

Responsible Recycling of E-Waste in the Greater Ann Arbor Area

Dow Sustainability Fellowship Final Project Report

Team Members:

Joel Adu-Brimpong

Samantha Becker

Mark Green

Mike Ilardi

Rand Pummill

Emily Van Dam

Faculty Advisor:

Dr. Richard Neitzel, PhD, MS, CIH

Environmental Health Sciences, School of Public Health

Client:

Andy Berki, Office of Campus Sustainability



Executive Summary

The purpose of this project was to gather data on recycling rates of electronic waste (e-waste) in the greater Ann Arbor community, to assess barriers that could lower e-waste recycling rates and inform potential interventions to increase overall recycling rates. Our client is the University of Michigan Office of Campus Sustainability and its Director, Andrew Berki. Mr. Berki informed us that e-waste purchased and used by the University is currently being responsibly disposed of, but was interested in finding out more about the e-waste storage and disposal behavior of faculty, staff, and students who live off campus. He wanted to learn: 1) How much e-waste this population generates 2) How much of this e-waste they sustainably recycle and 3) What the barriers are that keep this population from recycling their e-waste. We developed and administered a survey to help inform both answers to these questions as well as a potential intervention to increase e-waste sustainable recycling rates in the greater Ann Arbor community.

Electronic waste, or “e-waste,” refers to almost any electronic equipment that has been discarded as waste without the intention of re-use. Common examples include televisions, computers, laptops, tablets, and cell phones. There are serious problems associated with a variety of methods to dispose of e-waste. First, disposing of e-waste in the municipal trash is highly problematic. E-waste contains many toxic materials, such as lead, cadmium, chromium, brominated flame retardants, and polychlorinated biphenyls (PCBs). When landfills are not equipped to handle these toxic materials, which is the norm, these substances can leach out and contaminate groundwater or affect nearby air quality if the waste is incinerated. Recycling e-waste using standard channels is also an imperfect solution. Previous studies have shown that much of the e-waste recycled in the United States ends up dumped in countries with typically looser environmental and labor protection laws, where it is often incinerated for precious metal content. However, using dedicated e-waste recycling facilities both reduces the amount of hazardous waste sent to landfills and also allows for the safe recovery of precious metals that would otherwise have to be mined to produce new electronics.

From 2008-2016, The University of Michigan co-sponsored a yearly community-wide e-waste recycling event. After the corporate recycling partner dropped out, however, the University discontinued the program. This created a gap in the availability of sustainable e-waste recycling on-campus and in central Ann Arbor, which has been only limitedly filled. Washtenaw County sponsors Clean Up Days where residents can drop off their waste, but there are restrictions on what items can be dropped off, where, and when. Outside of Clean Up Days, there are fees associated with recycling e-waste in Washtenaw County, which can be quite high (e.g. \$60 for a 60 inch television).

A 15-question survey (excluding demographic questions) was administered to collect data on e-waste in the Ann Arbor community across four main areas: 1) Ownership and knowledge of e-waste products 2) E-waste recycling behaviors 3) Knowledge of local e-waste recycling options and 4) Degree of action and willingness to engage in appropriate recycling. The survey was designed in Qualtrics and distributed through email to 2,500 randomly selected students across the 19 schools at the University of Michigan as well as to 5,000 randomly selected faculty and staff. The surveying period was two weeks (Monday, October 29th to Monday, November 12th). In all, we received 1,530 complete responses that were used to inform our analysis and suggested intervention.

The results of the survey found that, on average, people living in off-campus locations were more likely to have disposed of e-waste items than those living on-campus (60% to 44%). They were also nearly twice as likely to have disposed of an item through a community e-waste collection event (31% to 17%). This indicates that a community collection event may be an effective way of helping residents dispose of unwanted electronic items.

Our data demonstrates that free disposal is by far the most important factor in encouraging recycling. In our survey, 70% of respondents listed free disposal as “very important.” Of the remaining respondents, 23% listed free recycling as “important.” Only 1% of respondents said free disposal was “not important,” with 6% saying it was “somewhat important.” More respondents said free disposal was “very important” than any other category across all affiliations, with 91.7% of faculty and staff saying free disposal was either “very important” or “important.” We also asked questions specifically on willingness to pay for e-waste recycling. Among all the categories, there was demonstrable reluctance to paying a fee, with 33.4% of respondents saying they would be willing to do so. Faculty and staff who said they were willing to pay a fee said they were only willing to pay, on average, about \$14 to recycle a TV. For undergraduates and graduate students who indicated they were willing to pay to sustainably recycle a television, the amounts were about \$17 and \$18, respectively. For context, in Ann Arbor the cost to recycle a television is \$1 per diagonal screen inch—likely more than \$18 given the average size of most modern TVs.

Given these responses, alongside the rest of the survey data, we were able to draw several conclusions about the types of interventions that would likely be most effective in increasing the rate of sustainable e-waste recycling in the greater Ann Arbor community. First, given the overwhelming preference for free disposal detailed above, a major priority of a subsequent study should be to determine the feasibility of acquiring a new corporate partner in the hope of reviving the annual community-wide e-waste recycling event. This could be done by conducting a cost-benefit analysis for the prospective new sponsor, using the item counts and behavioral data from our survey as the basis for estimating the potential equipment yield and, thus, associated monetary value of such an event.

Additionally, the data support the need for two types of community-based intervention: education on the hazards of e-waste and on the options for sustainably disposing of e-waste. When asked if they considered the environmental impact of electronics purchases, 57% of respondents said “no,” with an additional 13% responding “unsure.” This means that 70% of the sample population could benefit from education on the hazards of e-waste, which, based evidence from prior studies, could significantly increase participants knowledge of e-waste hazards, and potentially result in adjusted disposal behavior. In addition, 71% of respondents said that they were not aware of e-waste recycling options in their local area. This ratio also roughly held for the 33% of respondents who said they would be willing to pay for e-waste disposal, with 67% of that subset unaware of e-waste recycling options.

Finally, the data indicate that over half of respondents that currently do not sustainably recycle their e-waste still take relatively non-harmful actions to dispose of it (i.e., excluding trash and standard recycling). This means that over half of target intervention population is likely willing to take some action regarding disposal, and is well-positioned for being guided, via educational interventions on the hazards of e-waste and options for disposal, toward more sustainable solutions.

Introduction & Background

Purpose:

The purpose of this project was to gather data on recycling rates of electronic waste (e-waste) in the greater Ann Arbor community, to assess barriers that could lower e-waste recycling rates and inform potential interventions to increase overall recycling rates. Our client is the University of Michigan Office of Campus Sustainability and its Director, Andrew Berki. Mr. Berki informed us that e-waste purchased and used by the University is currently being responsibly disposed of, but was interested in finding out more about the e-waste storage and disposal behavior of faculty, staff, and students who live off campus. He wanted to learn: 1) How much e-waste this population generates 2) How much of this e-waste they sustainably recycle and 3) What the barriers are that keep this population from recycling their e-waste. We developed and administered a survey to help inform both answers to these questions as well as a potential intervention to increase e-waste sustainable recycling rates in the greater Ann Arbor community.

Problem of E-Waste:

Electronic waste, or “e-waste”, refers to almost any electronic equipment that has been discarded as waste, without the intention of re-use.¹ Common examples include televisions, computers, laptops, tablets, and cell phones.¹⁻²

There are serious problems associated with a variety of e-waste disposal methods. First, disposing of e-waste in the municipal waste stream is highly problematic. E-waste contains many toxic materials, such as lead, cadmium, chromium, brominated flame retardants, and polychlorinated biphenyls (PCBs).³ When landfills are not equipped to handle these toxic materials, which is the norm, these substances can leach out and contaminate groundwater or affect nearby air quality if the waste is incinerated.⁴ Recycling e-waste using standard channels is also an imperfect solution. Previous studies have shown that much of the e-waste recycled in the United States ends up dumped in countries with typically looser environmental and labor protection laws, where it is often incinerated for precious metal content.⁵ However, using dedicated e-waste recycling facilities both reduces the amount of hazardous waste sent to landfills and also allows for the safe recovery of precious metals that would otherwise have to be mined to produce new electronics.⁶

The State of Michigan, recognizing these problems, created an Electronic Waste Takeback Program in 2008, which requires manufacturers who sell new TVs and computers in Michigan to register with the Department of Environmental Quality (MDEQ) and to have an electronic recycling program that is free and convenient for households and small businesses. The law is limited to TVs and computers, although the definition of computer includes most tablets. As of 2013, Michigan saw 93% compliance with the law, although a majority of manufacturers (57%) chose to maintain mail-back only programs to comply with the law.⁷

From 2008-2016, The University of Michigan co-sponsored a yearly community-wide e-waste recycling event.⁸ After the corporate recycling partner dropped out, however, the University discontinued the program. This has left a gap in the availability of e-waste recycling on-campus and in central Ann Arbor.

Recycling Rates

Historically, the State of Michigan has had a low overall recycling rate (15% in 2013) compared to the national average (34.3% in 2013).⁹ The rate of e-waste recycling is no different. In 2015, the EPA

estimated that 3.1 million tons of consumer electronics were generated in the United States - 1.2 million tons of which were recycled, resulting in a national e-waste recycling rate of 37.5%.¹⁰ In Michigan, 210,334 tons of e-waste were generated and only 21,010 tons were recycled which resulted in a e-waste recycling rate of only 5.7%.¹¹⁻¹²

Only 25 of Michigan's 83 counties offer recycling centers most of which are not able to accept electronic waste. In Washtenaw County, there is only one location (on E. Ellsworth Road in Ann Arbor) that accepts e-waste and it only does so for an additional fee. The charges range from \$2 for a small electronic devices to \$65 for a 65-in TV (\$1 per diagonal screen inch). These prices could potentially be a barrier to e-waste recycling by discouraging residents from properly disposing of their waste.

The *Washtenaw County Solid Waste Plan 2017* provides some statistics from a 2016 survey performed by the county on how much usage the county recycling center receives.¹³ The report states that 35% of respondents use the drop-off station located on E. Ellsworth Road in Ann Arbor with most respondents dropping off items once annually, but some visiting as often as four times per year. About half of those 35% visited the center to dispose of e-waste. According to the data, 87% of the respondents live within 10 miles of the recycling center. When asked why they choose not to use the site, the most common response was that the center is located too far away from residences. The second most common response was that recycling e-waste was not legally required.

Washtenaw County sponsors clean-up day events, but there are significant restrictions on how useful this could be to Ann Arbor residents. The events are restricted to Washtenaw County residents only, and are not open to businesses. Residents may bring one television, appliance or computer, but a \$10 donation is suggested for each additional item. Most significantly, however, in 2018 (with 2019's schedule not posted yet) there were no events held in Ann Arbor itself. Instead, events were held in more distant communities, such as Chelsea, Whitmore Lake, Ypsilanti, and Saline. For people without a car, this could be a significant barrier to attending one of these events.

Literature Review – other interventions

We reviewed ten studies conducted to understand e-waste awareness and/or its resulting behavior among specific student populations.¹⁴⁻²³ The studies were conducted from 1998 through 2016 and based in seven countries, with 80% conducted outside of the United States. 90% of the studies either primarily or secondarily assessed student awareness of e-waste, and from the breadth of these awareness initiatives we identified an intervention spectrum that informed part of our own recommendations. The first stage of intervention is what constitutes e-waste; the second is what risks are affiliated with e-waste; and the third is how to responsibly dispose of e-waste, acknowledging that this last piece must be addressed on a community-specific basis. Additionally, one 2016 study conducted at Kurnool Medical College in Kurnool, India, demonstrated a statistically significant gain in knowledge regarding e-waste management after an educational intervention.²² While this is only a single study, we plan to use the structure of this successful intervention as a basis for any interventions we recommend along the spectrum defined above.

Methods

Survey Design

A 30-question survey was generated from a critical review of online literature of electronic waste (e-waste). Through group discussions, the survey was narrowed to 20 questions to hone in on important

questions of interests. E-waste experts (faculty and staff) along with our advisor and our client at the University of Michigan were consulted to further sharpen the focus of the questionnaire. The final survey consisted of 15 questions (excluding demographics) assessing four main concepts: 1) Ownership and Knowledge of E-waste Products, 2) E-waste Recycling Behaviors, 3) Knowledge of E-waste Recycling Options in Area, and 4) Degree of Action and Willingness to Engage in Appropriate Recycling.

Distribution and Analysis

The survey was built in Qualtrics and distributed through email to 2,500 students across the 19 schools at the University of Michigan as well as 5,000 randomly selected faculty and staff. The surveying period was two weeks (Monday, October 29th to Monday, November 12th) and one hundred \$20 gift cards were utilized as incentives for participation, with all survey participants having equal probability of winning a gift card. This study was approved by the Institutional Review Board at the University of Michigan (HUM00152896). Data analysis was conducted using Microsoft Excel. Descriptive statistics and analyses are reported below. Primary objectives of the survey include understanding baseline e-waste recycling rates among: 1) a broad range of participants (Undergraduate, Graduate, Professional and Faculty/Staff), 2) across different residential areas (Off-Campus and On-Campus), and 3) barriers to proper e-waste recycling and management in Ann Arbor and neighboring cities. Our findings inform potential interventions to improve e-waste awareness, knowledge, and opportunities for engagement in proper e-waste management practices amongst the University of Michigan and the surrounding communities. However, we also recognize that there may have been self-selection bias in those responding to the survey either due to interest in environmental management and/or because of interest in receiving gift card. This may potentially limit the generalizability of our findings.

Results

Demographics

Overall, we received 1,636 responses with 106 responses removed from analyses due to unfinished surveys and/or respondents being less than 18 years old. Our final sample size was 1,530. Females made up the majority of survey respondents at 68.7% (n=1,051). Males constituted 28.4% (n=435) of respondents and Non-binary individuals or those who did not indicate gender made up 2.9% (n=44). 61.3% of respondents identified as Non-Hispanic Whites, 17.8% as Asian, 4.8% as Non-Hispanic Blacks, 4.8% as Hispanic and 10.9% aggregated as Other (e.g., mixed race/ethnicity). Regarding affiliation, Faculty/Staff made up the largest group of respondents at 43.6% followed by Graduate students (Masters and PhD students) at 33.3%. Undergraduate students constituted 15.2% of respondents and Professional Studies students (e.g., Law, Medicine), 7.1%. Lastly, 86.2% (n=1,319) of respondents reported living in Off-Campus Housing as compared to roughly 12% of respondents who live in On-Campus Housing (Graduate students: 6.1%, Undergraduate: 5.8%). (See Table 1).

E-waste data -- how much, what people do with it, and what they know:

Our client, the Office of Campus Sustainability, stressed the importance of understanding, on average, how much e-waste individuals have, both on-campus and off. To get this data, we asked respondents to estimate the number of devices they owned across several categories, including desktop and laptop computers, computer accessories, handheld devices, televisions and monitors, small appliances,

stereos and speakers, and other devices such as game consoles. Our results showed that the average person owns about 15 such devices. **(See Table 2).** We also specifically asked about obsolete devices, where we found that the average person has an estimated 4 obsolete devices that they would like to donate or recycle. **(See Table 3).** The data for both categories (current and obsolete devices) show that faculty and staff own significantly more devices than students. For example, for current devices, faculty and staff owned about 18.5 devices while students on average own 12.5 devices. These differences can likely be attributed to age differences in the populations and the fact that staff and faculty live off-campus in their own homes.

This is borne out when the data is examined by living arrangement rather than school affiliation. People living in off-campus houses own about 17.3 devices to an average of 12 reported by people living in on-campus arrangements. It is important for our client to know that the amount of e-waste in off-campus locations is about 50% higher than what is found in on-campus locations.

We also asked what people do with their e-waste when they're ready to dispose of it. **(See Table 4).** This survey question asked about specific behaviors and allowed respondents to select as many of the behaviors as applied. The listed behaviors included not doing anything with the e-waste, putting it in a trash bin, putting it in a standard recycling bin, donating the item, selling the item, disposing of it via an e-waste collection event, and taking the item to a facility. Overall, people living in off-campus locations were more likely to have disposed of e-waste items than those living on-campus (60% to 44%). They were also nearly twice as likely to have disposed of an item through a community e-waste collection event (31% to 17%). This indicates that a community collection event may be an effective way of helping residents dispose of unwanted electronic items.

Barriers – awareness, location, price:

Our data demonstrates that free disposal is by far the most important factor in encouraging recycling. In our survey, 70% of respondents listed free disposal as “very important.” Of the remaining respondents, 23% listed free recycling as “important.” Only 1% of respondents said free disposal was “Not important,” with 6% saying it was somewhat important. More respondents said free disposal was very important than any other category across all affiliations, with 91.7% of faculty and staff saying free disposal was either “very important” or “important.” This is an especially significant result given the very limited opportunities for free disposal in Ann Arbor. Only the Washtenaw County Clean-up days offer free recycling, and those are very limited in number. Last year none were held in the City of Ann Arbor. **(See Tables 5-9, Figures 1-2).**

We also asked questions specifically on willingness to pay for e-waste recycling. **(See Table 10 and Figure 3).** Of the undergraduate students surveyed, over 35% indicated they were unwilling to pay a fee to recycle e-waste. This number dropped among graduate student and faculty & staff to 28.9% and 27.6% respectively. Among all the categories, however, there was significant resistance to paying a fee. Only 33.4% of respondents said they were willing to pay a fee; the rest either said “no” or were unsure.

The responses for how much people were willing to pay was also significant. **(See Tables 11).** Faculty & Staff, while the most willing to pay, said they were willing to pay the least amount of money. Faculty & Staff who said they were willing to pay a fee said they were only willing to pay, on average, about \$14 to recycle a TV. For undergraduates and graduate students, that amount was about \$17 and \$18, respectively. It should be noted that these numbers are only for the people who indicated that they were willing to pay a fee at all, and that currently in Ann Arbor, the cost to recycle a television is \$1 per diagonal screen inch -- so very likely considerably more than \$18.

The fact that no free recycling events were held in Ann Arbor last year also implicates the second-most important factors. Fifty-one percent of respondents said that the distance to drop-off was a “very important” factor to them, compared to 1% who said it was not important. Distance to drop-off was slightly more important for both graduate and undergraduate students compared to Faculty and Staff (88% vs 86% said it was either important or very important).

The second largest concern for faculty and staff, after free disposal, was flexible hours. Fifty-four percent of faculty and staff listed flexible hours as “very important,” and another 33.8% said it was important. This result can likely be extrapolated to the greater Ann Arbor community, as adults with busy working lives need increased flexibility outside of working hours, while students are more concerned with transportation and have more flexible schedules. **(See Tables 5-9).**

Curbside pick-up and knowing how e-waste is recycled were rated as less important by respondents. For both factors, 13% of respondents said they were “not important,” compared with the 0.9% and the 0.6% that claimed that free disposal and distance to drop-off were not important. **(See Tables 5-9).**

Interestingly, incentives such as gift cards and vouchers were the least important factors across all three affiliations, although incentives appealed the most to undergraduate students. 32.3% of undergrads listed incentives as “very important” while only 18% of faculty and staff said that. Graduate students were in the middle, with 23% saying incentives were very important. The numbers were almost exactly flipped for not important: 34% of staff said incentives were not important compared to 20% of undergrads who said incentives were not important. **(See Tables 5-9).**

This data demonstrates that the most important factor of a successful e-waste program will be free disposal. This is especially important in light of the fact that opportunities for free disposal are currently very limited in Ann Arbor. After that, a successful e-waste program will also be at a convenient location with flexible hours.

Behavioral Analysis

For an additional layer of analysis, we segmented the sample population into six groups based on their current e-waste disposal behavior. The idea behind this segmentation was to provide a basis for identifying which subgroups of the population would be the best targets for an intervention, how large these target segments are (key for supporting the need for an intervention), and if the current e-waste disposal behavior displays any positive correlation with subjects’ consideration of the environmental impact of their purchases (our best proxy for subjects’ knowledge as to the hazards of e-waste, which could support the need for an educational intervention).

The six segments for categorizing current e-waste disposal practices are:

1. Exclusive use of e-waste collection events and corporate buy-back programs
2. Donation and reselling of e-waste
3. Various methods for disposing of e-waste excluding trash and standard recycling¹
4. Storing items at home
5. Various method for disposing of e-waste including trash and standard recycling²

¹ Including e-waste collection events, corporate buybacks, donation, reselling, storage at home

² All methods, including trash and standard recycling

6. Exclusive use of trash and standard recycling

The idea behind this segmentation was to create a spectrum of behavior from most desirable (exclusive use of e-waste collection events and corporate buyback programs) to least desirable (exclusive use of trash and standard recycling), with each subsequent category representing greater potential for environmental harm. The results of this segmentation analysis are as follows:

1. Sample distribution: Only 13% of the sample population falls into segment 1, indicating that 87% of the sample population—which we expect to be biased toward caring about e-waste, given their self-selection into this survey—could improve their e-waste disposal behavior. (See Figure 4).

2. Low-hanging fruit: 19% of this population is engaged in a variety of e-waste disposal practices excluding the use of trash and standard recycling. This means that almost one fifth of the sample population is sufficiently motivated to take action in excess of passive storage at least some of the time, and thus, theoretically, can be motivated to use more desirable disposal techniques with adequate incentives. In addition, 24% of the population is simply storing their e-waste at home, which indicates that they are aware that disposing of it using the trash or standard recycling (almost zero-effort activities) is not acceptable. Given this, it is plausible that this segment could be incentivized to dispose of their stored e-waste sustainably with adequate motivation.

3. Evidence for environmental educational intervention: Of the entire population, 87% took a Yes/No stance on whether they consider the environmental impact of a product at the time of purchase. 57% said “No,” and when a demographic filter was applied to this result there was no clear indication that any one Affiliation group (e.g., undergraduates, faculty, staff) was primarily responsible for this result. This indicates that 70% of this population—“No” + “Unsure”—would be well-positioned for an educational intervention on the hazards of e-waste disposal. (See Figure 5).

4. Preliminary evidence of hazard awareness influencing behavior: Of the 30% of the population that said they do consider the environmental impact of their purchases, we observed a 54% incidence of desirable behavior (use of e-waste collection events and buybacks, donate and resell, and various methods of disposal excluding trash and standard recycling) vs a 46% rate of undesirable behavior. Compare this to the instances of desirable vs. undesirable behavior among the 57% of the population that said they do not consider the environmental impact of their purchases, which are 35% and 65%, respectively. Although significance is to be determined, the data directionally indicate that this knowledge is linked to behavior.

5. Evidence for e-waste recycling options intervention: Of the 33% of respondents willing to pay for the sustainable disposal of e-waste, only 33% of that population (182 members of the total sample) are aware of e-waste recycling options in the UM area. This means that an intervention geared toward informing people toward the options available to them—not convincing them to change their behavior—could easily influence the 22% of the overall population who are willing to pay but unaware of the options. (See Figure 6).

6. Pay-to-recycle is not attractive for majority of the population: Despite 60% of respondents saying that sustainable disposal options are a high priority, only 23% of respondents are willing to pay for these

options. Furthermore, of the 85% of respondents who said these options were a "Med-High" and "High" priority, only 30% of respondents are willing to pay for them. Of this 85%, a full 21% are NOT willing to pay for these options.

7. Most important factors for e-waste recycling consistent across segments - In order, the most important factors to the UM community are: 1. Free disposal 2. Distance to facility 3. Flexible facility hours. Interestingly, despite free disposal being the primary factor, monetary incentives were consistently ranked as the least important factor. (See Figure 7).

Recommendations

Based on these results, we drew several conclusions about the types of interventions that would likely be most effective in increasing the rate of sustainable e-waste recycling in the greater Ann Arbor community.

First, given the overwhelming preference for free disposal, a major priority of any subsequent project should be to determine the feasibility of acquiring a new corporate partner in the hope of reviving the community-wide e-waste recycling event. This could be done by conducting a cost-benefit analysis for the prospective new sponsor, using the item count and behavioral data from our survey as the basis for estimating the potential equipment yield and, thus, associated monetary value of such an event.

Additionally, the data support the need for two types of community-based intervention: education on the hazards of e-waste and on the options for sustainably disposing of e-waste. When asked if they considered the environmental impact of electronics purchases, 57% of respondents said “no,” with an additional 13% responding “unsure.” This means that 70% of the sample population could benefit from education on the hazards of e-waste, which, based evidence from prior studies, could significantly increase participants knowledge of e-waste hazards, and potentially result in adjusted disposal behavior. In addition, 71% of respondents said that they were not aware of e-waste recycling options in their local area. This ratio also roughly held for the 33% of respondents who said they would be willing to pay for e-waste disposal, with 67% of that subset unaware of e-waste recycling options.

Finally, the data indicate that over half of respondents that currently do not sustainably recycle their e-waste still take relatively non-harmful actions to dispose of it (i.e., excluding trash and standard recycling). This means that over half of target intervention population is likely willing to take some action regarding disposal, and is well-positioned for being guided, via educational interventions on the hazards of e-waste and options for disposal, toward more sustainable solutions.

Anticipated Community Impact

The ultimate purpose of this project is to use the data we collected to inform the design and implementation of an educational intervention(s) on e-waste for the broader Ann Arbor and Washtenaw County communities. Our results are relevant to these stakeholders due to the interdependencies of waste management infrastructure in the area. For example, any type of robust collection program will likely involve the city of Ann Arbor and Washtenaw County, at least from an administrative capacity. In addition, the students and faculty that we surveyed live on the University of Michigan campus, in off-campus housing, and nearby towns such as Saline and Ypsilanti.

The recommendations that we have made, and which the University of Michigan Office of Campus Sustainability can now assess for their implementation potential, intentionally consider this broad spectrum of stakeholders in order to inform sustainable and long-term electronic waste recycling decisions that are representative of the community at large. Considering these goals on a realistic timescale, our objective is to set up a new team of Dow Sustainability Fellows to once again partner with the Office of Campus Sustainability, this time to use our analysis and recommendations as the basis for implementing an electronic waste recycling program that will have county-wide impact. Our plan is to have them work with the same client that we have already sourced to lighten their load and better enable them to begin work immediately on building the project rather than sourcing a client and project. We are confident that this will result in a more effective sustainable e-waste recycling intervention.

From a tactical perspective, we will provide the cohort with the raw survey data, our analyses, suggested recommendations, and other relevant information to assist them and their client, possibly the Office of Campus Sustainability, to implement an appropriate intervention that is robust and long-lasting.

Improvements to the Study

Naturally, there are some ways that we could have improved approach in this project. After reflection, we have identified the following ways to improve our approach.

First, we were very satisfied with our sample size. The University of Michigan and the Dow Foundation were extremely supportive of our endeavor; our project would not have been as successful without their support. We were able to administer our survey to a random selection of 2,500 students and 5,000 staff in addition to our respective student bodies in the Public Policy, Public Health, Law, Business, Information, and Environment schools. An improvement in this area would be to have reached a larger undergraduate sample given that this population will be a substantial focus of our proposed interventions. Even so, our sample size is significant.

Analyzing the questions asked, some could have been framed better to improve clarity. For example, one of our questions received a large volume of “unsure” answers. The question was: “Would you be willing to pay a fee at the time of purchase to cover the cost of recycling your waste electronics in a sustainable manner at the end of the product's life?” While this does do a good job of helping us better understand the amount of doubt in our respondents, it is possible that if we framed the question differently, we could have received answers more indicative of the cause of this uncertainty.

Another improvement could have been how we compensated the people who filled out our survey. It came to our attention after we had collected all of the randomly selected winner email addresses that the University of Michigan will not allow us to send out an electronic gift card which was our original plan. Instead, we were required to reach out individually to each of the randomly selected winners to then get their address to mail them a gift card. This is extra work and adds a level of complexity that we recommend future teams try to avoid or plan for if using monetary incentives.

In conclusion, our Dow Sustainability Project has resulted in a much greater understanding of the e-waste behavior among the University of Michigan, Ann Arbor, and Washtenaw County communities. We are grateful to Dow for allowing us this unique opportunity, to the Office of Campus Sustainability for being our client, and to Rick Neitzel for his support and guidance as our advisor. We are excited and

hopeful that our analysis and recommendations lead to a community with higher e-waste recycling rates and lower e-waste recycling barriers.

Appendices

Appendix I: Team member info

Team Member	College	Contact Information
Joel Adu-Brimpong	School of Information and School of Public Health	jadu@umich.edu
Samantha Becker (Team Lead)	School of Public Health	sebec@umich.edu
Mark Green	School of Business and School of Environment	mhgreen@umich.edu
Mike Ilardi	School of Business and School of Environment	mjilardi@umich.edu
Rand Rummill	School of Law	randp@umich.edu
Emily Van Dam	School of Law	emvandam@umich.edu

Key Stakeholders:

- Office of Campus Sustainability (client) (Andy Berki, aberki@umich.edu)
- UM Community (students, faculty, and staff)
- E-waste Recyclers

Faculty Advisor:

- Dr. Richard Neitzel, PhD, MS, CIH (rneitzel@umich.edu)

Client

- Andy Berki, Office of Campus Sustainability (aberki@umich.edu)

Appendix 2: Tables

Table 1. Demographic Breakdown of Survey Respondents

Characteristics	
Overall n	1530 (100%)
No. of Study Participants, (%) ^a	
Female	1051 (68.7)
Male	434 (28.4)
Other	42 (2.7)
Sociodemographic Characteristics	
Race/Ethnicity, No. (%)	
Non-Hispanic White	938 (61.3)
Non-Hispanic Black	73 (4.8)
Hispanic	74 (4.8)
Asian	273 (17.8)
Other	167 (10.9)
Affiliation, No. (%)	
Faculty/Staff	667 (43.6)
Graduate Students	510 (33.3)
Professional Students	108 (7.1)
Undergraduate Students	233 (15.2)
Other	12 (0.8)
Area of Residence, No. (%) ^b	
Off-Campus Housing	1319 (86.2)
On-Campus Housing (Graduate)	94 (6.1)
On-Campus Housing (Undergraduate)	88 (5.8)

Table 2. Average number of current electronic devices by affiliation.

<i>Affiliation</i>	<i>Computer Accessories</i>	<i>Desktops and Laptops</i>	<i>Handheld Devices</i>	<i>TV's and Monitors</i>	<i>Small Appliances</i>	<i>Stereos and Speakers</i>	<i>Other (game consoles, etc.)</i>	<i>Total</i>
All	2.4	1.9	2.7	1.7	3.3	1.5	1.2	14.9
Faculty	3.2	2.7	2.9	2.6	4.0	2.2	1.5	19.2
Staff	2.8	2.3	3.3	2.5	3.8	1.8	1.6	18.0
Undergrad	1.9	1.6	2.2	1.1	2.7	1.4	1.1	12.0
Masters	2.0	1.7	2.4	1.1	3.0	1.2	0.9	12.2
Graduate	2.7	1.9	2.3	1.4	3.2	1.3	0.9	13.7
Professional	1.9	1.5	2.2	1.0	3.0	1.4	0.9	11.9

Table 3. Number of obsolete electronic devices by affiliation.

<i>Affiliation</i>	<i>Computer Accessories</i>	<i>Desktops and Laptops</i>	<i>Handheld Devices</i>	<i>TV's and Monitors</i>	<i>Small Appliances</i>	<i>Stereos and Speakers</i>	<i>Other (game consoles, etc.)</i>	<i>Total</i>
All	0.8	0.7	1.2	0.3	0.5	0.3	0.3	4.1
Faculty	1.5	1.2	1.7	0.4	0.5	0.5	0.4	6.2
Staff	1.1	0.8	1.5	0.5	0.6	0.4	0.4	5.3
Undergrad	0.5	0.4	0.8	0.3	0.4	0.3	0.4	3.1
Masters	0.6	0.6	1.1	0.2	0.4	0.2	0.2	3.4
Graduate	0.6	0.6	1.0	0.2	0.4	0.2	0.2	3.1
Professional	0.4	0.4	0.8	0.1	0.3	0.1	0.1	2.2

Table 4. Recycling behaviors by housing location.

<i>Housing</i>	<i>No action</i>	<i>Recycling event</i>	<i>Standard recycling bin</i>	<i>Trash bin</i>	<i>Donated</i>	<i>Resell</i>
Off-campus	40%	31%	13%	30%	42%	13%
On-campus	56%	17%	10%	24%	28%	13%

Table 5. What factors are important to e-waste recycling? All Respondents

	<i>Free Disposal</i>	<i>Distance to drop-off</i>	<i>Curbside pickup</i>	<i>Knowing how it is recycled</i>	<i>Incentives (e.g. gift cards)</i>	<i>Flexible Hours</i>
Very Important	70.0%	50.8%	37.4%	35.7%	22.2%	49.8%
Important	23.1%	36.7%	27.2%	29.1%	20.7%	35.3%
Somewhat Important	6.0%	11.9%	22.3%	22.2%	27.6%	12.5%
Not Important	0.9%	0.6%	13.1%	13.0%	29.5%	2.4%

Table 6. What factors are important to e-waste recycling? Faculty & Staff

	<i>Free Disposal</i>	<i>Distance to drop-off</i>	<i>Curbside pickup</i>	<i>Knowing how it is recycled</i>	<i>Incentives (e.g. gift cards)</i>	<i>Flexible Hours</i>
Very Important	69.8%	44.5%	37.1%	34.7%	18.0%	54.4%
Important	22.0%	41.1%	25.7%	29.8%	19.9%	33.8%
Somewhat Important	7.2%	13.5%	23.3%	23.0%	27.7%	10.5%
Not Important	1.0%	0.9%	13.8%	12.5%	34.4%	1.3%

Table 7. What factors are important to e-waste recycling? Undergraduate Students.

	<i>Free Disposal</i>	<i>Distance to drop-off</i>	<i>Curbside pickup</i>	<i>Knowing how it is recycled</i>	<i>Incentives (e.g. gift cards)</i>	<i>Flexible Hours</i>
Very Important	66.1%	54.5%	38.6%	39.7%	32.3%	44.0%
Important	27.0%	33.9%	28.8%	29.7%	24.1%	37.9%
Somewhat Important	5.6%	11.6%	22.3%	20.3%	23.7%	15.1%
Not Important	1.3%	0.0%	10.3%	10.3%	19.8%	3.0%

Table 8. What factors are important to e-waste recycling? Graduate Students.

	<i>Free Disposal</i>	<i>Distance to drop-off</i>	<i>Curbside pickup</i>	<i>Knowing how it is recycled</i>	<i>Incentives (e.g. gift cards)</i>	<i>Flexible Hours</i>
Very Important	72.6%	57.5%	38.0%	34.4%	22.8%	47.0%
Important	22.1%	32.1%	28.1%	29.4%	20.3%	35.7%
Somewhat Important	4.8%	9.9%	20.5%	22.9%	28.2%	14.0%
Not Important	0.5%	0.5%	13.4%	13.3%	28.7%	3.3%

Table 9. Which factors were considered either important or very important?

	<i>Free Disposal</i>	<i>Distance to drop-off</i>	<i>Curbside pickup</i>	<i>Knowing how it is recycled</i>	<i>Incentives (e.g. gift cards)</i>	<i>Flexible Hours</i>
Undergrad	93.1%	88.4%	67.4%	69.4%	56.5%	81.9%
Graduate	94.7%	89.6%	66.1%	63.8%	43.1%	82.7%
Faculty & Staff	91.7%	85.6%	62.9%	64.5%	37.8%	88.1%

Table 10. Are you willing to pay a fee to recycle your e-waste?

	<i>Yes</i>	<i>No</i>	<i>Unsure</i>
Faculty & Staff	32.6%	27.6%	39.9%
Undergrad	25.3%	35.4%	39.3%
Graduate	33.6%	28.9%	37.4%
Everyone	33.4%	28.2%	38.4%

Table 11. (If you are willing to pay a fee) how much are you willing to pay (on average)?

Faculty & Staff	\$14.40
Undergrad	\$16.55
Graduate	\$17.64
Everyone	\$16.14

Appendix 3: Figures

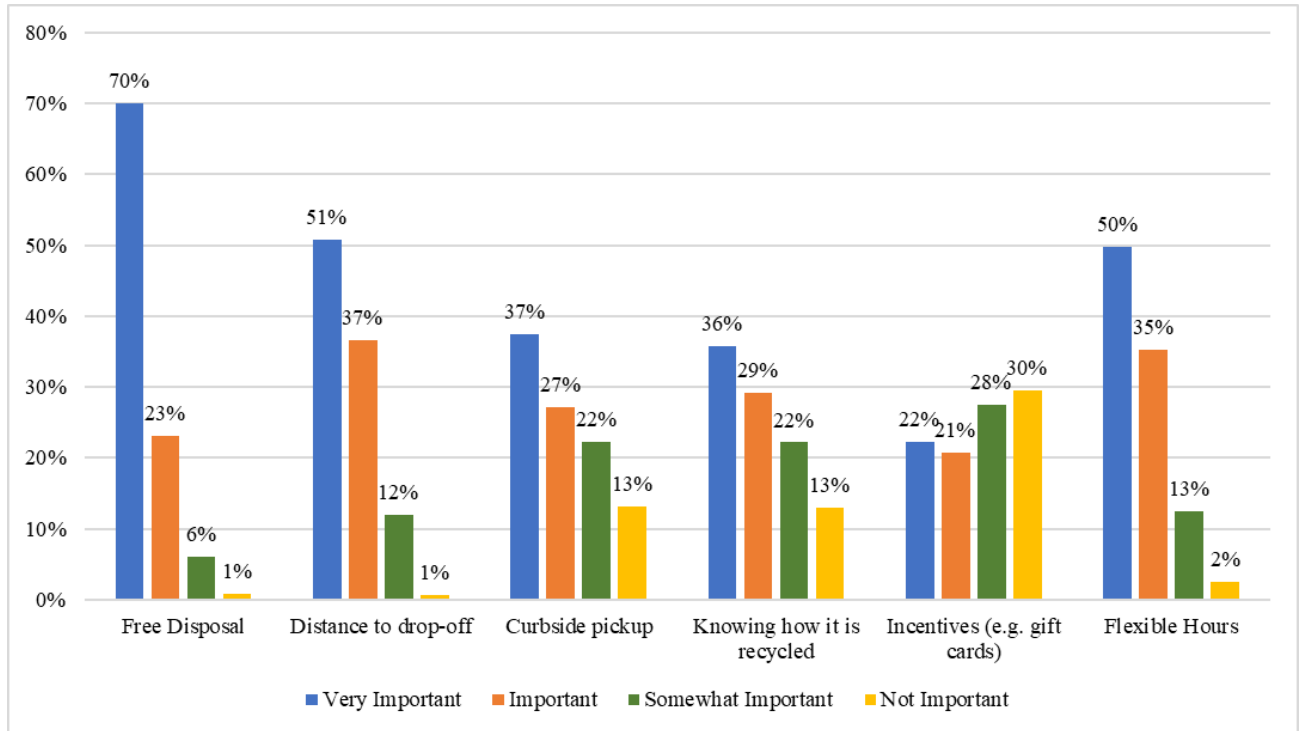


Figure 1. Relative importance of various factors for e-waste recycling. All Respondents.

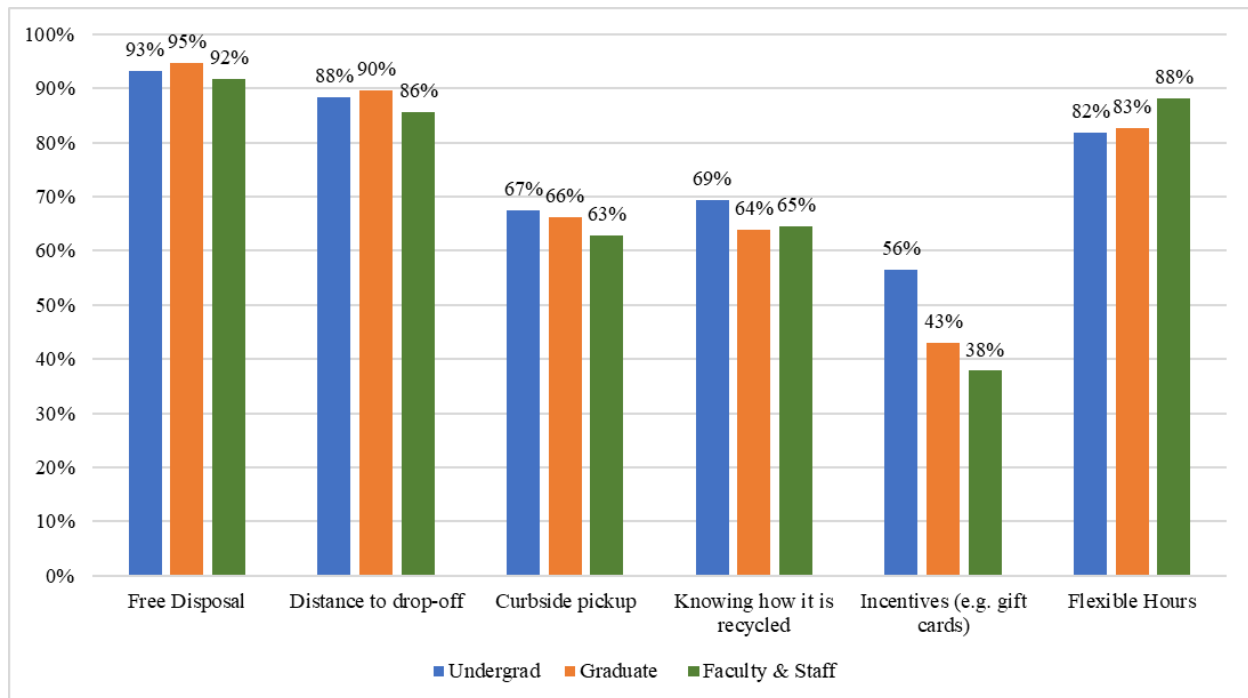


Figure 2. Factors Listed as either “important” or “very important.”

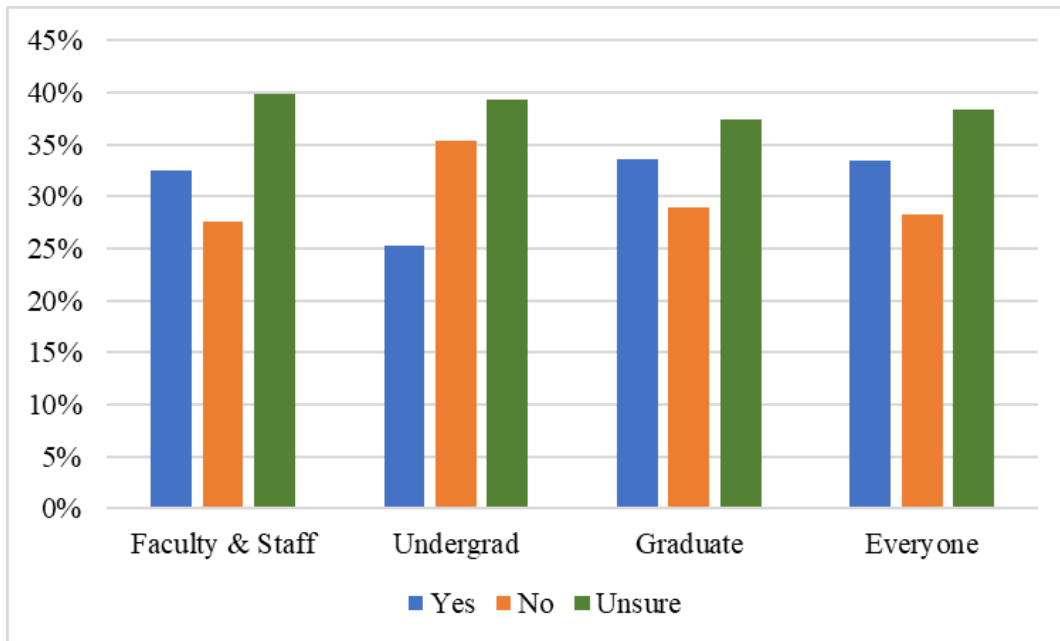


Figure 3. Are you willing to pay a fee to recycle e-waste?

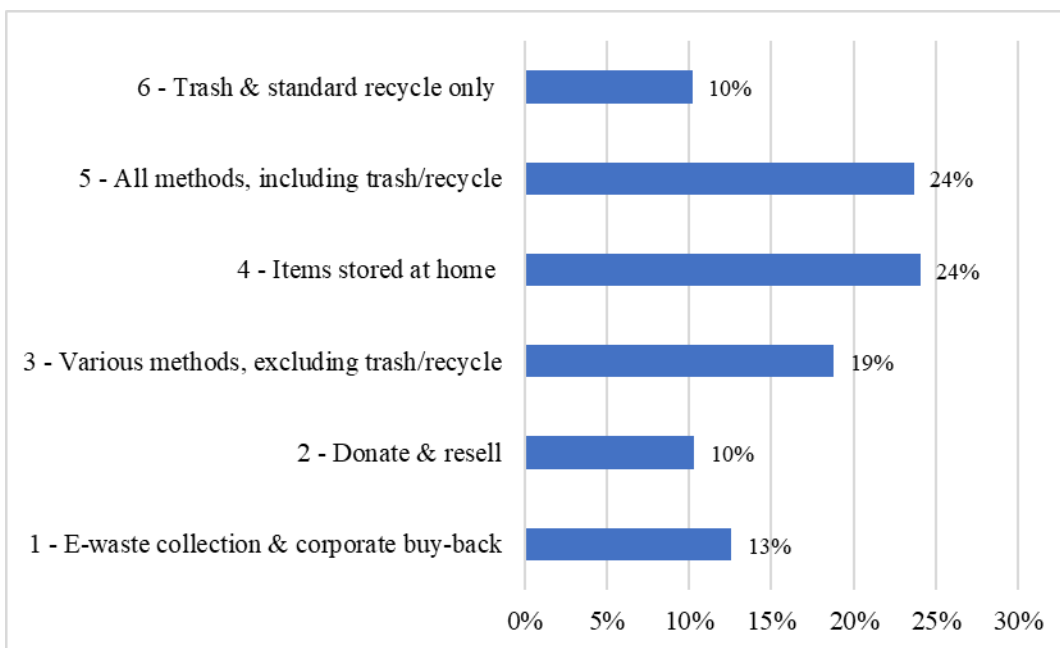


Figure 4. E-Waste disposal behavior by segment

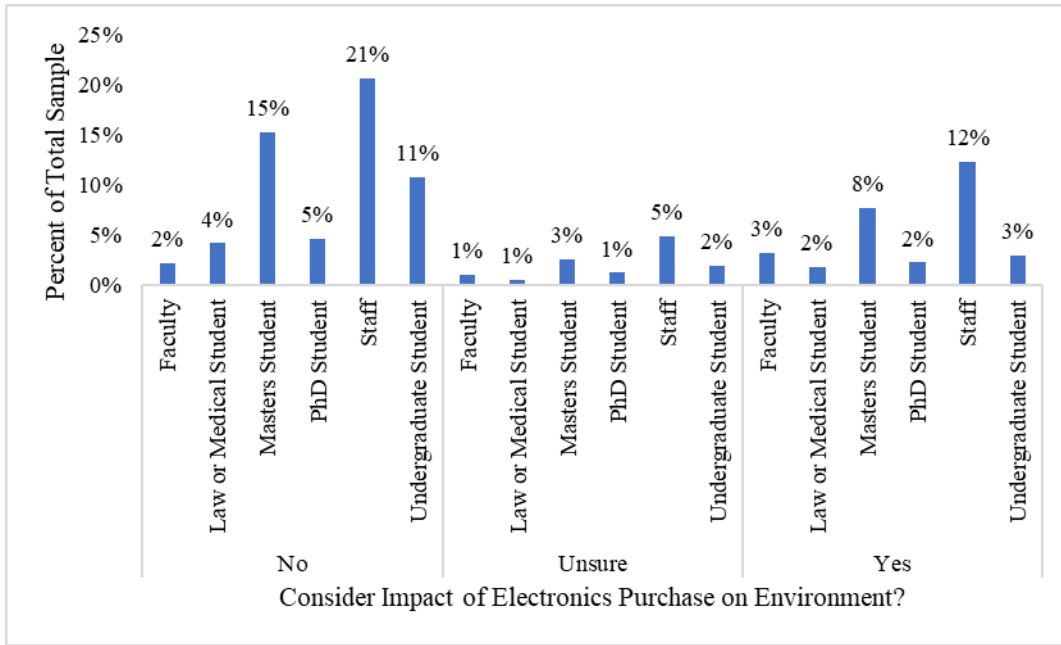


Figure 5. Consideration of environmental impact of purchase

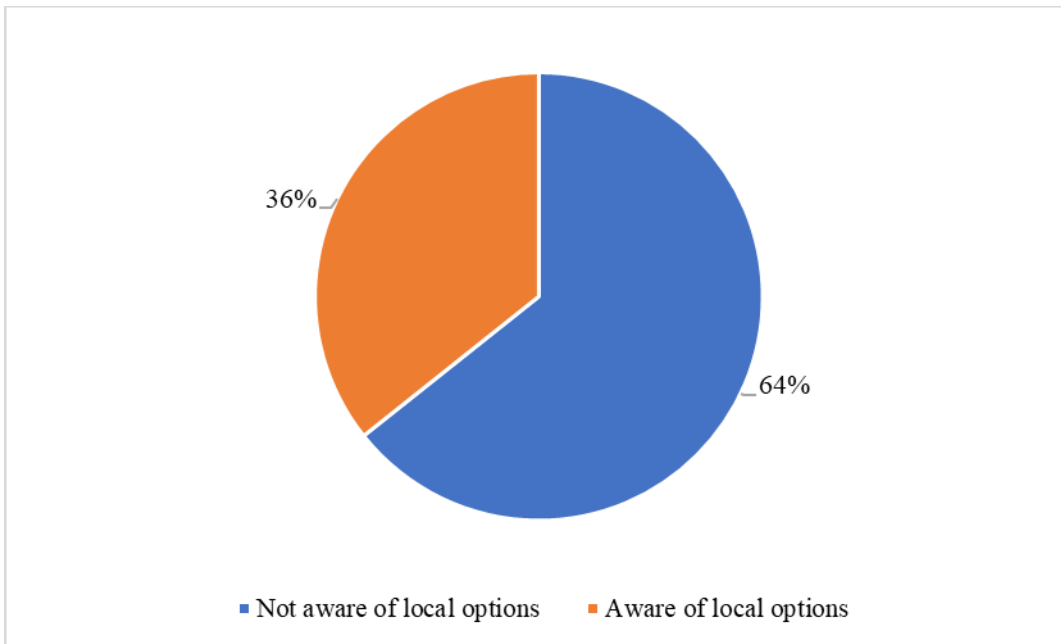


Figure 6. Awareness of e-waste recycling options among respondents willing to pay to recycle e-waste

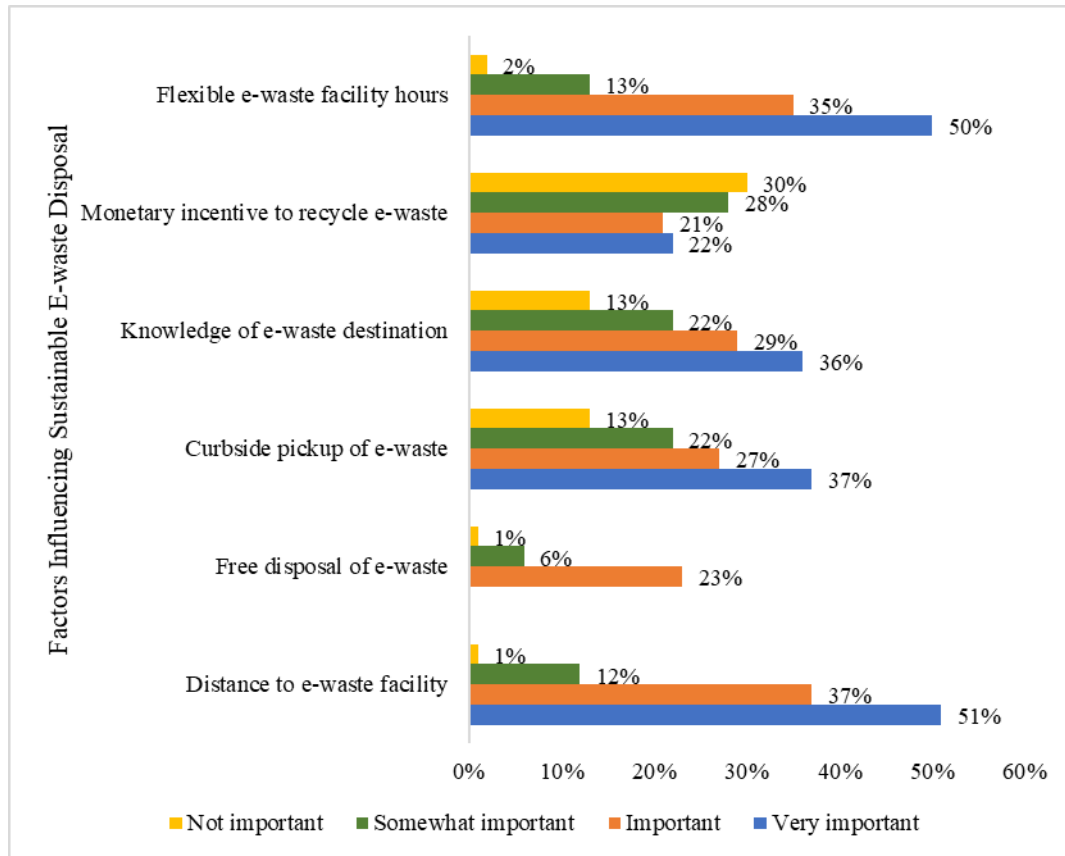


Figure 7. Importance of factors that influence willingness to recycle e-waste sustainably

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