



Evaluation of Awareness about Electronic Waste and Concern for the Environment in Tayma Governorate, Tabuk Region, Saudi Arabia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study was carried out to evaluate the people's awareness level about electronic waste (e-waste) disposal and management practices as well as their impact on environment, also provides recommendations for moving forward on this problem in Tayma governorate, KSA. The data for this work were collected during the distribution of 96 questionnaires on householders and governmental organizations (municipality and health sector). Likert Scale was used for the analysis of the participants. The results of householders exhibited that awareness are low or medium various degrees for e-waste disposal and management practices as well as their impact on environment and there is no formal or informal e-waste sector in Tayma governorate. The participants reported

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that they use all electronic home appliances, computers, laptops and Mobile phone and more than double the equipment was disposed of as e-waste during the past 10 years, which increases e-waste. The responses from the Tayma governorate's municipality and health sector revealed that a large number of people (from 68% to 88%) did not know a person or company that could collect their used electronics for reuse, resale, recycling, or dismantling; they were also unaware of any electronic waste management policies currently in place in Tayma; and there was a very low perception of public awareness of the laws in place for e-waste and for the control of exposure. Also, there are hazards to the growing amount of e-waste in Tayma and they must be support the unorganized sector's role in waste management (while providing for safer practices). They added, no companies and the general population complied with electronic waste management policies and not found priority of government and individual levels for e-waste problem now. Finally, they said the vision 2030 for Kingdom of Saudi Arabia is gives full attention to the e-waste problem. The participants needs to more information on government rules and regulation for e-waste management. Government entities in Tayma Governorate must therefore make invest more in raising public awareness at all levels of society as well as at the legislative and institutional levels.

Keywords: Awareness; householders; governmental organizations; e-waste; Tayma; KSA.

1. INTRODUCTION

Electronic Waste (e-waste) is a term used to include all electrical and electronic equipment that has been has reached its end-of-life (EoL) and regarded by its user as waste and without the intent of reuse [1]. Waste Electrical and Electronic Equipment (WEEE) is another common phrase. However, there is no standard definition of E-waste or WEEE. A wide variety of products that are powered by electricity or batteries and contain circuitry or electric components are included in the category of "e-waste". These can be divided into the following categories: displays, monitors, toys, lighting, leisure and sports equipment, large electrical equipment, medical devices, small electrical equipment, and small information technology (IT) and communications equipment. The word "e-waste" only refers to televisions and information and communication technology (ICT) equipment in Northern America. Four product categories, including TVs, air conditioners, refrigerators, and washing machines, are referred to as "e-waste" in Japan [2-4].

In general, e-waste contains more than 1000 different substances, which can be classified into "hazardous" and "non-hazardous" categories [5]. Plastic, glass, wood, plywood, printed circuit boards, concrete, ceramics, rubber, and other materials are all found in e-waste along with ferrous and non-ferrous metals. E-waste makes up 50% of iron steel, 21% of plastic, and 13% of non-ferrous metals like copper and aluminum as well as precious metals like silver, gold, platinum, palladium, and others. Smith et al. [6] mentioned that, large household appliances represent the

largest proportion (about 50%) of e-waste, followed by information and communications technology equipment (about 30%) and consumer electronics (about 10%). Increasing quantities of e-waste and its mismanagement represent a major concern across the world due to the presence of hazardous substances such as heavy metals and hazardous chemical elements (lead, cadmium, chromium, mercury, copper, manganese, nickel, arsenic, zinc, iron, and aluminum [2,7], as well as persistent organic pollutants [8] and poly cyclic aromatic hydrocarbons [9]. E-waste, on the other hand, contains precious components that can be recovered, including gold, silver, copper, platinum, palladium, iron, aluminum, indium, gallium, and rare earth metals. This helps to promote sustainable resource management [4]. Since e-waste is a complex mixture of harmful substances, improper handling might have a permanent negative influence on both the environment and human health [8].

E-waste production is rising quickly, which is related to the rising demand and supply of electrical equipment with short lifespans [10]. The total weight of global WEEE consumption rises yearly by an average of 2.5 million metric tons, according to the global e-waste monitor 2020 study [11]. The Middle East's largest producer of e-waste is thought to be Saudi Arabia. The Kingdom produced five million tons of electronic garbage in 2016, a rise of 25% per year, highlighting the need to step up efforts and programs to recycle technology [12]. An estimated 1.4 kilogram of garbage are produced per person every day. Waste is gathered from household or public trash cans and dumped in

landfills [13,14]. According to estimates, Saudi Arabia produces 12.5 kg of electronic waste per person year, with a total national production of roughly 378 000 tons [15]. Vision 2030 of the Kingdom of Saudi Arabia states "By preserving our environment and natural resources, we fulfill our Islamic, human and moral duties. Preservation is also our responsibility to future generations and essential to the quality of our daily lives. We will seek to safeguard our environment by increasing the efficiency of waste management, establishing comprehensive recycling projects, reducing all types of pollution and fighting desertification" [16].

The goal of this study is to gather pertinent information about the demographics of those who deal with e-waste, their awareness of the risks involved in improper waste handling and disposal, the amounts of e-waste generated, disposal methods, reuse and recycling habits, and their knowledge of the health risks and environmental effects related to e-waste. It will address the issue from a systems analysis perspective, look for solutions, and offer potential routes for e-waste in the Tayma governorate, Saudi Arabia.

2. MATERIALS AND METHODS

2.1 Participants and Questionnaires

Data were taken from the Voice of the householders, municipality and health sector of Tayma governorate survey during 2017, a voluntary and confidential based survey offered to all participants. The overall allocation scheme was aimed toward equalizing the number of questionnaires at participants. In this study the questionnaires were used to evaluation of public awareness regarding e-waste hazards during identify the current status of e-waste management practices, the effect of e-waste on environment and disposal of e-waste in Tayma governorate. The questionnaires with a short description of the current study and intended use of collected data were also distributed on householders, municipality and health sector of Tayma governorate by hand which created room for one on one interaction with the respondents. The questionnaires were developed in English and then translated in the Arabic. Participants were asked to complete a self-administered structured questionnaire.

The data had collected through the distribution of 96 well-structured questionnaires distributed

among different respondents with numbers of 63, 25 and 8 on householders, municipality and health Sector of Tayma governorate, respectively. The questionnaire for householders was divided into four sections i.e., personal data, involvement in e-waste generation, generation and management of e-waste and impact on the environment. Generally, the questionnaires focus on use of household electronics, waste disposal, waste hazards on environment, e-waste management policies government role and role of the informal sector. The Questionnaires for householders, municipality and health sector of Tayma governorate were listed in Appendix A, B and C, respectively.

2.2 Statistical Analysis

The Likert scale analysis [17] was the statistical method used for the analysis of the respondents, in which the responses were coded using numerical data to quantify the responses. Mean answers were compared with the critical zone and means of coding values were used as the crucial region to determine whether the hypothesis should be accepted. To calculate the critical region and mean response rates for surveys in this study, we used the following equations:

$$\text{Critical region} = \frac{\text{Summation of coding values}}{\text{Number of coding values}}$$

$$\text{Mean response} = \frac{\text{Number of responses to your survey}}{\text{Number of people you sent the survey}}$$

Accept the null hypothesis if the value of mean response was lower than the values of critical region. While, reject the null hypothesis if the value of mean response was higher than the values of critical region. Charts were utilized to better understand the data that was available and the demographic data of the respondents.

3. RESULTS AND DISCUSSION

It might be mentioned that, results will be presented according to questionnaires are used in this work as follows:

1. Householders.
2. Municipality of Tayma governorate.
3. Health Sector - Ministry of Health, Tayma governorate.

3.1 Householders

3.1.1 Personal Data

The personal data i.e., sex, age, are you currently, marital status, qualification and annual income were common demographic questions asked in surveys. Most likely answer the questions were differently by the respondents, due to that the respondents were various in these personal data. The data in Table 1 results displayed that, reject of the null hypothesis for sex and educational qualification, therefore there are significant differences. However, accept of null hypothesis for other studied personal data in this study.

The descriptive characteristics of households are presented in Table 2. Out of the number of participants (63), female (56), 20 - 29 year (32), student (28), married (30), University (42) and Under SR 50,000 (37) were recorded the highest values of frequency for sex, age, are you currently, marital status, qualification and annual income, respectively. A significant determinant of good understanding and a favorable opinion of e-waste management was male gender, higher education, and skilled and professional staff [18].

In Fig. 1, the valid percentages of the respondents in sex were 89% at female and 11% at male, indicating most of the respondents are female. As for age, 52%, 23%, 21% and 3% of the participants are 20 - 29, 30 - 39, 40 - 49 and 50 and above years, respectively, this indicates that the majority of young people were used in this study. 44%, 35%, 16%, 5% and 0% of the participants are student, employed, unemployed, retired and other, respectively, indicating that the largest proportion of respondents in this voting are workers in Tayma governorate. On the other hand, the highest percentage of the participants in case marital status were registered by married (48%) followed by single (44%), divorced (5%) and Widowed (5%). In relation to educational qualification, the represented 68% of the total participants collected was found for university qualification, however, the remaining 32% was collected mainly from uneducated (5%), primary (5%), preparatory (2%) and secondary (20) qualifications, this meaning most of the participants in this study are graduates and learners in different stages. Finally, under SR 50,000 (61%) of annual income was gave the largest valid percentage of participants followed by SR 50,000-SR 99,999 (20%), SR 100,000-

SR 149,999 (16%) and Over SR 150,000 (3%), indicating most of participants are low annual income. Okoye and Odoh [19] studied demographic information of respondents for assessment of the level of awareness of e-waste management and concern for the environment amongst the householders; they mentioned that most of the respondents were female, 30 to 39 years, married and holders certificates. In order to establish lasting values for health, the environment, and the nation, it is crucial that future generations have a greater understanding of e-waste [20]. The participants' awareness of e-waste and their qualifications were substantially correlated [21].

3.1.2 Involvement in electrical/electronic waste generation

The participants were asked "what are the namely of used electronics in the house?" (First question), the participants reported that they use all electronic home appliances, computers, laptops and mobile phone in house. As for the second and third questions "How many household electronics have you purchased/replaced in the past 10 years? and How many household electronics do you still used of the ones you have purchased in the past 10 years?", the participants mentioned that, during the past 10 years purchased and still used on average, 22.8 and 10.6 household electronics, respectively. These results indicate that more than double the equipment was disposed of as e-waste. According to Shah et al. [22], 94% of survey respondents said they use household electronics, which were again classified in this study as mobile phones and personal computers, while 85% said they use both regularly. Respondents purchased averaged 4.3 cell phones and 2.5 personal computers over the past ten years.

The results in Table 3 show reject of the null hypothesis for the sixth, eighth and ninth questions, indicating that awareness of these questions are high (reason of purchasing the new household electronics, aware of government regulation on e-waste management in in Saudi Arabia and they have rules guiding activities in the association, respectively). On the other hand, accept of null hypothesis for the questions 4, 5 and 7 and therefore low awareness of these questions (knowledge of electronic wastes, use these household electronics frequently and the model of disposal of e-waste adopted in the house, respectively).

Table 1. The mean response, critical region and null hypothesis of personal data for householders

Personal data	Mean response	Critical region	Null hypothesis
Sex	1.89	1.50	Reject
Age	1.75	2.50	Accept
Are you currently	3.00	3.00	Accept
Marital status	1.67	2.50	Accept
Qualification	4.42	4.00	Reject
Annual income	1.62	2.50	Accept

Table 2. Number of blanks and valid responses from personal data for householders

Personal data	Frequency						
	Blanks	No. of valid responses according to Likert scale coding					Total
		1	2	3	4	5	
Sex	0	7 (Male)	56 (Female)				63
Age	2	32 (20 – 29)	14 (30 – 39)	13 (40 – 49)	2 (50 and above)		61
Are you currently	0	3 (Retired)	22 (Employed)	10 (Unemployed)	28 (Student)	0 (Other)	63
Marital status	0	28 (Single)	30 (Married)	3 (Divorced)	2 (Widowed)		63
Qualification	1	3 (Uneducated)	3 (Primary)	1 (Preparatory)	13 (Secondary)	42 (University)	62
Annual income (SR)	2	37 (Under 50,000)	12 (50,000-99,999)	10 (100,000-149,999)	2 (Over 150,000)		61

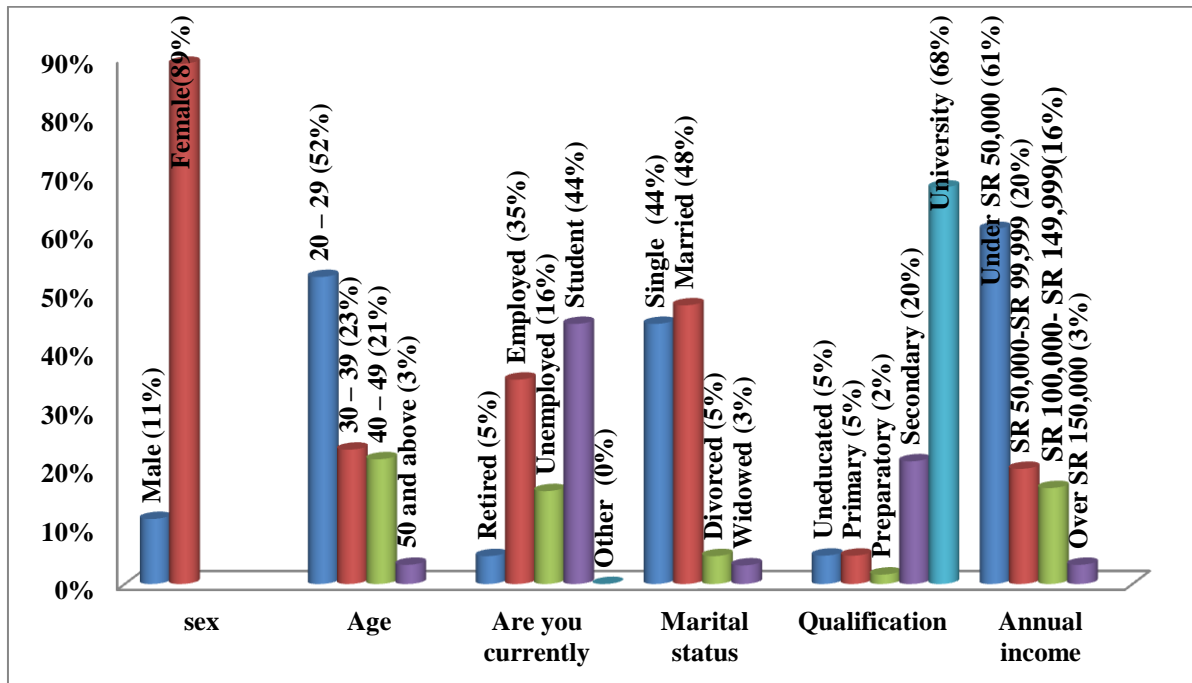


Fig. 1. The data collected through the demographic questions for householder’s

Data collected for number of valid responses according to Likert Scale Coding as Table 4 were showed that most of the participants chose yes (41 and 54) for the questions 4 and 5,

respectively, desire for newest technology (20) for the Question 6, sell to recycler (26) for the Question 7 as well as no (48 and 51) for the two questions 8 and 9, respectively. Responses on

the Questions 4 and 5 shows that 66% and 87% of respondents are said “yes”, respectively, but, remaining respondents are said “no”. These results indicating that, most respondents on complete knowledge with electronic wastes and they use these household electronics frequently.

The Fig. 2 depicts data collected from the questions about involvement in e-waste generation. Data collected from the Question 6 exhibited the respondents say that reason for purchasing the new household electronics, 6% of physical damage, 14% of loss of function, 30% of need for greater functionality, 33% of desire for newest technology and 7% of others reasons, this indicate 66% of participants want to replace old electronics with modern electronics, which increases e-waste. The survey results of the Question 7 confirm that 29%, 41%, 19% and 11% of participants disposal of e-waste adopted in the house by dump in designated places/refuse dump, sell to recycler, keep at

home and burning/incineration, respectively, this result means that a very large proportion of participants (89%) deal with e-waste in a good ways, while a small proportion (11%) of them are harmful of the environment and human. People were asked to comment on the eighth and ninth Questions, 84% and 81% of participants showed no are not aware of any government regulation on e-waste management in Saudi Arabia and no do not have rules guiding your activities in the association, respectively. When participants were chose yes for the Question 9, 65% of participants are chose yes, this indicating the participants correspond the rules with government regulation for waste management, but the remaining respondents are chose no. As for How effectively are the rules enforced?, 18%, 54% and 28% of participants were mentioned that the rules enforce strongly, fairly and not enforced, respectively. These results indicating that the participants in this study needs to more information on government rules and regulation for waste management.

Table 3. The mean response, critical region and null hypothesis of involvement in e-waste generation for householders

No.	Questions	Mean response	Critical region	Null hypothesis
Q ₄	Do you know what electronic wastes are?	1.34	1.50	Accept
Q ₅	Do you use these household electronics frequently?	1.13	1.50	Accept
Q ₆	What was your reason for purchasing the new household electronics?	3.40	3.00	Reject
Q ₇	Which of the following is the model of disposal of e-waste adopted in the house?	2.13	2.50	Accept
Q ₈	Are you aware of any government regulation on e-waste management in Saudi Arabia?	1.84	1.50	Reject
Q ₉	Do you have rules guiding your activities in the association?	1.80	1.50	Reject

Table 4. Number of blanks and valid responses from involvement in e-waste generation for householders

Questions	Frequency						Total
	Blanks	No. of valid responses according to Likert scale Coding					
		1	2	3	4	5	
Q ₄	1	21(No)	41(Yes)				62
Q ₅	1	8 (No)	54 (Yes)				62
Q ₆	0	4 (Physical Damage)	9 (Loss of Function)	19 (Need for Greater Functionality)	20 (Desire for Newest Technology)	11 (Other)	63
Q ₇	0	18 (Dump in designated places)	26 (Sell to recycler)	12 (Keep at home)	7 (Burning)		63
Q ₈	6	48 (No)	9 (Yes)				57
Q ₉	1	51(No)	11(Yes)				62

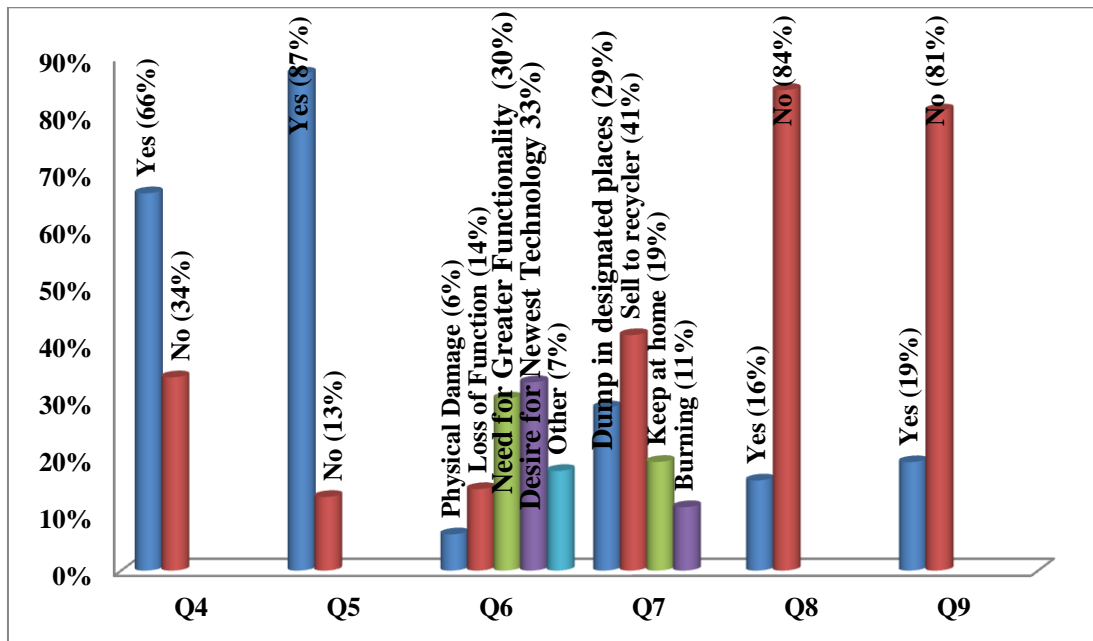


Fig. 2. The data collected through the questions of Involvement in e-waste generation for householders

The data obtained from householders involvement in e-waste generation Okoye and Odoh [19] reported that more respondents had phones than other appliances. 36.36 of the households dispose of their e-waste in the designated rubbish disposal, compared to 54.54% who store it at home. The other 9% market theirs to recyclers. This necessitates an immediate informational effort about the importance of recycling e-waste, its advantages, and the consequences of combining it with other municipal rubbish. Also they added, the awareness for government regulation of e-waste management is low among the selected householders. According to Shah et al. [22], 61% of respondents said they bought new electronics because they wanted the newest technology.

3.1.3 E-waste management

In this study we are require from the participants answer on the first question "What volume of electrical/electronic waste do you handle per day?" the participants were reported that the average of volume of electrical/electronic waste do you handle per day was 7.34 and ranged between electronic home appliances, computers, laptops, mobile phone, battery and circuit board. In response to Question 2 "Indicate the volume of reusable, recyclable and residue from your work", the participants were say the average of the volume of reusable, recyclable and residue

from your work was 4.0 and varied among washer, mobile phone, TV, fan, stereos, batteries and computer.

Reject of the null hypothesis for the Questions 4 and 5 (Table 5), this indicates awareness of recover any of the electrical/electronic equipment/components from waste and they do with the recovered equipment/components are high. While, accept of null hypothesis for the question 3, this indicating awareness of the electronics appliances that you no longer use is low.

The number of valid responses to the Questions 3, 4 and 5 about "generation and management of e-waste" revealed that, 29, 50 and 26 of participants were chose kept in home, no and sell to repairers when answer on this questions, respectively as Table 6.

The data for the questions about management of e-waste are illustrated in Fig. 3. In relative to the Question 3, 46%, 29%, 2%, 6% and 17% of respondents were chose kept in home, given/sold to a personal contact, sold to informal system, sold to formal system and trash, respectively, this implies a large proportion of the participants (83%) benefit from e-waste unused at home by different used methods. The data in the Fig. 1 based on the Question 4 were showed that, 21% and 79% of participants are chose yes

and no, respectively. Unrecovered any of the electrical/electronic equipment/components from waste had general direction for most participants. When participants were chose yes (21%) for the Question 4,we asked "Which equipment?", 19%, 22%, 17% and 42% of participants are say computer, laptop, TV and mobile phone, respectively. Also, we asked "Which component do you recycle/recover?" the answers were circuit board (14%) battery (50%) plastics (22%) iron (8%) copper (6%), aluminum (0%) and others (0%). The participants sell to repairers (43%) or sell to recyclers (18%) and reuse (39%) when we asked the question 5 "What do you do with the recovered equipment/components? " this suggests that the participants benefit from e-waste unused at home. Okoye and Odoh [19] revealed that the items mainly sort after are cathode ray tube (54%), mobile phones (30%),

laptops (6%) and other (10%). Unused electronics are frequently purchased or given to friends or family members (35%), or people retain them at home (26%). The majority of respondents (61%) do not view discarded electronics as trash because they may often be repaired, repurposed, or even used as a source of raw materials or replacement parts [22]. According to Mohideen et al. [23] the respondents demonstrated a high degree of awareness as well as an adequate level of understanding of the significance of e-waste management. Shahabuddin et al. [24] noted that country-specific standards and legislation, public awareness, effective implementation, and government incentives for creating cost-effective technologies are sought in order to effectively manage e-waste, which will play a significant role in the circular economy.

Table 5. The mean response, critical region and null hypothesis of e-waste management for householders

No.	Questions	Mean response	Critical region	Null hypothesis
Q ₃	What have you done with the electronics that you no longer use?	2.21	3.00	Accept
Q ₄	Do you recover any of the electrical/electronic equipment/components from waste?	1.79	1.50	Reject
Q ₅	What do you do with the recovered equipment/components?	2.00	2.00	Reject

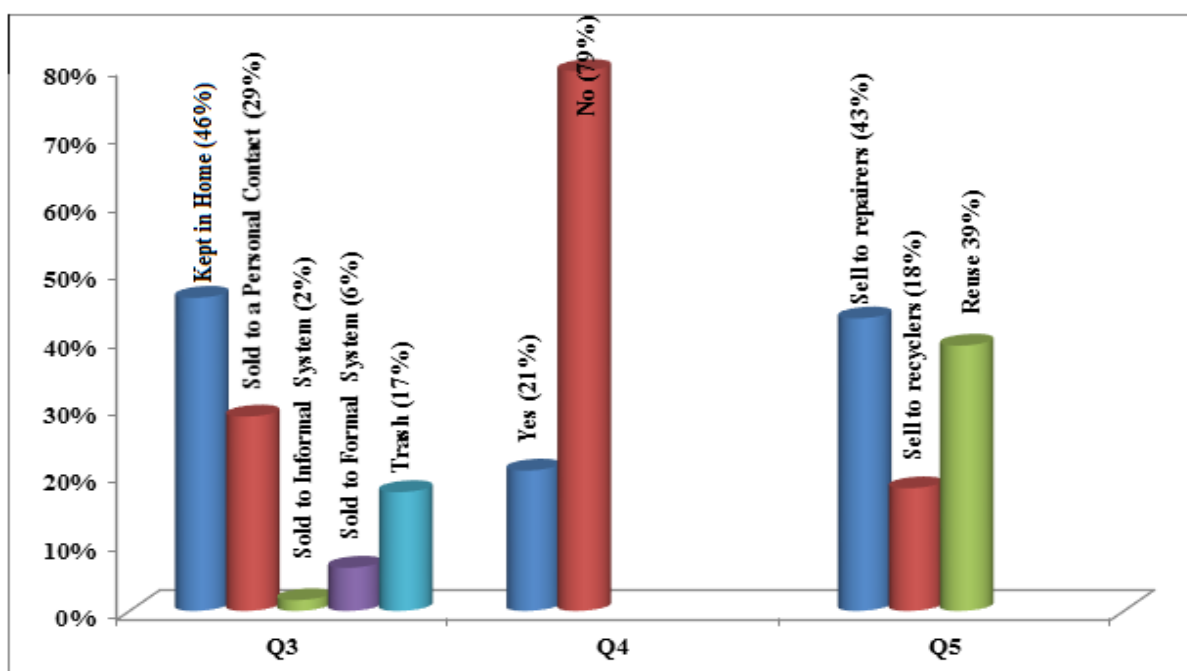


Fig. 3. The data collected through the questions of e-waste management for householders

3.1.4 Impact of e-waste on environment

From the data in Table 7, accept null hypothesis were found for the Questions 1 and from 4 to 8, this suggesting that awareness are low for known health risks associated with electronic wastes, information about the environmental issues in your local area, concerned about your environment, knowledge some components of electronic devices contain toxic/hazardous materials, know toxic/hazardous materials require special treatment for environmentally sound disposal and disposal/treatment method in use for electronic waste have any impact on the environment. On the other hand, the null hypothesis for the remaining other Questions were reject, this indicating that the highest awareness were found for known local programs, projects or activities pertaining to electronic waste management and aware of recycling/trading fairs for electronic wastes.

According to Likert Scale Coding for the questions in the Table 8, the highest number of valid responses with values 46, 42, 35 and 42 of

participants are chose yes during the Questions 1, 6, 7 and 8, respectively, with values 33 and 41 of participants are chose no during the Questions 2 and 3, with value 27 of participants is chose somewhat informed and concerned through the Questions 4 and 5. The effect of e-waste on environment is presented in Fig. 4. Regarding the questions 1, 6, 7 and 8 the respondents are chose yes, they are demonstrated a good understanding of health risks associated with electronic wastes (73%), know that some components of electronic devices contain toxic/hazardous materials (67%), toxic/hazardous materials require special treatment for environmentally sound disposal (59%) and disposal/treatment method in use for electronic waste have any impact on the environment (74%), while, with 21%, 33%, 41% and 26% replying "no". On the other hand, the respondents are chose no, therefore they do not aware of local programs, projects or activities pertaining to electronic waste management (55%) and not know recycling/trading fairs for electronic wastes (67%), while, 45% and 33% replying "yes" during the questions 2 and 3.

Table 6. Number of blanks and valid responses from e-waste management for householders

Questions	Frequency	No. of valid responses according to Likert scale Coding					Total
		1	2	3	4	5	
Q ₃	0	29 (Kept in Home)	18 (Sold to a Personal Contact)	1 (Sold to Informal System)	4 (Sold to Formal System)	11 (Trash)	63
Q ₄	0	50 (No)	13 (Yes)				63
Q ₅	2	26 (Sell to repairers)	11 (Sell to recyclers)	24 (Reuse)			61

Table 7. The mean response, critical region and null hypothesis for impact of e-waste on environment and human in householders

No.	Questions	Mean response	Critical region	Null hypothesis
Q ₁	Are you aware of any health risk/s associated with electronic wastes?	1.27	1.50	Accept
Q ₂	Are you aware of local programs, projects or activities pertaining to electronic waste management?	1.55	1.50	Reject
Q ₃	Are you aware of recycling/trading fairs for electronic wastes?	1.67	1.50	Reject
Q ₄	How informed are you about the environmental issues in your local area?	2.25	2.50	Accept
Q ₅	Are you concerned about your environment?	2.13	2.50	Accept
Q ₆	Do you know that some components of electronic devices contain toxic/hazardous materials?	1.33	1.50	Accept
Q ₇	Are you aware that these toxic/hazardous materials require special treatment for environmentally sound disposal?	1.41	1.50	Accept
Q ₈	Does the disposal/treatment method in use for electronic waste have any impact on the environment?	1.38	2.00	Accept

Table 8. Number of blanks and valid responses from impact of e-waste on environment and human for householders

Questions	Frequency	No. of valid responses according to Likert scale Coding				Total
		1	2	3	4	
Q ₁	0	17 (No)	46 (Yes)			63
Q ₂	3	33 (No)	27 (Yes)			60
Q ₃	2	41(No)	20 (Yes)			61
Q ₄	0	10 (Very Informed)	27 (Somewhat Informed)	26 (Not Informed)	0 (I do not care about them at all)	63
Q ₅	0	19 (Not concerned)	17 (Barely concerned)	27 (Concerned)	0 (Very concerned)	63
Q ₆	0	21(No)	42 (Yes)			63
Q ₇	4	24 (No)	35 (Yes)			59
Q ₈	7	7 (No)	7 (Not sure)	42 (Yes)		56

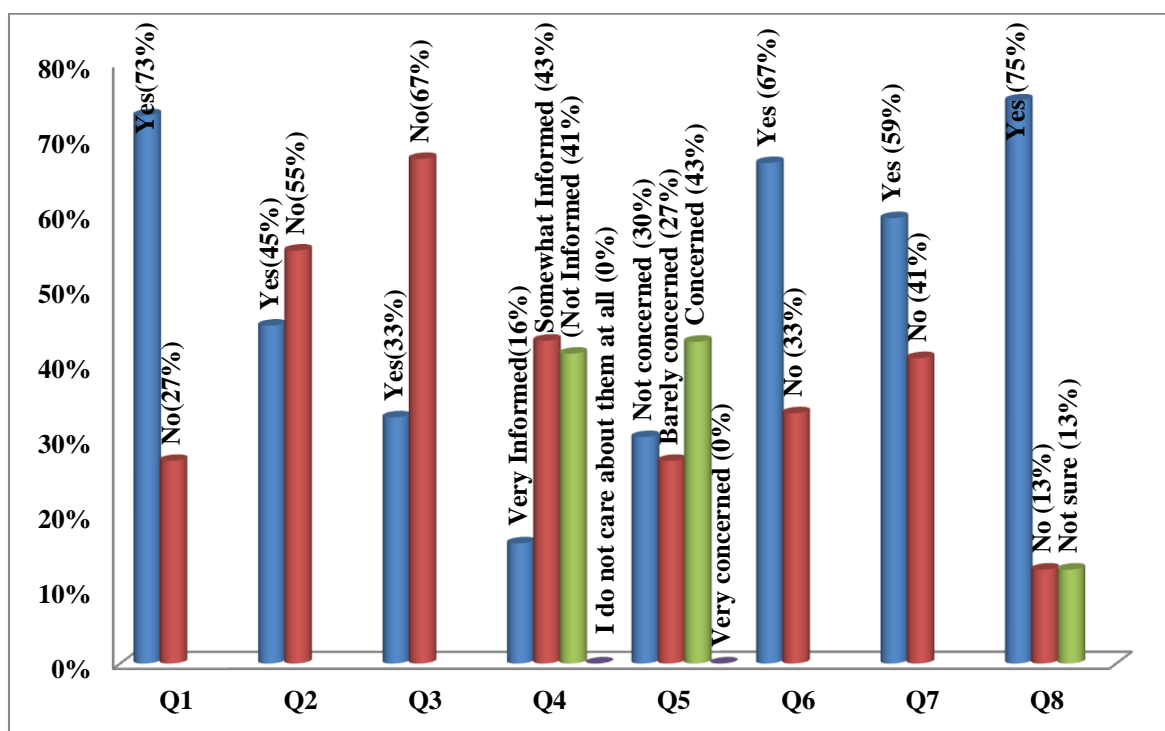


Fig. 4. The data collected through the questions from impact of e-waste on environment and human for householders

As for the Question 4, 16%, 43% and 41% of the participants were very informed, somewhat informed and not informed with environmental issues in local area. The participants were asked "Are you concerned about your environment?", they replying not concerned (30%) barely concerned, (27%), concerned, (43%) and very concerned (0%), this implies that a large proportion of the participants not interested environmental issues in local area and concerned about environment. According to Okoye and Odoh [19] analysis of data on the

impact of e-waste on humans and the environment, the majority of households (96% of them) are worried about the environment. The respondents' knowledge of the toxic elements in e-waste was also put to the test. The findings indicate that the majority of householders (78%) are unaware of the dangers associated with e-waste.

When participants were chose yes for the Question 8 (74%) we asked "what is part of the environment affected and rate the impact?".

During the data in Table 9, reject null hypothesis for all environments parts, this indicating the high effect of e- waste on environment.

In Fig. 5, 90%, 90, 63%, 55% and 74% of respondents mentioned that the effect of e-waste on land, air, surface water, underground water and vegetation were strong or very strong, respectively, while the remaining percentages for fairly effect or not effect on environment's parts. The responses on negative impact of the waste on environment show that most of the respondents are not aware of the harmful effect of the products [19]. Sankhla et al. [8] mentioned that, the e-wastes are unsafe since various electronic product components contain hazardous elements depending on their density and state. The environment and human health are at risk due to these materials' hazardous composition. Its poisonous emissions mix with uncontaminated soil and air and have a negative direct or indirect impact on the entire biota. Acids, toxic substances, including heavy metals, and chemicals that because cancer are examples of direct effects. Indirect consequences include biomagnification of heavy metals. If discarded improperly, old electronics such as computers, TVs, DVD players, stereos, copiers, fax machines, electric lights, cell phones, audio equipment, and batteries can

leach lead and other materials into the ground and soil. Although the majority of respondents were aware that e-waste materials contained harmful or dangerous substances, they nevertheless gave the environmental impact of e-waste a low rating and used improper disposal techniques [21].

3.2 Municipality of Tayma Governorate

The data in Table 10 revealed that, the participants were showed the low awareness of someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, they see any hazards or risks to the growing amount of e-waste in Tayma and do think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices), due to accepted of null hypothesis for the Questions 1, 2 and 7. In contrast, the participants were good aware for knowledge e-waste management policies currently implemented in Tayma , are there flaws to these policies, perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals and are people aware of the hazardous chemicals found in e-waste, due to rejected of null hypothesis for the Questions 3, 4, 5 and 6.

Table 9. The mean response, critical region and null hypothesis for impact of e-Waste on environment parts

Parts	Mean response	Critical region	Null hypothesis
Land	3.52	2.50	Reject
Air	3.45	2.50	Reject
Surface water	2.88	2.50	Reject
Underground water	2.71	2.50	Reject
Vegetation	3.05	2.50	Reject

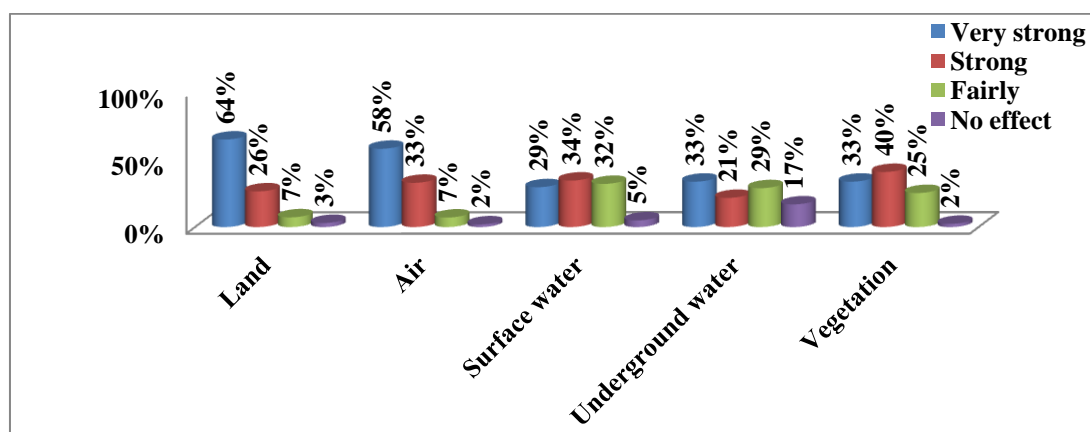


Fig. 5. The effect of e-waste on environment components

Table 10. The mean response, critical region and null hypothesis for the questions of municipality

No.	Questions	Mean response	Critical region	Null hypothesis
Q ₁	Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?	1.56	2.00	Accept
Q ₂	Do you see any hazards or risks to the growing amount of e-waste in Tayma ?	2.17	2.50	Accept
Q ₃	Do you know of any electronic waste management policies currently implemented in Tayma ?	1.88	1.50	Reject
Q ₄	Are there flaws to these policies?	1.81	1.50	Reject
Q ₅	What is your perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals?	1.79	1.50	Reject
Q ₆	Are people aware of the hazardous chemicals found in e-waste?	1.72	1.50	Reject
Q ₇	Do you think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices)?	1.20	1.50	Accept

During questionnaire of municipality of Tayma governorate, the Questions 1, 3, 4, 5 and 6 were demonstrated that, 68%, 88%, 81%, 79% and 72% of the participants were chose no as shown in Fig. 6, respectively, this indicates the large of the participants not know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, they not know of any electronic waste management policies currently implemented in Tayma , not flaws to these policies, very low perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals and the people are not aware of the hazardous chemicals found in e-waste. On the other hand, 75% and 80% of participants are replied with yes, this result is meaning they see hazards or risks to the growing amount of e-waste in Tayma and they think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices).

Regarding Question 6, when the participants were replied yes (28%). we asked "who informs them?" the participants said "there is no one ignorant of the dangers of electronic waste" and "provide the guides and the mentors for that", while when the participants were choose no (72%), we asked them "what is the best way for creating mass awareness?" some participants replied through educational courses and social media.

During the Question 8, the participants were asked "How well have companies and the general population complied with electronic waste management policies", the participants said "unknown" or "there is no". As for the question 9 "How much of a priority is this issue at the government level? At the individual level", the participants mentioned that not found priority for government and individual levels. In relation to the Question 10 "How much should the public and government prioritize e-waste management, relative to other public issues", some participants are replied "this is the vision 2030 for Kingdom of Saudi Arabia where gives full attention to the e-waste with percentages ranging from 80% to100%", other participants are replied "unknown" or "there is no". The participants' understanding of e-waste and its detrimental effects on commercial consumers is strong, but their knowledge of laws and government regulations is poor [21].

3.3 Health Sector - Ministry of Health, Tayma Governorate

During questionnaire of Health Sector - Health Ministry, Tayma governorate, null hypothesis was accepted for the Questions 1, 2, 4 and 7 as Table 11, this showed the awareness was low for knowledge on someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, for the hazards or risks to the growing amount of medical e-waste and others in Tayma , for the policies flaws and for they think would be viable

to support the unorganized sector's role in management of medical e-waste and others (while providing for safer practices). Otherwise, the null hypothesis for the other Questions were rejected, this indicates that the awareness was high for the medical e-waste and others management policies currently implemented in Tayma, for perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals and for the people aware of the hazardous chemicals found in medical e-waste and others.

The chart in Fig. 7 demonstrates that, 88%, 12%, 100%, 0%, 100%, 100% and 12% of participants were chose no for the Questions are presented in Table 1, while the remaining percentages are chose yes for same the Questions, respectively, these results indicate that they do not know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling, also they do not know of any medical e-waste and others management policies currently implemented in Tayma , then they do not perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals and finally the people do not aware of the hazardous chemicals found in medical e-waste and others. But, they see

hazards or risks from the growing amount of medical e-waste and others in Tayma, flaws to these policies and think it would be viable to support the unorganized sector's role in management of medical e-waste and others (while providing for safer practices).

During the Question 6 and when participants were chosen no (100%), we asked them "what is the best way for creating mass awareness?" they replied through educational courses and social media. The participants were asked of the question 8 " How well have companies and the general population complied with medical e-waste and others management policies?" the participants were replied lack of knowledge of companies and the general population with the culture of these policies. In respect to the Question 9 "How much of a priority is this issue at the government level? At the individual level?" some participants said "ignoring of e-waste on government and individual levels" and others did not respond. As for the Question 10 "How much should the health sector prioritize for management of medical e-waste and others, relative to other public issues?" some of them answered that the health sector must be gives full attention to the medical e-waste and others in percentages ranging between 95% and 100%, while others are in percentages ranging between 0% and 30%.

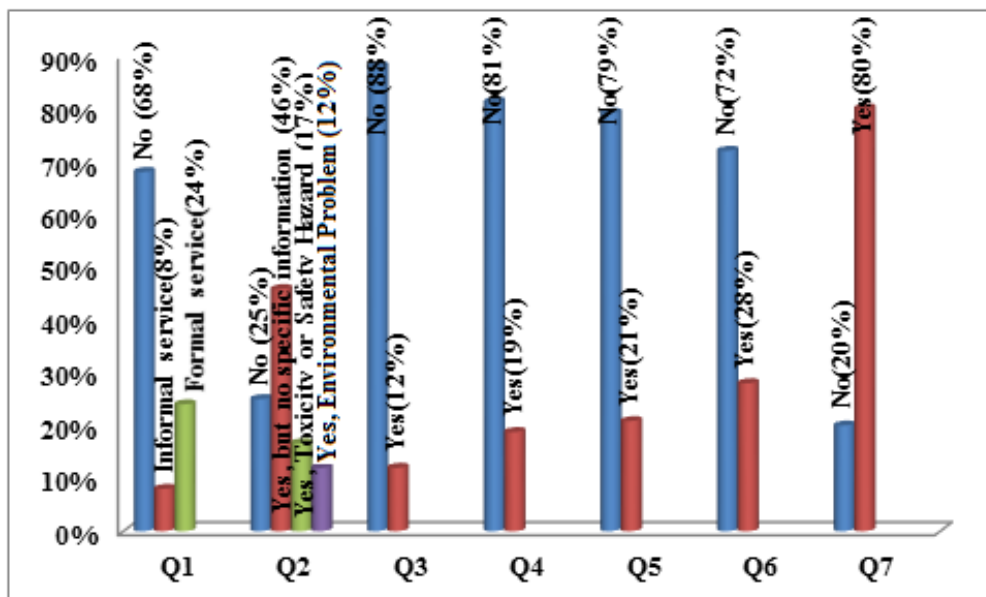


Fig. 6. The data collected through the municipality questionnaire

Table 11. The mean response, critical region and null hypothesis for the questions of health sector

No.	Questions	Mean response	Critical region	Null hypothesis
Q ₁	Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?	1.13	2.00	Accept
Q ₂	Do you see any hazards or risks to the growing amount of medical e-waste and others in Tayma ?	1.88	3.00	Accept
Q ₃	Do you know of any medical e-waste and others management policies currently implemented in Tayma ?	2.00	1.50	Reject
Q ₄	Are there flaws to these policies?	1.00	1.50	Accept
Q ₅	What is your perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals?	2.00	1.50	Reject
Q ₆	Are people aware of the hazardous chemicals found in medical e-waste and others?	2.00	1.50	Reject
Q ₇	Do you think it would be viable to support the unorganized sector's role in management of medical e-waste and others (while providing for safer practices)?	1.13	1.50	Accept

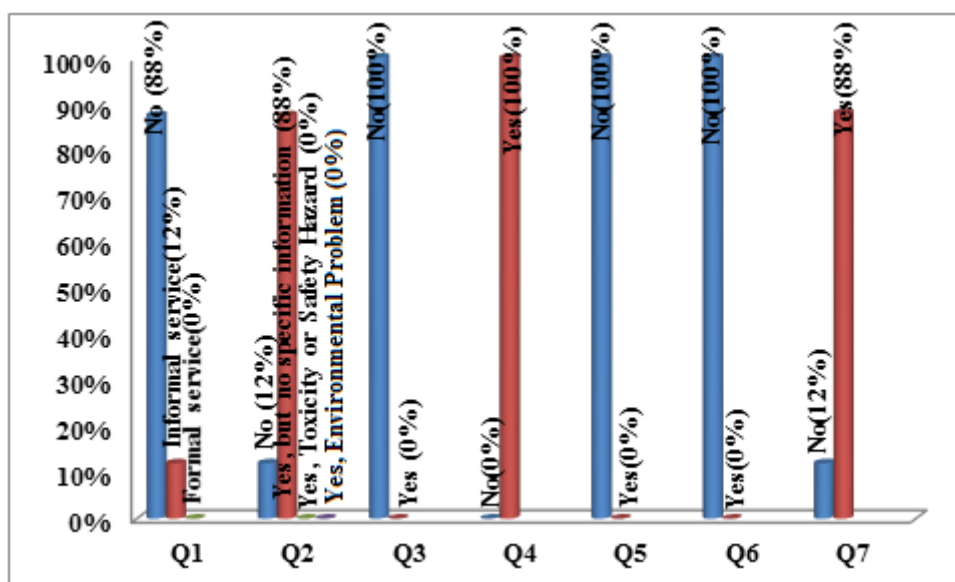


Fig. 7. The data collected through the health sector questionnaire

Generally speaking, the environment in poorer countries that received them for recycling and the recovery of their valuable metals was significantly deteriorated by the pollution produced by their erratic management. There are no adequately well-researched scientific studies that address the effects of e-waste on ecosystems, human health, and environmental restoration in places affected by particular pollution [25]. It is crucial to separate e-waste from other types of solid garbage and recycle it in order to recover valuable raw materials and vital metals [25].

Shah et al. [22] studied the assessment of public's knowledge of e-waste hazards and management techniques and revealed that 63% of respondents either aren't aware of any formal services for collecting used electronics or only are aware of informal services, while 37% of respondents are aware of formal collection services. While 65% of respondents either do not believe that e-waste poses any health or environmental risks or are unaware of any such risks. However, 89% of respondents either said they did not aware of any relevant rules or regulatory organizations or did not believe there

were any government policies in place to handle e-waste. Similar percentages of respondents in each age group were either unaware of any threats, aware of health hazards, or aware of both environmental and health concerns.

Arab nations are very poorly and unevenly informed on the dangers of WEEE and proper disposal methods for end-of-life ICT goods [3]. There has been little to no incentive to create a national policy on proper e-waste management as opposed to waste management generally because most countries are still in the stage of absorbing ICT products. However, collection and shipping systems are controlled by private corporations in specific nations and the regional environment for nations like Switzerland that have a well-developed recycling culture [26]. Making every effort to guarantee that hazardous wastes or other wastes are managed in a way that will safeguard the environment and human health from any negative consequences these wastes may have is referred to as environmentally sound waste management. Through resource recovery, this strategy benefits the economy while preserving the environment and human health. Reuse is the greatest choice since it increases an asset's overall value, extends its usable life, and delays the use of energy and raw resources to create new assets. Recycling through a certified recycler is the next best choice when component reuse is not an option [26].

According to Allam and Inauen [3], governmental, nongovernmental, and private institutions collaborate on the majority of e-waste initiatives. All studies concur that the Gulf Cooperation Council (GCC) countries and the MENA countries are not doing enough to address the problem of e-waste. Many components of a complete framework for the management and treatment of e-waste are lacking in the countries, including pilot programs for collection and separation. The majority of research indicates lack of awareness people of e-waste. Additionally, there is no material flow monitoring system in the GCC countries [12]. The responders' degree of awareness is extremely low and is impacted by a number of intricate aspects [10]. Nisha et al. [18] reported there is a need for increased e-waste disposal method awareness.

4. CONCLUSION

In this study, the results leads to the assumption that awareness on householders and

governmental level is low or medium various degrees for e-waste disposal and management techniques as well as their impact on environment and there is no formal or informal e-waste sector in Tayma governorate. During the last decades, the increase in e-waste generation was due to the substantial increase in the standards of living. In the absence of any mechanism for the safe disposal of this equipment, there were growing signs that this electronic waste was ending up in landfills, creating a potential environmental hazard. e-waste management need to for developed regulatory and legal framework for e-waste management and it implemented, and more basic data collection, inventories and assessment studies. The answers of participants indicate that there is a need for raising E-waste awareness in the Tayma governorate.

5. RECOMMENDATIONS

The results of this study lead to several recommendations for the Tayma governorate, KSA:

- 1- The government bodies must invest more in awareness rising not only in society but also on legislation and institutional levels, where the raise of awareness is a key element of a starting e-waste management system, active participation in management systems and the ability to put pressure on producer compliance in Tayma governorate.
- 2- The public awareness can be reached during:
 - Educational courses in school, university and clubs.
 - Social media like Facebook and Twitter.
 - Education initiatives that provide details on workplace health and safety practices.
 - Printing and distributing informational flyers and booklets to the public is required.
- 3- Work an annual conference on electronic waste to draw attention to this issue and alert the general public to the potential dangers of e-waste
- 4- Must be developed regulatory and legal framework for e-waste management and it implemented.

- 5- Basic data collection, inventories and assessment studies for e-waste management.
- 6- Establish a centralized collection point for electronic waste so they can be disposed of in an environmentally friendly way and benefit from it.
- 7- E-waste management pilot projects illustrating the advantages of a sustainable e-waste management system and permitting the development of regionalized techniques.
- 8- A legal framework for the ICT and recycling sector needs to be developed and put into place based on pilot projects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Appendix A: Questions for householders in Tayma Region.

Please let us know about your perceptions on the e-waste. Please read the following prior to answering questions.

Section (I): Personal Data:

- 1- Sex: Male () Female ()
- 2- Age: 20 – 29 (), 30 – 39 (), 40 – 49 (), 50 and above
- 3- Are you currently: Retired () Employed () Unemployed () Student () Other ()
- 4- Marital status: Single () Married () Divorced () Widowed ()
- 5- Qualification: Uneducated () Primary () Preparatory () Secondary () University.
- 6- What is range of your annual household income? Under SR 50,000 () SR 50,000-SR 99,999 () SR 100,000- SR 149,999 () Over SR 150,000 ()

Section (II): Involvement in Electronic Waste Generation:

- 1- What are the names of used electronics in the house?.....
- 2- How many household electronics have you purchased/replaced in the past 10 years?
- 3- How many household electronics do you still use of the ones you have purchased in the past 10 years?
- 4- Do you know what electronic wastes are? Yes () No ().
- 5- Do you use these household electronics frequently? Yes () No ()
- 6- What was your reason for purchasing the new household electronics?
Physical Damage () Loss of Function () Need for Greater Functionality ()
Desire for Newest Technology () Other ()
- 7- Which of the following is the model of disposal of e-waste adopted in the house?
Dump in designated places/refuse dump () Sell to recycler () Keep at home ()
Burning/incineration ()
- 8- Are you aware of any government regulation on e-waste management in Saudi Arabia? Yes () No ()
- 9- Do you have rules guiding your activities in the association? Yes () No ()
If yes,
 - Are the rules in compliance with government regulation for waste management? Yes () No () Others (please specify).....
 - How effectively are the rules enforced? Strongly () Fairly () Not enforced ()

Section (III): E-Waste Management:

- 1- What volume of electrical/electronic waste do you handle?.....
- 2- Indicate the volume of reusable, recyclable and residue from your work
- 3- What have you done with the electronics that you no longer use?
Kept in Home () Given/Sold to a Personal Contact () Sold to Informal System ()
Sold to Formal System () Trash ()
- 4- Do you recover any of the electrical/electronic equipment/components from waste?
Yes () No ()
If yes,
 - Which equipment? PC () Laptop () TV () Mobile phone ()
 - Which component do you recycle/recover
Circuit board () Battery () Plastics () Iron () Copper ()
Aluminium () Others (please specify).....
- 5- What do you do with the recovered equipment/components?
Sell to repairers () Sell to recyclers () Reuse ()

Section (IV): Impact of E-Waste on Environment:

- 1- Are you aware of any health risks associated with electronic wastes? Yes () No ()

- 2- Are you aware of local programs, projects or activities pertaining to electronic waste management? Yes () No ()
- 3- Are you aware of recycling/trading fairs for electronic wastes? Yes () No ()
- 4- How informed are you about the environmental issues in your local area?
Very Informed () Somewhat Informed () Not Informed ()
I do not care about them at all
- 5- Are you concerned about your environment?
Not concerned () Barely concerned () Concerned () Very concerned ()
- 6- Do you know that some components of electronic devices contain toxic/hazardous materials?
Yes () No ()
- 7- Are you aware that these toxic/hazardous materials require special treatment for environmentally sound disposal? Yes () No ()
- 8- Does the disposal/treatment method in use for electronic waste have any impact on the environment? Yes () No () Not sure ()
- 9- If yes, indicate the part(s) of the environment affected and rate the impact

Parts of environment affected	Impact			
	Very strong	Strong	Fairly	No effect
Land				
Air				
Surface water				
Underground water				
Vegetation				

Appendix B: Questions for Municipality of Taima Region.

Please let us know about your perceptions on the e-waste. Please read the following prior to answering questions.

- 1- Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?
 - No ()
 - Informal Service ()
 - Formal Service ()
- 2- Do you see any hazards or risks to the growing amount of e-waste in Tayma ?
 - No ()
 - Yes, but no specific information ()
 - Yes, Toxicity or Safety Hazard ()
 - Yes, Environmental Problem ()
- 3- Do you know of any electronic waste management policies currently implemented in Tayma ?
Yes () No ().
If yes, What are the current policies in place for e-waste management that span across KSA?
- 4- Are there flaws to these policies? Yes () No ()
- 5- What is your perception of public awareness of the regulations in place for e-waste, and for the control of exposure to hazardous chemicals? Yes () No ()
- 6- Are people aware of the hazardous chemicals found in e-waste? a. If yes, who informs them? b. If no, what is the best way for creating mass awareness?
- 7- Do you think it would be viable to support the unorganized sector's role in waste management (while providing for safer practices)? Yes () No ()
- 8- How well have companies and the general population complied with electronic waste management policies?
- 9- How much of a priority is this issue at the government level? At the individual level?

- 10- How much should the public and government prioritize e-waste management, relative to other public issues?

Appendix C: Questions for Health Sector, Ministry of Health, Taima Region.

Please let us know about your perceptions on the e-waste. Please read the following prior to answering questions.

1. Do you know someone or company who can collect your unused electronics for reuse, reselling, recycling, or dismantling?
 - No ()
 - Informal Service ()
 - Formal Service ()
2. Do you see any hazards or risks to the growing amount of medical e-waste and others in Tayma ?
 - No ()
 - Yes, but no specific information ()
 - Yes, Toxicity or Safety Hazard ()
 - Yes, Environmental Problem ()
3. Do you know of any medical e-waste and others management policies currently implemented in Tayma ? Yes () No ().
If yes, What are the current policies in place for e-waste management that span across KSA?
4. Are there flaws to these policies? Yes () No ().
5. What is your perception of public awareness of the regulations in place for medical e-waste and others, and for the control of exposure to hazardous chemicals? Yes () No ().
6. Are people aware of the hazardous chemicals found in medical e-waste and others? a. If yes, who informs them? b. If no, what is the best way for creating mass awareness?
7. Do you think it would be viable to support the unorganized sector's role in management of medical e-waste and others (while providing for safer practices)? Yes () No ().
8. How well have companies and the general population complied with medical e-waste and others management policies?
9. How much of a priority is this issue at the government level? At the individual level?
10. How much should the health sector prioritize for management of medical e-waste and others, relative to other public issues?

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