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Apprise of Used Electrical and Electronic Equipment in Residential Houses of Citizens of Yazd City and Determination of Their Knowledge, Attitude and Practice Regarding Electronic and Electrical Waste Management

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ABSTRACT

Introduction: The production of Waste Electrical and Electronic Equipment (WEEE) has grown rapidly in recent years. It is necessary to determine the amount of them for its effective management. The aim of this study was to determine the amount of WEEE stored in the houses of Yazd citizens and the level of Knowledge, Attitude and Practice (KAP) of citizens regarding WEEE management.

Materials and Methods: This descriptive, cross-sectional study was carried out using random sampling on 300 Yazdian citizens. To determine the amount of WEEE stored in houses and the level of KAP of people regarding WEEE, was used a researcher-made questionnaire whose validity and reliability were confirmed and data analysis was performed using nonparametric tests in SPSS.

Results: The amount of WEEE in the study population was 21.8 metric tons was obtained. Of these, the highest amount of waste was related to the refrigerator with 3.9 metric tons and the highest number of used equipment stored was related to cell phone, with 285 units. The levels of knowledge (with a mean score of 5.06 ± 2.5), attitude (with a mean score of 43.37 ± 5.21), and practice (with a mean score of 10.71 ± 2.95) were respectively in moderate, good and moderate conditions.

Conclusion: Given planning by the Waste Organization leads to job creation, access to valuable raw materials, and environmental protection. With increasing knowledge about the proper use of electronic and electrical equipment, their useful life can be increased and the process of their conversion to waste can be extended.

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Introduction

Consumer's demand, change in lifestyle and of technological development have increased the consumption rate of electronic and electrical products [1], and reduction in lifespan of most electronic and electrical products has steadily increased the amount of waste produced from these products in recent decade [2]. In 2016, the production of WEEE has grown by over 8% compared 2014, with more than 44.7 million metric tons of WEEE produced worldwide, over 76% of which are stored in houses [3], which has a lower danger. Recycling

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these types of wastes is the best management method because their burning generates and releases carcinogenic dioxin gases and its eruption into the atmosphere and burying or accumulating them in the environment, if they are broken, leads to the penetration of their toxic substances into groundwater aquifers [4]. For example: The cell phone contains over 40 elements, and about 12 of them are considerid hazardous substances that, if not handled properly, have potential threat to humans and the environment, so that the content in a cadmium battery of a cell phone can pollute about 600 m^3 water [5], and enter the food chain by accumulating in the tissues of plants and animals, which causes certain diseases such as disorders affecting reproductive system, nervous system, and circulation, pulmonary, gastrointestinal, and renal diseases as well as osteoporosis, poisoning, and various types of cancers [4] . If the electronic waste is recycled by appropriate methods, then several metals can be extracted so that from a ton of cell phone waste, 150-300 gr of gold can be obtained, while in gold mines from 1 metric ton ore 20-30 gr of gold is obtained [6]. In 2016, around 435,000 metric tons of wasted mobile phones was generated in the world, that the value of raw materials in wasted mobile phones was about 9.4 billion € [3]. In recent years, few studies have been conducted to investigate KAP regarding the WEEE. For example, Mehrabian [7] investigated citizens' awareness and attitudes toward electronic waste and its management in Kerman, and concluded that most citizens did not have knowledge about electronic waste, but their attitude was high. A study was conducted by Rahmani et al. [8] on estimates of waste electronic equipment that indicated that 20 million wasted computers until 2016 and 39 million wasted cell phones until 2014 in Iran. The statistics show that 20 million metric tons of waste is produced in Iran [9] every day but at the same time, there are no accurate data on the amount of electronic and electrical wastes on a daily basis in Iran, including Yazd [10] with a production of household waste of 350 metric tons per day, Unfortunately, there is no data on the amount of WEEE, because did not exist any management and since the study of KAP regarding waste management and recycling is the most important method to study public interest and the participation of public groups in waste management programs [11] , increasing knowledge and attitudes of the people will improve their practice and the level of their improvement [12] . Therefore, given the importance of the issue of WEEE, the present study, sought to determine the amount of the WEEE in the houses of citizens, as well as the level of their KAP regarding WEEE, as a set that plays an important role in reducing and increasing the production of these wastes in order to help develop a good and suitable management program for the management of the WEEE.

Materials and Methods

In this descriptive cross-sectional study conducted in 2017, the study population consisted of Yazd citizens, The sample size was determined to be 300 using the formula $n = (z_1\text{-}\alpha/2)^2/d^2$, confidence level of 0.95, SD of 3.12 for practice score, and 1-point error [13] . Using a random convenience sampling method, 300 households in Yazd were selected to determine the amount of electronic and electrical waste stored in urban residential houses and their KAP regarding WEEE in 2017. For this purpose, among 22 health centers in Yazd, 10 urban centers, and from each center, 30 households were randomly selected and questionnaires distributed among them. It should be noted that self-report questionnaire was completed and the respondents were allowed one month to complete the questionnaire. The data collection instrument was a researcher-made questionnaire whose validity was assessed by environmental health and health education professors and whose reliability in a pilot study where Cronbach's alpha (α) was obtained 0.713 for attitude [14], and correlation coefficient $r < 0.4$ for knowledge and practice [15] is confirmed. The questionnaire consisted of 60 items divided into five sections including demographic information with 6 items (age, gender, marital status, occupation, educational level, and household income), knowledge with 9 items (correct answer scored 1 and wrong answer scored 0), attitude with 12 items (rated on a five-point

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Likert scale ranging from Absolutely disagree scored 1 to Absolutely disagree scored 5 [16]), practice with 10 items (the answer indicating the best practice scored highest and other practices scored comparatively lower and lower depending the level of their importance), and the table of the amount and type of stored waste (23 items of household electrical and electronic equipment). After data collection, statistical analysis was performed in SPSS using descriptive statistics and non-parametric tests Mann-Whitney, Kruskal-Wallis, and Spearman's correlation coefficients, taking into account the significance level of 0.05 [13]. To determine the levels of the scores of knowledge, attitude, and practice, 33.3% or less of the score was considered undesirable (poor), 33.4-66.6% moderate, and 66.7-100% desirable (good) [17].

Ethical issues

This study was conducted with the approval of Shahid Sadoughi University of Medical Sciences and Health Services, Medical Ethics Committee. Code: IR. SSU. SPH.REC.1396.57

Results

The amount of WEEE in the houses of citizens of Yazd, which has been stored within several years, is presented in detail in Table 1. The total number of electronic and electrical equipment was 1,653 unit in the studied samples, 869,128 unit of which were obtained in Yazd in 2017, and according to the mean weight of equipment [18], the total amount of WEEE in the city was obtained approximately 11470 metric tons. According to the census of 2017 [19], the population of Yazd and the number of households were reported to be 530,000 and 3/6, respectively. Therefore, the amount of the stored WEEE per house was obtained 72.7 kg.

Table 1: Frequency and quantity of worn-out electronic and electrical equipment in residential houses

Row	Types of equipment in study samples	The number of worn-out items			The number of worn-out items in city	Mean weight (kg)	The amount of stored waste electrical and electronic equipment (WEEE) (kg)
		Minimum	Maximum	Total			
1	Cell phone	1	5	285	149851	0.1	14985.1
2	Computer	1	3	90	47321	29.6	1400702
3	Table telephone	1	4	99	52053	0.3	15615.9
4	Radio and tape recorder	1	2	87	45744	10	457440
5	Television	1	3	85	44692	30	1340760
6	Refrigerator	1	2	53	27867	75	2090025
7	Freezer	1	2	37	19454	75	1459050
8	Oven	1	3	48	25238	3.18	913110.8
9	Washing machine	1	2	48	25238	40	1009520
10	Dishwasher	1	2	14	7361	41	301801
11	Microwave	1	1	19	9990	18.5	184815
12	Vacuum cleaner	1	2	46	24186	7.4	178976.4
13	Iron	1	3	66	34702	1.4	48582.8
14	Meat grinder	1	2	38	19980	5.5	109890
15	Electric heater	1	3	23	12093	4.8	58046.4
16	Coffeemaker	1	3	18	9464	2.3	21767.2
17	Tea maker	1	3	25	10515	3.3	34699.5
18	Toaster	1	1	14	7361	6.5	47846.5
19	Fryer	1	1	15	8886	4.8	37852.8
20	Air conditioner	1	3	40	21031	80	1682480
21	Battery	1	20	263	138283	0.025	3457.075
22	Handycam	1	4	35	18402	0.22	4048.44
23	Different types of electric toys	1	20	210	110416	0.5	55208
24	Total	-		1653	869128	-	1147067.915

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According to Figure 1, the largest number of stored used equipment was obtained for cell phone, with a 17% proportion.

According to Figure 2, the refrigerator has the highest amount of used equipment with a proportion of 18%.

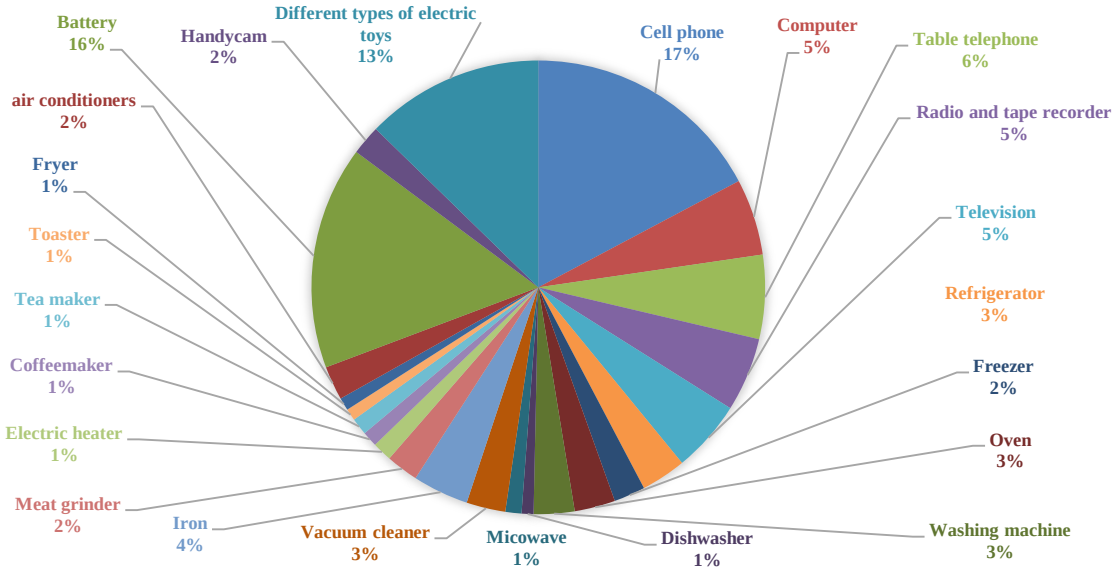

Figure 1: Comparison of the number of Waste Electrical and Electronic Equipment stored by the studied citizens

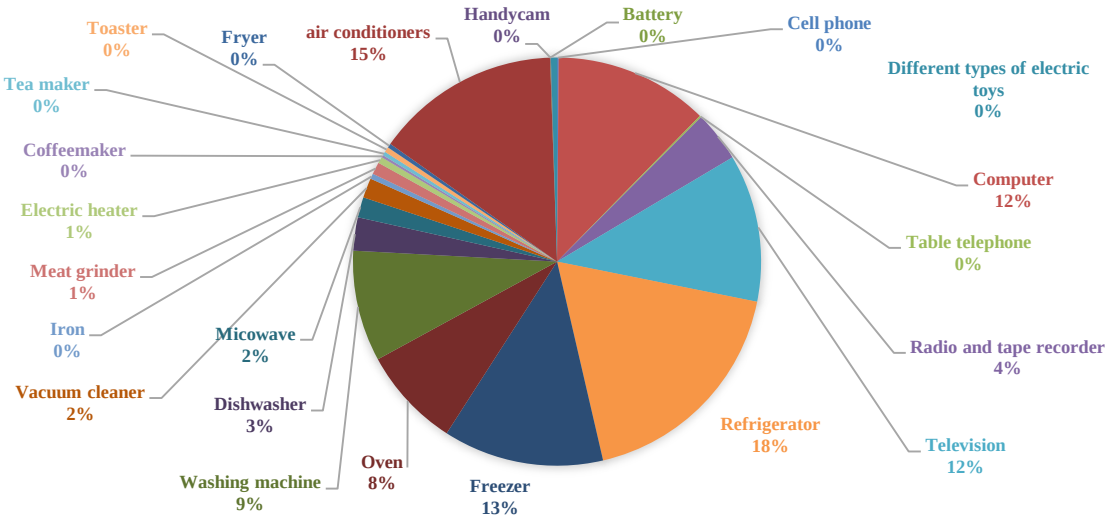

Figure 2: Comparison of the weight of different types of Waste Electrical and Electronic Equipment stored by the studied participants

Using the statistics [3] released by the United Nations University (UNU), the amount and value of raw materials extracted from the WEEE were determined, and given the same composition of wastes in Yazd and those produced across the world, the amount and value of WEEE in Yazd were estimated (Table 2).

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Table 2: The value of the raw material in the Waste Electrical and Electronic Equipment (WEEE) in the houses of the studied citizens

Materials	Per 1 metric ton waste	The value of 1 kg (euro)	The amounts of materials in the city's WEEE	The total value of the materials in the city's WEEE (euro)
Fe	364.27	0.2199	4178458.189	919194.0818
Cu	48.4116	4.4	555314.3476	2443999.005
Al	55.3020134	1.45	634351.6944	919963.9257
Ag	0.0357942	552.5	410.5838	226847.5556
Au	0.0111856	37680	128.3064	4834586.556
Pd	0.0044743	16845	51.3232	864540.3677
Plastic	273.6017897	1.23	31338398.554	3860255.883
Total	-	-	-	14069387.37

In sum, the overall WEEE value in the houses of Yazd citizens was 14 million euros.

Regarding scores on knowledge items, individuals attained a mean score of 5.06 ± 2.05 (minimum and maximum scores attained by the individuals 0 and 10, respectively) and a score level of 38.92%, which was moderate. In general, 40% of the people had poor knowledge, 54% had a moderate level of knowledge, and 6% had good knowledge. In the attitude section, individuals attained an average score of 43.37 ± 5.21 (minimum and maximum scores attained by the individuals 22 and 58, respectively) and a score level of 72.28%, which is desirable. In other words, 21% of the people had a moderate attitude and 79% had a good attitude. In the practice section, the individuals attained a mean score of 10.71 ± 2.95 (maximum and minimum score attained by the participants 20 and 3, respectively) and a score level of 51%, which is moderate, with 12.3% people having poor practice, 75% moderate practice, and 12.7% good practice.

In addition, based on Spearman's correlation test, there was a positive correlation between the level of knowledge and attitude (r = 0.382) and practice (r = 0.228) of people.

Based on the findings of this study, the level of knowledge (p = 0.043) and attitude (p = 0.001) in the age group of 36-57 years was significantly higher than others, while the age group of 58-75 years had the most practice level (p = 0.00). There was no statistically significant relationship between gender and knowledge (p = 0.555), attitude (p = 0.178), and practice (p = 0.179). There was not a significant relationship between marital status and knowledge (p = 0.159), but marital status was significantly associated with attitude and practice (p = 0.007, p = 0.037, respectively), so that the marrieds attained the highest score. There was a statistically significant relationship between occupation and knowledge level (p = 0.012), so that clerks and students had the highest and lowest levels of knowledge, respectively, while this variable was not statistically correlated with attitude and practice of individuals (p = 0.232 and 0.518, respectively). There was a significant relationship between the level of education of people and their knowledge level (p = 0.001) and attitude (p = 0.007), so that people with master's degree and higher degrees and those with education level under high school diploma had the highest and lowest levels of knowledge, respectively, and the people with master's degree and higher degrees and illiterate people had the highest and lowest levels of attitude, respectively. There was also a significant relationship between household economic status and attitude (p = 0.036), so that people with a good economic situation had the highest attitude, but the association of household economic status with knowledge (p = 0.144) and practice (p = 0.278) was not statistically significant.

Discussion

The aim of this study was to determine the amount of WEEE stored in the residential houses in Yazd and the level of KAP of Yazd citizens

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regarding WEEE management. Based on the results, the total weight of WEEEs stored in Yazd citizens' houses was 11470 metric tons. The main reason for this finding is storage of WEEE within a few years. In 2009, the WEEE collected in Romania [20] was 38,700 metric tons and in Italy [20], the amount of waste collected was 65,000 metric tons in 2008, and the amount of waste generated in 2011 in Ahvaz, Iran [18] has been estimated at 9552.25 metric tons.

Cell phone

Today, with the advent of technology and the production of various and interesting cell phones and, on the other hand, its short lifespan, author the consumption access of this product and there upon lead high production of its waste. The broken-down cell phones number in Yazd was 149,851 unit, while in Alavi's study [18] in Ahvaz, 250,000 disabled cell mobile were predicted for 2011, and in Rahmani's study [8] , the number of cell phones for Iran in 2014 was estimated at 39 million units and in Kim's study [21] in South Korea in 2010, there was 17 million units obsolete cell phone. The share of used cell phones used per one individual in the houses was 28.27 gr. In the study of Alavi [18], the share of used cell phone per one individual was 25 gr in Ahvaz. The reason for the high amount of this type of waste is the use of the majority of family members, which, due to their short life, increases the use of cell phones that people tend to maintain for various reasons, including maintaining personal information.

Computer

Computers are used by people for ease and accuracy in doing things for a variety of applications, such as: training, business, and entertainment, and after the end of their useful life, they are out of stock and some of their users will store them at home, and the amount of broken-down computers stored in this study was 1,400 metric tons. In the study of Steubing [22] in Chile, the amount of this waste was estimated at 10 and 20 kilotons for 2010 and 2020, respectively.

Fixed-line telephone

The amount of used Fixed-line telephones in Ahvaz [18] has been estimated at 10 metric tons for 2011, while in the present study the amount of this type of waste was 15.6 metric tons. The reason of the high amount of storage is the use of a high number of telephones at home.

Household appliances

One of the major sources of WEEE are household appliances. In this study, household appliances such as refrigerators, freezers, air conditioners, washing machines, and microwaves were studied. Information on the number and amount of these wastes is shown in Table 1. According to Table 1, the refrigerator, followed by air conditioners, accounts for the highest amount of stored WEEE due to its high volume and weight, while in Alavi's study [18], according to the prediction model, the highest WEEE production was related to air conditioner and refrigerator. Most numbers in WEEE stored was radio and tape recorders, and followed by TVs.

Battery

In any house, the number of batteries is high due to the use of remote controls for audio and video equipment, watches, and different types of toy. Alavi [18] estimated the production of worn-out batteries to be 147 metric tons in 2011, while Yazd citizens stored 45.3 metric tons batteries in their houses. This low amount is likely to be due to battery high excrete, and being collected along with MSW and then transferred to the landfill.

Knowledge, Attitude and Practice (KAP)

According to the results, the level of knowledge increased with increasing levels of education, which emphasizes the importance of training and raising the level of knowledge of individuals through educational programs. There was a significant relationship between occupation and knowledge level and the highest level of knowledge was obtained for clerks, which could be due to information interaction between them. The attitude was evaluated as positive in this study, so that 79% of the people had a good attitude and the clerks and the housewives had the highest attitude.

The practice of over half of the citizens in our study was moderate so that the workers and self-employed people had the highest and lowest

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practice, respectively, and most likely, this high practice score is due to the fact that workers, given their economic status, use the broken-down electronic and electrical equipment after repair, and provide second-hand goods for their houses. However, there was no significant relationship between the practice of individuals and their occupations. In this study, 36.7% of the samples reported that they discarded their electronic wastes as waste, but in the study of Ghorbanpor [4] in the field of electronic waste management, 16.3% of companies said that computers were themselves waste. The high percentage of the study is due to the high number of study samples and the number of wastes. Rahmani et al. [8] concluded in their study that 47.1% of Iranians use a cell phone for up to two years, but in the present study, only 15% of Yazd citizens use a cell phone for a shorter time, representing the good condition of Yazd city relative to the whole country. It is noteworthy that in some cases, practice was not consistent with the degree of knowledge of individuals, including the method of disposal of low-energy bulbs due to lack of collection program for this type of waste.

In this study, attitude and practice of married were significantly higher than those of single ones, while the levels of knowledge, attitude, and practice in the men and women were almost equal.

Conclusion

Given the high amount of waste stored in the households of Yazd citizens, it can be concluded that they have stored a high amount of WEEE, and this amount has been stored for several years, and the Waste Organization can inform the people and create certain locations in the city to collect the WEEE and to pay money or discount voucher for these types of wastes, according to their amount, for purchase of household appliances. In addition, given the low level of knowledge and practice of citizens in the management of WEEE and, on the other hand, the threats to human and environmental health, it seems that a training program through mass media, manufacturing companies, and suppliers can be of great help in raising the knowledge and practice of the people, because knowledge about the proper use of electronic and electrical equipment trepan increase the useful life of the products and consequently reduces the production of this type of waste.

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Conflict of interest

We have no competing interests.

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