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THE KNOWLEDGE LEVELS AND OPINIONS OF ACADEMICS FROM KARADENIZ TECHNICAL UNIVERSITY VOCATIONAL SCHOOLS, ENGINEERING AND TECHNOLOGY FACULTIES REGARDING ELECTRONIC WASTES AND THEIR EFFECTS ON HUMAN AND ENVIRONMENTAL HEALTH

Karadeniz Teknik Üniversitesi Meslek Yüksek Okulları, Mühendislik ve Teknoloji Fakülteleri akademisyenlerinin elektronik atıklar ve bu atıkların insan ve çevre sağlığına etkileri hakkındaki bilgi düzeyleri ve düşünceleri

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Abstract

The useful life of electrical and electronic devices is rapidly ending, there is a rapid transition to new products, and a new type of waste known as electronic waste (e-waste) emerges. The aim of this study was to examine the knowledge and opinions of academics concerning e-waste regulations in Turkey and the effects of e-waste on human and environmental health. This study involved 267 academics working at Karadeniz Technical University. An online questionnaire consisting of 50 questions was used for data collection. The Mann Whitney U, Kruskal Wallis, Pearson chi-square, Fisher's Exact test, and Spearman correlation were used for statistical analysis. Analysis showed that 45.3% of the participants reported not paying attention to the recycling, with 90.1% of those being unaware of the procedures involved. Only 4.9% of the participants had received education concerning e-waste. Participants who had received such education registered significantly higher mean total knowledge scores concerning e-waste regulations and the effects of e-waste on human and environmental health than those with no such education ($p<0.001$). Mean total knowledge scores were significantly higher among participants who paid attention to the recycling ($p<0.001$). Few participants have received education on e-waste, about half of them don't pay attention to recycling and a large part of those who don't pay attention are unaware of the relevant procedures. The high mean of knowledge scores among participants who paid attention to e-waste and contributed to recycling reveals the importance of policies and education programs aimed at increasing individual awareness and producing desired behaviors.

Keywords: Electronic waste, environmental health, public health, recycling.

Özet

Elektrikli ve elektronik cihazların kullanım ömürleri hızlı dolmakta, yeni ürünlere hızlı geçiş olmakta ve elektronik atık (e-atık) olarak bilinen yeni bir atık türü ortaya çıkmaktadır. Çalışmanın amacı, akademisyenlerin ülkemizdeki e-atık düzenlemeleri ile e-atıkların insan ve çevre sağlığına etkileri konusundaki bilgi ve düşüncelerini incelemektir. Bu çalışma Karadeniz Teknik Üniversitesi'nde görev yapan akademisyenler üzerinde gerçekleştirilmiş ve çalışmaya 267 akademisyen dahil edilmiştir. Veri toplamak için 50 sorudan oluşan çevrimiçi bir anket kullanılmıştır. İstatistiksel analiz için Mann Whitney U, Kruskall Wallis, Pearson ki-kare, Fisher's Exact Test ve Spearman korelasyon analizi kullanılmıştır. Katılımcıların %45,3'ü e-atık geri dönüşümüne dikkat etmediğini, e-atık geri dönüşümüne dikkat etmeyenlerin ise %90,1'i ülkemizdeki uygulamaları bilmediğini belirtmiştir. Katılımcıların sadece %4,9'u e-atık konusunda eğitim almıştır. Eğitim alanların ülkemizdeki e-atık mevzuatı ve e-atıkların insan ve çevre sağlığına etkileri konusundaki toplam bilgi puan ortalamaları eğitim almayanlara göre istatistiksel olarak önemli bir şekilde yüksek bulunmuştur ($p<0,001$). Benzer şekilde, e-atıkların geri dönüşümüne dikkat edenlerin toplam bilgi puan ortalaması geri dönüşüm konusuna dikkat etmeyenlere göre önemli bir şekilde yüksek bulunmuştur ($p<0,001$). Çok az katılımcı e-atık konusunda eğitim almış olup katılımcıların yaklaşık yarısı geri dönüşüme dikkat etmemektedir ve geri dönüşümüne dikkat etmeyenlerin büyük bir bölümü uygulamaları bilmemektedir. E-atık konusuna önem veren ve geri dönüşüme katkı sağlayanların bilgi puanlarının yüksek olması, bireysel farkındalığı artırmak ve istendik yönde davranışları oluşturmak için uygulanacak politikaların ve eğitim programlarının önemini ortaya koymaktadır.

Anahtar kelimeler: Çevre sağlığı, elektronik atık, geri dönüşüm, halk sağlığı.

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Introduction

Urbanization and industrialization taking place in many developing countries have led to an increase in electrical and electronic devices. These are becoming indispensable part of life as technology advances. In addition, for reasons such as a desire for luxury products and ostentation, lack of knowledge concerning product use or uniformed use, high repair costs, and a short service life, the transition to new products is a rapid one. The wastes originating from end-of-life electrical and electronic devices, known as e-waste, are therefore becoming a rapidly growing global problem (1-3).

"Electronic waste" or "e-waste" for short is a generic term embracing various forms of electric and electronic equipment that have ceased to be of any value to their owners. In many country regulations, the definition in Directive of the European Parliament and the Council on Waste Electrical and Electronic Equipment has been adopted (4). Similarly, in the Turkish Regulation on the Control of Waste Electrical and Electronic Equipment, which came into force after publication in the Official Gazette (no. 28300 dated 22/5/2012), electrical and electronic equipment (EEE) is defined as: "Devices designed for use not exceeding 1000 volts with alternating current and 1500 volts with direct current, which are dependent on electric current or electromagnetic field for proper operation, and devices for the generation, transfer and measurement of these currents and fields". E-waste refers to EEEs that are discarded after the end of their useful life due to being old, unattractive, or broken (5). Components of EEE, such as batteries, circuit boards, plastic casings, cathode-ray tubes, activated glass, and lead capacitors, are also classified as e-waste (5, 6).

The "Global E-Waste Monitoring Report 2020" reported that the total amount of e-waste in 2019 was 53.6 million metric tons (Mt) and 7.3 kg/person. Only 17.4% of these wastes are recycled using appropriate methods and procedures (7).

EEEs contain numerous harmful components such as heavy metals and flammable chemicals. If these devices are not recovered or disposed of properly once they have completed their useful life, they can damage both the environment and human health (8). Heavy metals are elements that cannot be metabolized by the body and that eventually escape from its detoxification pathway and damage the cardiovascular system, immune system, nervous system, respiratory system, reproductive system, urinary system, skeletal and muscular system, DNA synthesis, gene/protein expression, and chromosome/telomere structures (9). In addition, in contrast to organic pollutants, heavy metals are non-degradable, meaning that they cannot be converted into less hazardous end-products (10). Dioxin and furan, produced by the combustion of chlorides and bromides frequently used in the plastic components of e-waste, escape into the air and pose a subsequent threat to human health (11).

When e-waste is not disposed of or recycled using appropriate methods, these heavy metals and hazardous chemicals (such as lead, mercury, and cadmium) mix with the soil, groundwater, and air and result in the deterioration of the structures of natural resources. Inappropriate e-waste recycling also leads to serious harmful changes in the natural mineral structure of the soil (12).

One of the most important steps in reducing the effects of e-waste on human and environmental health is to prevent and limit different types of e-waste at source. Examining individuals' levels of knowledge, attitudes, and behaviors in this area and determining the current situation will enable action plans to be implemented. The aim of this study is to examine the knowledge and opinions of academics, themselves members of the society that consumes these electronic products and who also work in close contact with a wide variety of electronic products, about e-waste regulations in Turkey and the effects of e-waste on human and environmental health.

Material and Method

The population of this descriptive study consisted of 331 academics. No sampling was performed, and we aimed to contact the entire population. Table 1 shows the number of academics in the university's faculties/departments/vocational schools and the proportions of those who participated in the research.

Table 1: Numbers of academics in faculties/departments/vocational schools and the proportions of those who participated in the research.

Faculties/Departments/ Vocational schools	Total number of academics	Research participants	
		n	%
Computer Engineering	24	24	100.0
Industrial Engineering	11	11	100.0
Metallurgy and Materials Engineering	14	13	92.8
Machine Engineering	35	31	88.6
Trabzon Vocational School	17	15	88.2
Map Engineering	25	21	84.0
Faculty of Technology	36	30	83.3
Electrical electronics Engineering	37	30	81.1
Mining Engineering	21	17	80.9
Arsin Vocational School	10	8	80.0
Geophysical Engineering	16	12	75.0
Civil Engineering	40	29	72.5
Geological Engineering	24	16	66.7
Sürmene Abdullah Kanca Vocational School	21	10	47.6
Total	**331**	**267**	**80.7**

Due to the COVID-19 pandemic, teaching in Turkish universities was conducted by means of distance education between May and August 2021, when the study was carried out. Face-to-face data could not therefore be collected since the academics were either working remotely or on a rotating basis. The online survey method was therefore adopted. The questionnaire was sent out via the university information management system in e-mail form, in line with the permission obtained from the Karadeniz Technical University Rector's Office (decision no. E-44710342-044-12687 dated 10.03.2021). Participation in the study was on a voluntary basis, and all participants who voluntarily answered the online questionnaire were included in the study.

The questionnaire was produced following a search of the literature by the researchers and consisted of 50 questions in four sections. The first part contained eight questions concerning the participants' sociodemographic and personal characteristics (gender, age, marital status, the individual members of the household, total number of household members, which faculty/department/vocational school they worked in, their academic title, and monthly income). The second part contained 10 questions evaluating the current situation regarding e-waste (whether participants had e-waste that they had not actively used or were not intending to use in the previous year at home or in premises owned by them, what these devices were, if applicable, what they did with EEEs that had become unusable or that they did not wish to use at home or at work, and the reasons for the emergence of an increase in e-waste). The third part consisted of 14 questions aimed at evaluating participants' state of knowledge concerning the legislation on e-waste in Turkey. Finally, the fourth part contained 13 questions evaluating academics' knowledge of the effects of e-waste on human and environmental health, two questions investigating receipt of education about e-waste and whether they shared information about e-waste within the courses/applications for which they were responsible, and three concerning how the participants evaluated themselves in terms of paying attention to e-waste and the reasons for paying or not paying attention. One point was awarded for each correct response to the questions in the third part about the e-waste regulations in Turkey and the questions in the fourth part about the effects of e-waste on human and environmental health.

Total possible scores from those two sections ranged between 0 and 26. However, in the analysis, the scores were converted into a 100-point system. The higher the score achieved, the higher that participant's level of knowledge about e-waste regulations in Turkey or the effects of e-waste on human and environmental health.

Before starting the research, approval was obtained from the Scientific Research Ethics Committee of the Karadeniz Technical University Faculty of Medicine (decision no. 24237859-356 dated 15.04.2021).

IBM SPSS v 23.0 was used for statistical analysis. Descriptive statistics and numbers and percentages were employed for categorical variables; mean, standard deviation, minimum and maximum values for numerical variables. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to test normality of distribution. The Mann Whitney U test and Kruskal Wallis analysis of variance were used in the analysis of non-normally distributed measurement variables. Pearson chi-square and Fisher's Exact test were used in the analysis of categorical data. Spearman correlation analysis was performed to evaluate correlations between non-normally distributed numerical variables. p values <0.05 were regarded as significant for all analyses.

Results

Two hundred sixty-seven individuals took part in the study, 58.1% (n=155) of whom were men, and 27.0% (n=72) of whom were research assistants. The mean age of the participants was 36.1±10.0 years (22-66). Various socio-demographic characteristics of the participants are shown in Table 2.

Table 1: Socio-demographic characteristics of the participants (n=267).

Characteristics	n	%
Gender		
Female	112	41.9
Male	155	58.1
Age (Years)		
Mean ± SD (min-max)	36.1 ± 10.0 (22-66)	
Marital status		
Married	119	44.6
Single	148	55.4

Family structure		
Nuclear family	223	83.5
Living alone	27	10.1
Extended family	17	6.4
Academic title		
Research assistant	72	27.0
Instructor	57	21.3
Associate professor	51	19.1
Doctor lecturer	47	17.6
Professor	40	15.0

The participants were asked whether there was any e-waste that they had not actively used/did not intend to use in the previous year at home or in a premises of their own. One hundred sixty-three (61.0%) participants stated that they had information and telecommunication equipment. Other available EEEs are shown in Chart 1.

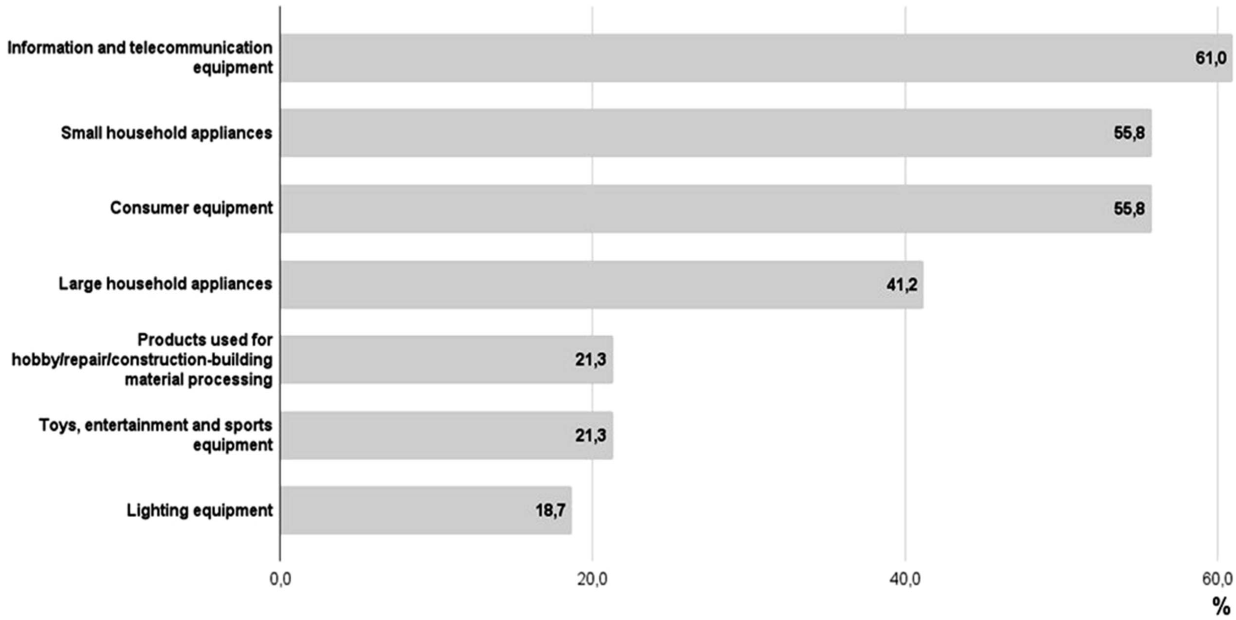

Chart 1: The current status of the participants about e-waste that the participants have not actively used/which do not consider to use in the last one year(n=267)

The participants were also asked about the reasons for the emergence of an increase in e-waste. One hundred ninety-nine (74.5%) reported that this was due to rapid developments in technology, 51.7% (n=138) considered that people were insufficiently informed about e-waste, and 46.4% (n=124) attributed it to people buying these technological products for purposes of ostentation.

When asked about the regulation regarding e-waste in Turkey in terms of the legislative hierarchy (on a spectrum from laws to local regulations), 55.1% (n=147) of the participants gave the correct answer. Analysis revealed no statistically significant differences in terms of academic title, being received education on e-waste, giving information about e-waste in the courses for which participants were responsible, or paying attention to e-waste recycling (p values 0.299, 0.292, 0.084. and 0.403, respectively).

A number of propositions were listed in order to determine participants' levels of knowledge concerning e-waste legislation in

Turkey. The proposition that “Manufacturers are obliged to provide information on the adverse effects of hazardous substances in electrical and electronic products on the environment and human health in order to enable consumers to contribute to waste collection systems” received the highest proportion of correct responses (76.8%). The propositions in the third part of the questionnaire and the proportions of participants whose answers were correct are shown in Figure 1.

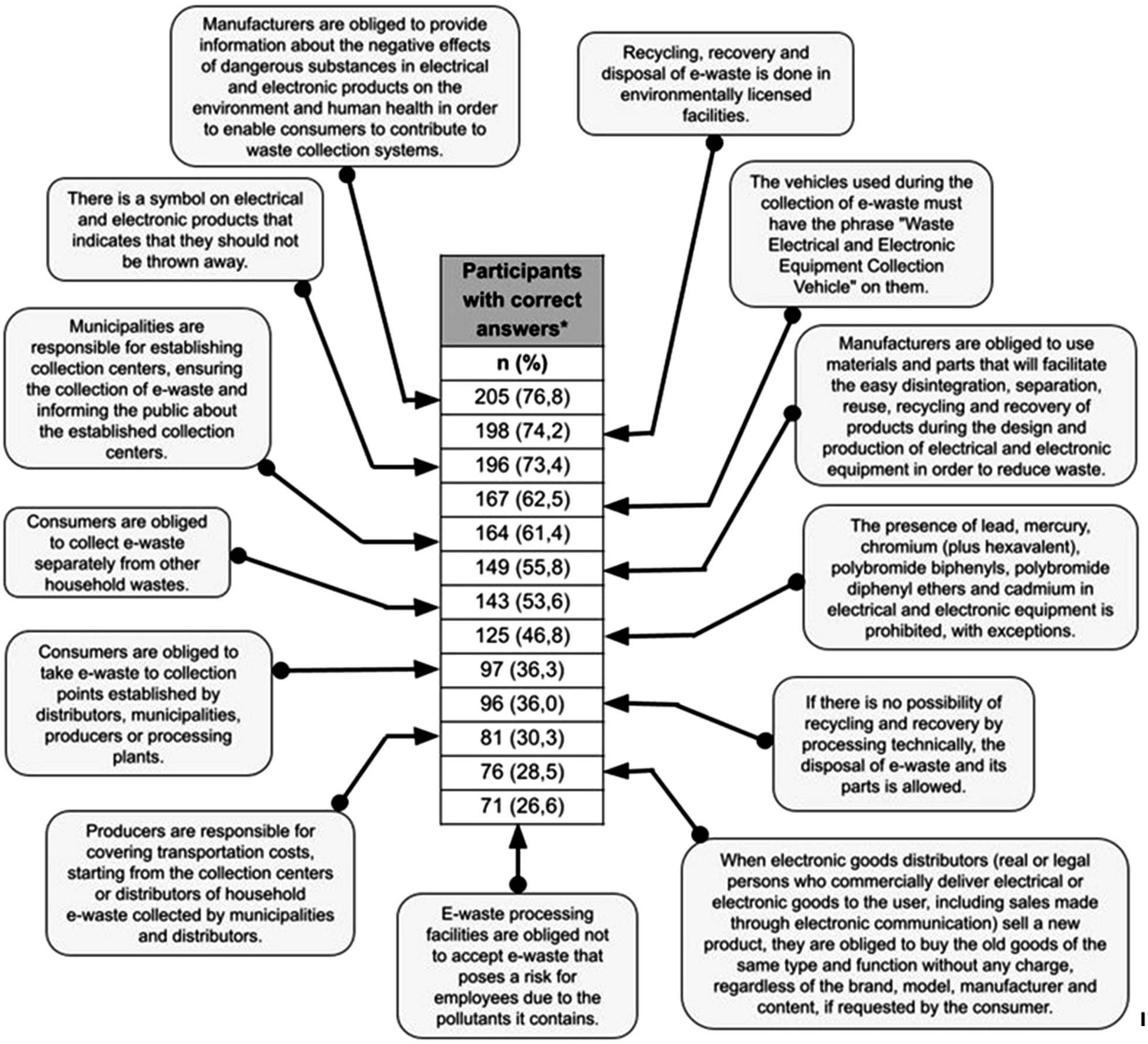

Figure 1: Provisions in the legislation regarding e-waste regulations in Turkey and numbers of participants giving correct responses (n=267).
*Who correctly selected the “true” option for all questions.

A number of statements were also given in order to evaluate participants’ knowledge levels about the effects of e-waste on the environment and human health. The statement “Metals such as lead, mercury, cadmium, chromium found in e-waste carry the risk of contaminating drinking water sources by leaching from the soil and reaching groundwater” attracted the highest proportion of correct responses (86.5%). All statements in the fourth part of the questionnaire and the proportion of participants whose responses were correct are shown in Figure 2.

Analysis revealed that 4.9% (n=13) of the participants had previously received education on the subject of e-waste and that 18.7% (n=50) gave information about e-waste in the theoretical courses or practical training for which they were responsible.

The participants were asked “How do

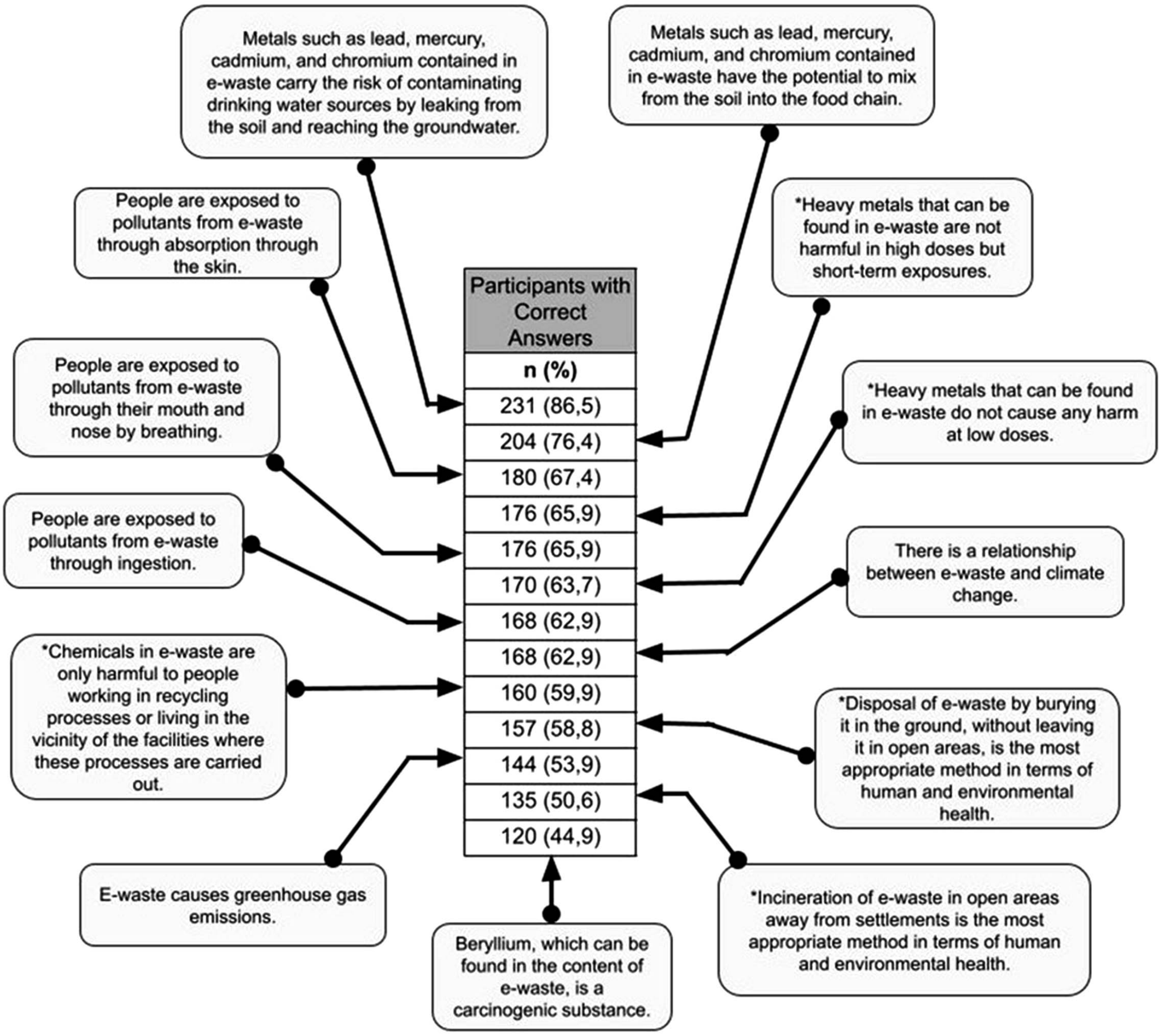

Figure 2: Statements about the effects of e-waste on human and environmental health and the distribution of the participants' responses (n=267).
*Who correctly selected the "False" option for all questions.

you evaluate yourself in terms of the recycling/recovery/disposal of e-waste?" to which 45.3% (n=121) answered that they paid no attention to it. Moreover, 90.1% (n=109) of those who did not pay attention were also unaware of the e-waste recycling procedures in their provinces, while 93.8% of those who paid attention expressed concerns about environmental health.

The participants' mean knowledge score concerning e-waste regulations in Turkey was 25.5±14.1, and the mean score concerning the effects of e-waste on human and environmental health was 31.5±13.3. When analyzed by gender, women achieved a significantly mean total knowledge scores concerning e-waste regulations and the effects of e-waste on human and environmental health than men (p=0.014). Women had a significantly higher level of knowledge concerning e-waste regulations in Turkey than men (p<0.001). Participants who had received education about e-waste achieved a significantly higher total knowledge score than those with no such education (p<0.001). In addition, academics who gave information about e-waste-related issues in the theoretical courses or practical measures for which they were responsible achieved statistically significantly higher scores than those who did not (p<0.001). The participants' knowledge scores depending on various sociodemographic and personal characteristics are presented in Table 3.

Table 3: Knowledge scores according to various sociodemographic and personal characteristics.

	Knowledge score concerning e-waste regulations in Turkey		Knowledge score concerning the effects of e-waste on human and environmental health		Total knowledge score°	
Total Score (Mean±SD)	25.5±14.1		31.5±13.3		57.0±23.3	
Characteristics	Mean±SD	p*	Mean±SD	p*	Mean±SD	p*
Gender						
Female	29.6±12.6	**<0.001**	32.4±12.7	0.580	62.0±20.7	**0.014**
Male	22.5±14.5		31.0±13.7		53.4±24.4	
Marital status						
Single	23.3±14.0	**<0.021**	31.5±14.0	0.847	54.8±23.2	0.112
Married	27.2±14.1		31.5±12.9		58.8±23.3	
Academic title						
Professor	25.9±12.6	0.382**	29.4±12.7	0.076**	55.3±18.9	0.339**
Associate Professor	21.7±16.4		32.4±13.2		54.1±25.0	
Doctor lecturer	28.0±14.3		29.9±13.4		57.9±23.6	
Instructor	25.0±14.4		29.9±14.1		54.9±25.6	
Research Assistant	26.7±12.5		34.4±12.8		61.1±22.1	
Education concerning e-waste status						
Received seducation on e-waste	38.1±8.9	**0.001**	40.0±8.5	**0.011**	78.1±14.2	**<0.001**
No such education received	24.8±14.0		31.1±13.4		55.9±23.2	
Giving information about e-waste-related issues in the theoretical courses practical applications for which participants were responsible						
Gave information about e-waste	32.9±10.7	**<0.001**	37.1±9.1	**0.003**	70.0±16.1	**<0.001**
Did not give information about e-waste	23.7±14.3		30.3±13.8		54.0±23.7	

** Mann-Whitney U Test, ** Kruskal-Wallis Test*

° The total knowledge score was calculated out of 100 points.

Table 4 shows a comparison of the participants' mean knowledge scores to the presence of electrical and electronic devices that they had not actively used / did not intend to use in the previous year at home or in a premises of their own. No statistically significant difference was observed in the mean knowledge scores (footer knowledge scores and total knowledge scores) between those who owned such devices and those who did not (p values 0.968, 0.303, and 0.721, respectively). Participants who reported paying attention to the recycling/recovery of e-waste registered statistically significantly higher mean total knowledge scores than those who did not pay such attention (p<0.001). In terms of evaluation of electrical and electronic devices that had become unusable in the institution for which participants worked, those who contributed to recycling achieved significantly higher scores on all three knowledge points than those who did not contribute to recycling (p values 0.036, 0.002, and 0.001, respectively).

Analysis revealed no correlation

Table 3: Comparison of knowledge scores according to participants' possession and evaluation of electrical and electronic equipment that they did not actively use or intend to use.

			Knowledge score on e-waste regulations in Turkey		Knowledge score on the effects of e-waste on human and environmental health		Total knowledge score°	
	n	**(%)**	**Mean±SD**	**p***	**Mean±SD**	**p***	**Mean±SD**	**p***
E-waste devices that are obsolete/unwanted								
Present	240	(89.9)	25.6±14.0	0.968	32.1±12.6	0,303	57.7±22.1	0.721
Absent	27	(10.1)	23.9±15.5		26.8±18.0		50.7±32.1	
Care and attention paid to the recycling/recovery of e-waste								
Yes	146	(54.7)	27.8±14.2	**<0.001**	35.1±11.1	**<0.001**	62.9±20.7	**<0.001**
No	121	(45.3)	22.6±13.6		27.3±14.6		49.9±24.3	
Recycling of electrical and electronic equipment that has become obsolete/unwanted at home								
Contributors	184	(68.9)	26.2±14.4	**0.039**	31.3±14.2	0.585	57.5±24.3	0.260
Non contributors	83	(31.1)	23.8±13.5		32.0±11.2		55.8±21.0	
Recycling of electronic equipment that has become obsolete/unwanted in the working environment								
Contributors	173	(64.8)	26.9±13.7	**0.036**	33.7±11.8	**0.002**	60.6±21.1	**0.001**
Non contributors	94	(35.2)	22.9±14.5		27.5±15.1		50.4±25.7	

** Mann-Whitney U Test*

° The total knowledge score was calculated out of 100 points.

existed between total knowledge scores and the total number of e-waste devices (rho=-0.119, p=0.065). Similarly, no significant correlation was found between the total number of e-waste devices and age, personal monthly mean income, or the number of household members.

Discussion

When electronic devices end their useful life, it is important to safely recycle/recover without harming the environment. A significantly higher proportion of women (76.8%) contributed to recycling than men (63.2%) in terms of the evaluation of e-waste devices at home. Previous studies have also suggested that women generally have higher levels of environmental concern than men (13), and women have been shown to participate more in various types of environmental behavior (14, 15). Various reasons why women feel a greater responsibility for the environment have been proposed, and women have been described as exhibiting a more emotional attitude toward nature. Higher environmental awareness in women has been associated with their desire to leave a clean and livable environment for future generations (16, 17).

Participants in the present study were asked about electrical and electronic devices that they had not actively used or did not intend to use in the previous year at home or in a premises of their own, and 61.0%

reported possessing information and telecommunication equipment, the most common of these being mobile phones (56.4%). In Ülgen's study, 37.5% of the participants reported having unused telephones in their homes (18). The recycling of phones is especially important in terms of the precious metals they contain. Strategies that will ensure the appropriate reuse or recycling of phones should be introduced in order to reclaim these precious metals and reintroduce them to the economy.

When asked about the causes of e-waste in this study, 51.7% of the participants stated that people lack sufficient knowledge of e-waste. Consistent with the present research, Çalış et al.'s study of prospective science teachers, in which 37.0% of the participants thought that the harmful effects of e-waste were not adequately explained (19).

The participants in this study were also asked “What do you do with your electrical and electronic devices that are no longer usable or that you do not plan to use in your home?” In response, 16.5% reported that they threw them away. Similar questions were put to engineering faculty students in Ülgen's study, and 16.0% also stated that they threw them away (18). Under the Waste Electrical and Electronic Equipment Control Regulation, manufacturers are obliged to mark electrical and electronic devices placed on the market with the symbol meaning "not to be thrown into the trash". Electrical and electronic device distributors are obliged to keep information on the collection and recycling of household e-waste, and to ensure that the symbol on the devices and the meaning thereof are where consumers can easily see them at the place of sale. The answers given suggest that the distributors of electrical and electronic devices did not provide sufficient information on this subject, or that consumers did not exhibit the necessary sensitivity, either consciously or unconsciously.

When the electrical and electronic devices used today become waste, the law states that they must sent to municipal waste collection centers, to transfer centers to be established by the producers and licensed processing facilities, or to the dealer or distributor from which the newly purchased product is purchased, all free of charge. In the present study, 55.1% of the participants gave the correct answer to the question about the regulation regarding e-waste in Turkey. In Deniz et al.’s study of engineering faculty students, 17.0% gave the correct answer regarding the existence of a regulation on e-waste (20). Şentürk measured levels of public awareness about the recycling of e-waste and reported that 33.0% of the participants were educated to undergraduate level, with 41.0% knowing about the regulation (21). Although the differences between these studies can be attributed to the different educational levels of the participants, it may also be concluded that there is insufficient information about the "Regulation on Control of Waste Electrical and Electronic Equipment" implemented in Turkey since 2012. Toprak et al. revealed that the implementation of e-waste policies and compliance with the regulation are largely directly related to the perceived importance of and interest in the subject. In terms of e-waste, important responsibilities fall to end-consumers as well as producers (22).

In the present study, 18.7% of the participants reported giving information about e-waste issues within the theoretical courses practical measures for which they were responsible. Eighty percent of these reported knowing what to do with e-waste and were careful to do that. Analysis showed that 88.0% of those individuals reported contributing to the recycling of devices that became unusable or were not intended to be used in their homes, while 82.0% of those individuals reported contributed to the recycling of devices that became unusable or where not intended to be used in the institutions for which they worked. These findings suggest that people assimilate the relevant knowledge and transform it into a desired form of behavior.

In the present study, 90.1% of participants who did not pay attention to the recycling of e-waste were also unaware of the practices regarding e-waste recycling in their cities. The findings of Deniz et al. (20), Nath et al. (23), and Ülgen's (18) research also support the present study. Therefore, with the adoption of a multidisciplinary approach, producers, distributors, municipalities, and consumers should be more interested and active in preventing e-waste, reducing the amounts of such waste, managing activities, and ensuring continuity.

Analysis revealed that 93.8% of participants who paid attention to the recycling/recovery of e-waste in the present research reported being concerned about its effects on environmental health. In addition, 80.1% of those individuals reported feeling discomfort due to the effects of e-waste on human health, and 70.5% stated that reuse reduces Turkey's dependence on foreign resources. Furthermore, 55.5% of those participants stated that reuse reduces Turkey's raw material needs, while 53.4% described the recycling of e-waste as an important market capable of creating a significant field of employment. Finally, 51.4% of those participants considered that they think that recycling e-waste relieves pressure on natural resources. In Ülgen's study, 68.5% of the participants thought that e-waste can harm both the economy and human health. In the same study, 88.1% of the participants thought that e-waste would contribute to the economy through recycling (18). While recycled e-waste benefits the economy, non-recyclable waste is deleterious to both human and environmental health. While more gold can be obtained from one ton of personal computer waste than from 17 tons of gold ore, recycling 1000 mobile phone batteries can yield 250 mg of silver, 24 mg of gold, 9 mg of palladium, and 9 g of copper. These are equivalent to the precious metal content of 250 tons of silver, 24 tons of gold, 9 tons of palladium, and 9000 tons of copper ore, respectively. Another no less important issue is the recovery of e-waste and the recovery of energy to be retained before it is consumed. The significance of these figures can be better understood by considering the fact that a very important part of global energy is used for mining activities (24).

While the paths of exposure to hazardous components of e-waste in general vary depending on the substance and the recycling process employed, people can be exposed to e-waste components and related pollutants through contact with contaminated soil, air, water, and food sources (3, 6, 25). In the present study, 86.5% of the participants stated that metals such as lead, mercury, cadmium, chromium in e-waste pose a risk of contaminating drinking water sources by leaking from the soil and reaching the groundwater, while 76.4% of the participants knew that such pollution could appear in the food chain from the soil. Grant et al. searched five electronic databases and summarized the evidence for the association between exposure to e-waste components and adverse health outcomes (6). Although adverse health outcomes were beyond the scope of the present, 63.7% of the participants stated that heavy metals that can be found in e-waste are harmful even at low doses, while 65.9% knew that these metals are harmful even in short-term exposure but at high doses. It may therefore be concluded that the participants in this study had a high level of awareness of possible e-waste contamination in soil, water, and food, as well as knowing that pollutants are harmful regardless of dose and exposure time.

Highlights and Limitations

Previous studies investigating the recycling of e-waste and its effects on human and environmental health have mostly been concentrated in developing countries. Many studies have been conducted in areas with recycling business facilities in order to assess the risk associated with e-waste recycling. However, studies that emphasize the importance of e-waste, that evaluate knowledge levels, and that and raise awareness are very rare both worldwide and in Turkey. The present research is the first to examine the levels of knowledge, opinions, and behaviors of academics working in departments that are in close contact with electrical and electronic equipment at the university where it was conducted. Although the participants could not be interviewed face to face due to the COVID-19 pandemic, the participation rate was still 80.7%. Although the results are not generalizable, this participation rate was regarded as satisfactory in terms of providing general information about the subject matter. However, while the knowledge, opinions, and behaviors of academics concerning e-waste were examined in terms of various different variables, the results of the study are limited by the data collection tool used.

Conclusion

E-waste is an important problem that adversely affects human and environmental health. It is particularly noteworthy that only a small proportion of the participants had received education concerning e-waste, approximately half paid no attention to the recycling/recovery/disposal of e-waste, and that most of those who paid no attention to e-waste recycling were unaware of the practices in their city. Analysis revealed that participants who did pay attention to the recycling of e-waste and who contribute to recycling had higher levels of knowledge regarding e-waste devices that become unusable at home or in the institution where they work. We conclude that policy solutions, education programs, and interventions aimed at reducing the e-waste exposure and the adverse health effects thereof can help create and improve individual awareness and the more efficient performance of relevant activities. Finally, we would suggest that this potential threat to public health can be prevented by detecting and eliminating disruptions in this process.

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