{n}{2}} h^{\frac{n}{2}} e^{-\frac{1}{2}h(y^* - x\beta)'(y^* - x\beta)} \quad (3)$$

Equations (2) and (3) produce the posterior distribution. Using the Gibbs sampler, the posterior distribution of model (1) is simulated [see for example 41].

A first model which estimates the WTP, the unconditional distribution of the WTP in the population is initially run [42]. A second model then includes the explanatory variables.

Markov Chain Monte Carlo (MCMC) was employed in estimating the models. The burn-in phase was set to 2000 iterations, after which 200,000 iterations in which every 20th observation was kept so as to minimize the dependence in the sequence, leading to 10,000 observations for model estimation. Convergence was diagnosed with both visual plots of the sequences of values created by the sampler and by modified t-tests for the hypothesis of 'no-difference' between the first and second halves of the sampled values for every parameter. Observations with a missing upper or lower bound were discarded. [2]

3. Field Survey, Data and Variables

Data for the study came from a survey of 102 artisans conducted in May, 2017 in five suburbs namely: Suame Magazine, Asafo Fitam, Amakom, Tafo and Afful Nkwanta in the Kumasi Metropolis of the Ashanti region of Ghana. A two-stage sampling approach was employed. First, suburbs with relatively higher concentration of artisans were purposely selected. The respondents were then chosen randomly, the sample size from each suburb based on the population of artisans present.

Through individual one-on-one interviews, data were obtained from respondents using a questionnaire which included a CV exercise. A polychotomous-choice multiple-bounded CV elicitation format with variations of yes/no answers to specify respondents' level of uncertainty [29, 30] was used to elicit artisans' WTP. The CV question format included seven bid amounts ranging from a high of GH¢35 to a low of GH¢5.[3] This range was informed by discussions with some artisans and experts. The CV question format is shown in Table 1. A description of variables used to explain WTP is given in Table 2.

Table 1. *CVM question answered by survey participants.*

Amount (Ghana Cedis/battery)	Definitely No	Probably No	Don't Know	Probably Yes	Definitely Yes
35					
30					
25					
20					
15					
10					
5					

2 We are grateful to Kelvin Balcombe for generously allowing us access to his Gauss code for estimation of the models.

3 The average exchange rate in 2017 was GH¢1to US$0.2410

Table 2. *Variable definitions and summary statistics.*

Variable	Definition	Mean N=102	S.D.
Explanatory variables			
Personal characteristics variables			
AGE	Age of respondent (in years)	37.23	10.204
EDUCAT	Level of education of respondent (in years)	8.20	3.409
WSTATUS	Dummy for position in work (1 if mentor, 0 if apprentice)	0.36	0.483
EXPERIN	Length of time respondent has been handling LAB (in years)	12.73	8.993
MINCOME	Respondent's monthly income (in GH¢)	1026.62	1553.217
Awareness, knowledge and safety measures variables			
TRAIN	Dummy for received training in safe LAB handling (1 if yes, 0 if no)	0.16	0.365
PH_RISK	Dummy, aware of LAB risk to personal health (1 if aware, 0 if otherwise)	0.79	0.406
ENV_RISK	Dummy, aware of LAB risk to the environment (1 if aware, 0 if otherwise)	0.84	0.365
P_CLOTH	Dummy, protective clothing worn when handling LAB observed (1 if worn, 0 if otherwise)	0.49	0.502
P_WORK	Dummy, other safety measures taken when handling LAB (1 if taken, 0 if otherwise)	0.13	0.335
EATPLACE	Dummy for place of eating when at work (1 if at workshop, 0 if otherwise)	0.87	0.335
SOAPWATR	Dummy, type of cleaning done before eating (1 if with soap and water, 0 if otherwise)	0.70	0.462
CFREQWASH	Dummy, frequency of washing work clothes (1 if at least once a week, 0 if otherwise)	0.51	0.502

4. Results and Discussion

4.1. Descriptive Statistics of Respondents

The descriptive statistics of the data are presented in Table 2. The average age of the respondents is 37 years. Artisans have generally low level of education, having spent an average of approximately only 8 years in formal school. Most of the respondents (64%) are apprentices, have been handling LABs for an average of 12 years and earn a mean monthly income of GH¢ 1,026.62 (US$247.42). It should be noted that 99 (97.06%) out of the 102 respondents are men and therefore gender is not included in the model as there is not enough variation in the variable.

A look at the variables measuring respondents' awareness, knowledge and safety measures shows that 84% have received no training on the safe way of handling LABs; 21% are not aware of the possible risks of LABs to their own health; 84% are aware of the probable risk LABs pose to the environment; 49% wear protective clothing at work; only 13% observe other safety measures; 87% eat at the workshop; 70% wash their hands with soap before eating; and 51% wash their work clothes at least once a week.

4.2. Distribution of Lower and Upper Bounds of WTP

The lower and upper bounds are the amounts that respondents are willing and not willing to pay respectively. The distribution of lower and upper bounds of WTP are shown in Table 3. The majority of artisans, 93.14%, have their lower bound WTP from GH¢5-15 (US$1.21-3.62), making this range the most important as far as numbers reporting is concerned. This indicates that 93.14% of the artisans surveyed are willing to pay GH¢5-15 (US$1.21-3.62), for the removal of LAB from their premises and the safe disposal of same. For the upper bound, most artisans, 82.36% have their upper bounds from GH¢20-35 (US$4.82-8.44), meaning that they are not willing to pay GH¢20-35 (US$4.82-8.44).

Table 3. *Distribution of lower and upper bounds of WTP.*

WTP	Lower bound	Upper bound
(GH¢/battery)	No. of responses (%)	No. of responses (%)
5	53 (51.96)	0 (0.00)
10	32 (31.37)	7 (6.86)
15	10 (9.80)	11 (10.78)
20	4 (3.92)	12 (11.76)
25	1 (0.98)	16 (15.69)
30	2 (1.96)	40 (39.22)
35	0 (0.00)	16 (15.69)
Total	102 (100.00)	102 (100.00)

Figures in parentheses are percentages

Table 4. *Interval-data model results.*

Variable	Coefficient	S.D
Constant	6.132	3.6871
AGE	0.263 *	0.1225
EDUCAT	-0.180	0.2033
WSTATUS	1.145	1.8606
EXPERIN	-0.367 *	0.1414
MINCOME	0.001 *	0.0006
TRAIN	2.806 *	1.800
PH_RISK	3.334*	3.1373
ENV_RISK	-2.614	2.8492
P_CLOTH	3.785*	1.5315
P_WORK	4.648*	2.1905
EATPLACE	1.618	2.1547
SOAPWATR	-0.477	1.6024
CFREQWASH	0.710	1.4907

Note: * pseudo t-value significant at 5%; Within Bayesian inference, the coefficient's confidence/credible interval excludes zero if the ratio of the estimate of the mean to the standard deviation exceeds 2.

4.3. Estimates of WTP

The estimated mean WTP, which is actually the unconditional WTP in the population is GH¢16.06 (US$3.87). Artisans are thus, on average, willing to pay this amount for the safe removal and recycling of any one (1) LAB from their premises.

A number of variables conjectured to explain artisans' WTP for safe removal and recycling of LAB are significant and reveal the general attitude of artisans towards handling and recycling of spent automobile LABs the eco-friendly way.

Important artisans' personal characteristics influencing WTP for the safe removal and recycling of automobile LAB significantly are age, length of time of handling LABs (i.e., experience), and monthly income. Age and monthly income of artisans influence WTP positively whilst experience influences WTP in a negatively. The positive relationship of income with WTP conforms with the results of Song et al. [43]; Gillespie and Bennet [44]; and Challcharoenwattana and Pharino [45] in their researches on WTP for recycling e-waste, WTP for kerbside recycling, and WTP for enhancing municipal solid waste recycling respectively. Older artisans are willing to pay more for the safe removal and disposal of any LABs than younger ones. This may be because older artisans are more aware of the risk of LABs to their health and environmental. This positive age-WTP relationship is not consistent with the findings of Challcharoenwattana and Pharino [45] and Song et al. [43]. Those who have more experience with LABs are willing to pay less for the spent LABs to be safely removed from their premises and recycled in an eco-friendly manner. Artisans who have been handling LABs for longer periods probably do not realize the possible harmful effect of LABs on their health and that of the environment. This result is not consistent with older artisans willing to pay more. The effect of income means that artisans with higher income are prepared to pay higher for the safe removal and recycling of any LABs than lower income artisans, i.e., artisans with higher income will pay more for the spent LABs on their premises to be removed and recycled safely in order to protect themselves and the environment. Contrary to the researches listed above, education is found to be a statistically insignificant personal characteristic in this research.

It is seen from Table 4 that among the variables measuring awareness, knowledge and safety, training received, awareness of risk of LABs to personal health, wearing of protective clothing, and other safety measures taken are found to be significant factors. All these variables have positive effect on WTP. Artisans who have received previous training on the right way of handling LABs are willing to pay GH¢2.81 (US$0.68) more than those without such training. Being aware of the risk of LABs to their own health influences artisans to be willing to pay GH¢3.33 (US$0.80) more for the safe collection and recycling of LABs than those who are unaware. All artisans who take safety measures, whether in wearing of protective clothing or other safety measures are willing to pay more than those who do not take safety measures. Those who wear protective clothing and also observe other safety measures are willing to pay GH¢3.79 (US$0.91) and GH¢4.65 (US$1.65) more respectively than those who do not do observe these safety measures. This may be because those who take safety measures are probably aware of the potential harm that LABs cause to humans and the environment.

5. Conclusions and Policy Recommendations

In this study, artisans' WTP for the safe collection and recycling of used LAB and the determinants of WTP in the Kumasi Metropolis of Ghana are estimated using data collected through the CVM in 2017. The study employed the interval data model in estimation. The estimated mean WTP for removal and disposal of any LAB from workshops is GH¢16.06 (US$ 3.87). This estimate could be used as a reference value for buying spent LABs from artisans for a possible payment scheme of an eco-friendly collection and recycling of spent LABs.

Age, monthly income, whether artisan has ever received training on LAB handling, wearing of protective clothing at work and other safety measures taken when handling LABs as well as awareness of potential risk of LABs to human health were statistically significant and had positive effect on WTP. Only experience had a significant negative influence on WTP. The fact, however, that some artisans did not know that LABs (spent or otherwise) could be harmful to both humans and the environment clearly implies that knowledge and awareness creation is needed. Therefore, health and environmental governmental and non-governmental organizations/bodies should sensitize artisans on the health and environmental effects of LABs. Furthermore, training on the safe way of handling LABs and the importance of observing safety measures should also be provided. For effective outcomes to be obtained, the sensitization and training provided need to be targeted mainly at younger artisans.

References

[1] ILA, "Lead Uses - Statistics," in *In: Lead facts* vol. 2018 London: International Lead Association, 2017.

[2] P. Gottesfeld and A. K. Pokhrel, "Review: Lead exposure in battery manufacturing and recycling in developing countries and among children in nearby communities," *J Occup Environ Hyg,* vol. 8, pp. 520-532, 2011.

[3] UNEP, "National management plans for used lead acid batteries. Training manual for the preparation of national used lead acid batteries environmentally sound management plans in the context of the implementation of the Basel Convention. Basel Convention Series / SBC No 2004/5," Geneva: United Nations Environment Programme, 2004.

[4] S. Zafar, "The Problem of Used Lead-Acid Batteries." vol. 2018: Echoing Sustainability in MENA, 2016.

[5] S. A. Ahmad, M. H. Khan, S. Khandker, A. F. M. Sarwar, N. Yasmin, M. H. Faruquee, and R. Yasmin, "Blood Lead Levels and Health Problems of Lead Acid Battery Workers in Bangladesh," *The Scientific World Journal,* pp. 7, 2014.

[6] ATSDR, "Toxicological profile for lead," Atlanta, GA: Agency for Toxic Substances and Disease Registry: U.S. Department of Health and Human Services, Public Health Service, 2007.

[7] A. A. El Karim, A. A. S. Hamed, Y. A. A. Elhaimi, and Y. Osman, "Effects of Exposure to Lead among Lead-Acid Battery Factory Workers in Sudan," *Archives of Environmental Health: An International Journal,* vol. 41, pp. 261-265, 1986.

[8] A. Gao, X. T. Lu, Q. Y. Li, and L. Tian, "Effect of the delta-aminolevulinic acid dehydratase gene polymorphism on renal and neurobehavioral function in workers exposed to lead in China," *Sci Total Environ,* vol. 408, pp. 4052-5, Sep 1, 2010.

[9] M. J. Kosnett, R. P. Wedeen, S. J. Rothenberg, K. L. Hipkins, B. L. Materna, B. S. Schwartz, H. Hu, and A. Woolf, "Recommendations for Medical Management of Adult Lead Exposure," *Environmental Health Perspectives,* vol. 115, pp. 463-471, 2007.

[10] C. R. Malavika, "Environmental Effects Associated with Battery Disposal." vol. 2018: Frost & Sullivan, 2004.

[11] Q. Zhang, "The Current Status on the Recycling of Lead-acid Batteries in China," *International Journal of Electrochemical Science,* vol. 8, pp. 6457-6466, 2013.

[12] K. R. Mahaffey, "Nutrition and lead: strategies for public health," *Environ Health Perspect,* vol. 103, pp. 191–196, 1995.

[13] WHO, "Recycling used lead acid batteries: health considerations," World Health Organization, Geneva 2017.

[14] O. A. Ogunseitan and T. R. Smith, "The cost of environmental lead (Pb) poisoning in Nigeria," *African Journal of Environmental Science and Technology,* vol. 1, pp. 27-36, 2007.

[15] A. Manhart and T. Schleicher, "The recycling chain for used lead-acid batteries in Ghana - Observations and general considerations," Institute for Applied Ecology, Freiburg, 2015.

[16] T. J. van der Kuijp, L. Huang, and C. R. Cherry, "Health hazards of China's lead-acid battery industry: a review of its market drivers, production processes, and health impacts," *Environmental Health,* vol. 12, pp. 61-61, 2013.

[17] W. E. Daniell, L. Van Tung, R. M. Wallace, D. J. Havens, C. J. Karr, N. Bich Diep, G. A. Croteau, N. J. Beaudet, and N. Duy Bao, "Childhood Lead Exposure from Battery Recycling in Vietnam," *BioMed Research International,* pp. 10, 2015.

[18] UNEP, "Technical guidelines for the environmentally sound management of waste lead-acid batteries," in *Technical Working Group of the Basel Convention* Geneva: United Nations Environment Programme, 2002.

[19] P. Kumar, S. G. Husain, R. C. Murthy, S. P. Srivastava, M. Anand, M. M. Ali, and P. K. Seth, "Neuropsychological studies on lead battery workers," *Veterinary and Human Toxicology,* vol. 44, pp. 76-78, 2002.

[20] R. Minozzo, E. L. Minozzo, L. I. Deimling, and R. Santos-Mello, "Blood lead levels in the battery recycling industry of the metropolitan region of Porto Alegre," *Brazilian Journal of Pathology and Laboratory Medicine,* vol. 44, pp. 407-412, 2008.

[21] A. O. Peter, "Total blood and urinary lead levels in battery charging artisans in two metropolitan cities of South West Nigeria," *Journal of Applied Biosciences,* vol. 14, pp. 796-799, 2009.

[22] E. Dartey, B. Berlinger, Y. Thomassen, D. G. Ellingsen, J. Ã. Odland, V. K. Nartey, F. A. Yeboah, and S. Weinbruch, "Bioaccessibility of lead in airborne particulates from car battery repair work," *Environmental Science: Processes & Impacts,* vol. 16, pp. 2782-2788, 2014.

[23] E. Dartey, B. Berlinger, S. Weinbruch, Y. Thomassen, J. Ã. Odland, J. Brox, V. K. Nartey, F. A. Yeboah, and D. G. Ellingsen, "Essential and non-essential trace elements among working populations in Ghana," *Journal of Trace Elements in Medicine and Biology,* vol. 44, pp. 279-287, 2017.

[24] E. Dartey, K. Sarpong, and I. Owusu-Mensah, "Association between Soil and Blood Lead Levels of Small Scale Battery Repair Workers in Kumasi Metropolis of Ghana," *International Journal of Environmental Protection,* vol. 6, pp. 75-80, 2016.

[25] J. L. Knetsch and J. A. Sinden, "Willingness to Pay and Compensation Demanded: Experimental Evidence of an Unexpected Disparity in Measures of Value," *The Quarterly Journal of Economics,* vol. 99, pp. 507-521, 1984.

[26] J. Anderson, D. Vadnjal, and H.-E. Uhlin, "Moral dimensions of the WTA-WTP disparity: an experimental examination," *Ecological Economics,* vol. 32, pp. 153-162, 2000.

[27] J. L. Knetsch, "Biased valuations, damage assessments, and policy choices: The choice of measure matters," *Ecological Economics,* vol. 63, pp. 684-689, 2007.

[28] R. C. Ready, J. C. Whitehead, and G. C. Blomquist, "Contingent Valuation When Respondents Are Ambivalent," *Journal of Environmental Economics and Management,* vol. 29, pp. 181-196, 1995.

[29] FAO, *Applications of the contingent valuation method in developing countries: A survey* vol. 146. Rome: United Nations Food and Agriculture Organization, 2000.

[30] R. C. Mitchell and R. T. Carson, *Using surveys to value public goods: The contingent valuation method*: Resources for the Future, Washington DC, 1989.

[31] A. Alberini, "Efficiency vs Bias of Willingness-to-Pay Estimates: Bivariate and Interval-Data Models," *Journal of Environmental Economics and Management,* vol. 29, pp. 169-180, 1995.

[32] C. A. Vossler, J. Kerkvliet, S. Polasky, and O. Gainutdinova, "Externally validating contingent valuation: an open-space survey and referendum in Corvallis, Oregon," *Journal of Economic Behavior & Organization,* vol. 51, pp. 261-277, 2003.

[33] T. Broberg and R. Brännlund, "An alternative interpretation of multiple bounded WTP data--Certainty dependent payment card intervals," *Resource and Energy Economics,* vol. 30, pp. 555-567, 2008.

[34] M. P. Welsh and G. L. Poe, "Elicitation Effects in Contingent Valuation: Comparisons to a Multiple Bounded Discrete Choice Approach," *Journal of Environmental Economics and Management,* vol. 36, pp. 170-185, 1998.

[35] M. Kobayashi, K. Rollins, and M. D. R. Evans, "Sensitivity of WTP Estimates to Definition of ˜Yes': Reinterpreting Expressed Response Intensity," *Agricultural and Resource Economics Review,* vol. 39, pp. 37-55, 2010.

[36] M. F. Evans, N. E. Flores, and K. J. Boyle, "Multiple-Bounded Uncertainty Choice Data as Probabilistic Intentions," *Land Economics,* vol. 79, pp. 549-560, November 1, 2003 2003.

[37] W. M. Hanemann, "Willingness to Pay and Willingness to Accept: How Much Can They Differ?," *The American Economic Review,* vol. 81, pp. 635-647, 1991.

[38] A. Alberini, K. Boyle, and M. Welsh, "Analysis of contingent valuation data with multiple bids and response options allowing respondents to express uncertainty," *Journal of Environmental Economics and Management,* vol. 45, pp. 40-62, 2003.

[39] T. A. Cameron, G. L. Poe, R. G. Ethier, and W. D. Schulze, "Alternative Non-market Value-Elicitation Methods: Are the Underlying Preferences the Same?," *Journal of Environmental Economics and Management,* vol. 44, pp. 391-425, 2002.

[40] K. Balcombe, A. Chalak, and I. Fraser, "Model selection for the mixed logit with Bayesian estimation," *Journal of Environmental Economics and Management,* vol. 57, pp. 226-237, 2009.

[41] G. Koop, *Bayesian Econometrics*. Chichester, West Sussex: John Wiley & Sons Ltd, 2003.

[42] M. Verbeek, *A Guide to Modern Econometrics*. Chichester: John Wiley & Sons, Ltd, 2004.

[43] Q. Song, Z. Wang, and J. Li, "Residents' behaviors, attitudes, and willingness to pay for recycling e-waste in Macau," *Journal of Environmental Management,* vol. 106, pp. 8-16, 2012.

[44] R. Gillespie and J. Bennett, "Willingness to pay for kerbside recycling in Brisbane, Australia," *Journal of Environmental Planning and Management,* vol. 56, pp. 362-377, 2013.

[45] A. Challcharoenwattana and C. Pharino, "Wishing to finance a recycling program? Willingness-to-pay study for enhancing municipal solid waste recycling in urban settlements in Thailand," *Habitat International,* vol. 51, pp. 23-30, 2016.