

Research Article

Knowledge pattern assessment of potential safety threats of compact fluorescent lamps in Kuwait

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Article Info

[https://doi.org/10.31018/](https://doi.org/10.31018/jans.v13i4.3007)

[jans.v13i4.3007](https://doi.org/10.31018/jans.v13i4.3007) Received:

September 16, 2021

Revised: October 29, 2021

Accepted: November 4, 2021

How to Cite

Alsanad, A. *et al.* (2021). Knowledge pattern assessment of potential safety threats of compact fluorescent lamps in Kuwait. *Journal of Applied and Natural Science*, 13(4), 1256 - 1264. <https://doi.org/10.31018/jans.v13i4.3007>

Abstract

Globally, compact fluorescent lamps (CFLs) are increasing consistently, and Kuwait is not an exception. However, these lamps contain mercury, which is highly injurious to human health and the environment. This study assessed Kuwaiti respondents' awareness using a large-scale national survey conducted on a random sample of 6210 individuals (response rate 84.3%). The questionnaire was comprised of four sections and utilized skip logic branching. The modes were paper-based, face-to-face interviews, and electronic structured questionnaires. Data were also analyzed through the Pearson chi-square test to know the significant differences in lamp type preferences and the reasons for the preferences. Almost half of the participants (51.4%) knew the difference between incandescent and fluorescent lamps. Only 11.1% were using incandescent lamps solely in their houses. The remaining 88.9% used fluorescent lamps (38.4%) or both types (50.5%). The results showed that 48.3% think fluorescent lamps save energy, whereas 81.3% of people were unaware of their mercury content. The knowledge patterns towards breakage showed that respondents who chose the proper response were 31.9% for evacuation, 14.6% for aeration, and 7.3% for turning off the AC. The awareness of populations to take appropriate actions towards proper disposal was very poor in case of fluorescent lamp accidental breakage or when it completes its life cycle because most of them did not know about the proper evacuation, aeration, and cleanup measures. These findings are beneficial for the government and policymakers to take essential steps to create relevant awareness channels among the country's communities for safety from expected health hazards.

Keywords: Compact fluorescent lamp, Energy saving, Kuwait, Mercury, Ultraviolet

INTRODUCTION

Compared to incandescent light bulbs, compact fluorescent light bulbs are more energy-efficient and last longer. Fluorescent lamps were discovered in 1925 (Khan and Abas, 2011, Poda, 2020). There are different sizes and shapes for compact fluorescent lamps (CFLs), and their compactness comes from a folded-tube technology. Compact fluorescent light bulbs can produce a similar colour phosphors (Brautigan, 1997, Gaffur *et al.*, 2021). The luminous power of a 23 W compact fluorescent light bulb is comparable to a 100 W incandescent bulb. The input power to a white light conversion of CFLs is from 6.6 to 8.8%, whereas it is only 2.6% in an incan-

descent lightbulb. Over its estimated 6000–15,000 h lifespan, compact fluorescent lights save 30 dollars over traditional bulbs due to lasting up to 10 times more prolonged and consuming up to 5 times less power (Ngoffe, 2019, Khan and Abas, 2011). The efficiency of CFLs decreases with extreme temperatures because the optimal operating temperature is 20 °C. Hence, CFLs are not suitable for microwaves and refrigerators (Khan and Abas, 2011). Increased greenhouse gas emissions in the atmosphere contribute to the enhanced greenhouse effect (Hansen *et al.*, 1981), which is directly related to energy consumption. The higher the consumption of energy, the higher the concentration of greenhouse gases. This has led many communities to energy-saving appliances, such as compact fluo-

rescent lamps (CFLs) and light-emitting diode (LED) lamps. Unlike the United States and European countries, which rely partially on alternative sources for power, almost all of the electricity generated in Kuwait is produced by burning fossil fuels, primarily oil and natural gas (Ansari and Holtz, 2020, USEIA, 2016). It was recently reported that in 2015, the CO₂ emissions from the Kuwaiti-based fossil fuel power plants were an estimated 34 million tons, which might double in less than ten years (Abotalib *et al.*, 2021).

The long lifespan of compact fluorescent lamps (Brautigan, 1997) and their energy-saving properties make them very economical compared to traditional incandescent lamps. The problem with CFLs is that they contain trace amounts of mercury (Dunmire *et al.*, 2003). Exposure to high mercury levels can adversely affect the digestive, nervous, renal, and ocular systems, as well as the overall development of organs (ATSDR, 2011). A typical CFL bulb is coated with phosphor and contains argon and mercury vapours. When electricity passes between the fixed electrodes, the contained gases get excited and release an ultraviolet (UV) light; this invisible light excites the phosphor coating making the light visible at the color we see. Studies have shown that the metal content of CFLs is higher than that of incandescent light bulbs. Compared to incandescent bulbs, compact fluorescent lamps contain more antimony, copper, iron, lead, mercury, yttrium, and zinc. CFLs work bypassing AC between the fixed electrodes, which excites the mercury atoms and make them release invisible ultraviolet light (UV), which becomes visible light once it comes in contact with the inside fluorescent coating (phosphor) of the glass tube (Lim *et al.*, 2013). Spent fluorescent lamps contain between 0.7 and 115 mg of mercury per lamp (Jang *et al.*, 2005). The compact fluorescent lamps category averages 3 to 5 mg of mercury per lamp (Johnson *et al.*, 2008). Usually, the higher the wattage, the higher the amount of mercury in CFLs. To limit the amount of mercury, the National Electrical Manufacturers Association (NEMA) requires manufacturers to use a maximum of 5 mg Hg for 25W CFLs or smaller wattage and 6 mg Hg for higher wattage CFLs. Since manufacturers are producing lower mercury versions, the actual mercury content in compact fluorescent is approximately 3 to 4 mg/lamp. This amount of mercury is minimal compared to oral thermometers, which may contain up to 1 gram or 200 times the amount of mercury found in CFLs (NEMA, 2018). This is of more concern when additional sources of mercury are taken daily, for example, by consuming certain types of seafood, vegetables, and fruits. Over the CFLs lifespan, the contained mercury gets absorbed by the glass tubes and electrodes. If this continues and the mercury is depleted, the light colour changes to dark pink. According to CFL manufacturers, there is 0.012 mg Hg loss per kilowatt-hour (Khan and Abas,

2011).

Kuwait has one of the highest kilowatt per capita rates globally and ranked fourth with 15,591 kWh/capita (OECD/IEA, 2014). This high electric power consumption can be attributed to Kuwaiti citizens' high standard of living and the climate of Kuwait. The summer temperature in Kuwait can reach 54°C (SKDGCA, 2017), which increases the need for air conditioning systems and the associated electrical load. The objective of this study is to assess CFLs' knowledge patterns in society. Knowledge assessment involved the difference between compact fluorescent lamps and the traditional incandescent lamps, the presence of mercury in compact fluorescent lamps, mercury impacts on human health and the environment, handling and cleaning procedure in case of the breakage of CFLs, and lastly, the fate of the spent compact fluorescent lamps. The awareness assessment was conducted by employing questionnaires served to the participants from all of Kuwait's governorates.

MATERIALS AND METHODS

Study area and respondents

A large-scale national survey was conducted on a random sample of the Kuwaiti population to have a holistic perspective of respondents' awareness levels. The survey was distributed to 6210 individuals. The number of people who completed the questionnaire was 5237, a completion rate of 84.3 percent. Participants belonged to various groups of age, gender, education, and nationality (expatriates). The respondents represented all the six governorates of Kuwait: Asima, Hawalli, Farwaniya, Mubarak Alkabeer, Ahmadi, and Jahra.

Questionnaire design

The questionnaire comprised 19 questions divided into four major sections (Fig.1- population demographics (1), the types of lamps used in the local market (2), the respondents' preferences, how people deal with breakage or disposal (3), and mercury knowledge and risk factors (4). The skip logic branching technique was utilized through multiple survey parts to improve the questionnaire outcomes (SurveyMonkey Inc., 2020). Skip logic customizes the path respondents take while answering the survey; in other words, future questions are shown based on current answers. It was used, for example, to exclude those who do not know the difference between incandescent light bulbs and CFLs from answering the question about the presence of mercury in CFLs. Skip logic branching also tends to filter out irrelevant data and make the survey shorter, increasing the chances of completion. It should be noted that most of the questions were derived from the literature examining mercury fate and transport (Murphy *et al.*, 2018, SurveyMonkey Inc., 2020).

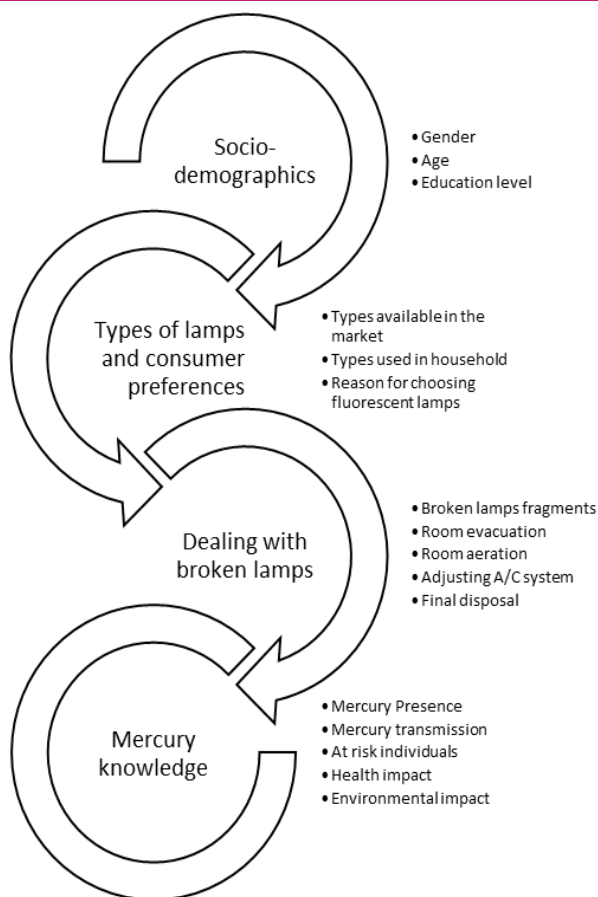


Fig. 1. Survey Structure of the population of Kuwait

Data collection and analysis

The methods used to collect the data were paper-based questionnaires, face-to-face interviews, and electronic structured questionnaires. The face-to-face survey mode was mainly aimed at the elderly and those who have a reading disadvantage. A total number of 38 collectors helped in gathering the questionnaires. After the data collection process, IBM's Statistical Package for the Social Sciences (SPSS) software (IBM, 2019) was used for data analysis.

RESULTS AND DISCUSSION

Socio-demographics and respondents' characteristics

The replies to the socio-demographic questions (Table 1) showed that 1177 males with a percentage of 22.5%, had completed the survey. The number of females was 4060, forming 77.5% of the sample. The age structure revealed that most respondents (69.1%) were of college and early career (18-39 years old). The education level of the respondents is relatively high because 17.1% have a college diploma, 59% of them hold a bachelor's degree, and 7% hold a graduate degree. Thus, respondents with higher education comprised 83% of the overall study sample. The spatial distribution of the survey respondents indicated that most of

them reside (24.4%) in the Asima governorate, followed by Hawalli (22.3%). Both governorates comprise almost half of the respondents (46.7%), and the rest belong to the other four governorates.

Types of lamps and consumers' preferences

The second set of questions focused on the types of lamps people used in their houses and why they used them instead of other lamps. The first question in this set asked if they knew the types of lamps available in the market; if their answer was no, they were provided with an image showing the different types of lamps. This ensures the accuracy of the rest of the survey questions, which focus primarily on fluorescent lamps. Once informed, the respondents were asked about the types of lamps used in their houses. The survey results showed that fluorescent lamps are hugely popular among the Kuwaiti population, as 50.5 % use both types of lamps, while 38.4% use fluorescent lamps exclusively. The incandescent lamp participants were only 11.1%, significantly lesser ($P < 0.001$, Table 2). Whether the participants knew about the types of lamps available in the market or not, the tendency to use incandescent lamps remains significantly low ($P < 0.001$, Post hoc test).

Respondents preferred using fluorescent lamps either due to the relatively long lifespan (58.5%), or energy-saving properties (48.3%), market availability (14.8%), and cost (9.8%). This question was a multiple answer question where overlapping preferences are allowed (Table 3). As shown in Fig. 2, the study sample preferred fluorescent lamps primarily for their long lifespan and energy-saving properties. The figure also shows that despite the popularity of fluorescent, relatively low cost and market availability are not the driving factors for usage.

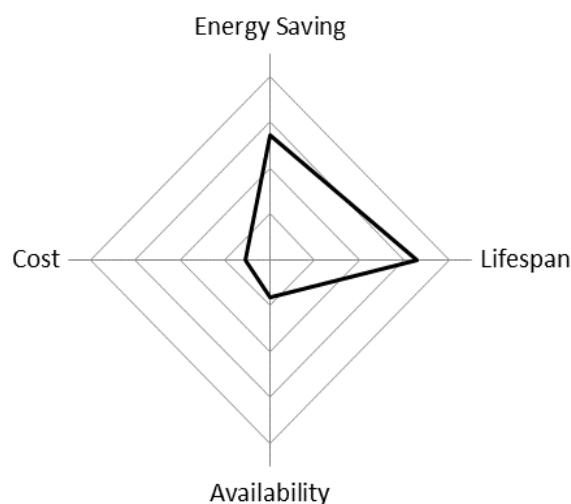


Fig. 2. Factors affecting the respondents' preferences towards fluorescent lamps

Table 1. Frequency distribution (n) of demographics and other characteristics of the respondents' (% in parenthesis) of Kuwait

| Respondents | Total | Asima | Hawalli | Farwaniya | Mubarak Alkabeer | Ahmadi | Jahra |
|------------------------|-------------|-------------|-------------|------------|------------------|------------|------------|
| Total | 5237 | 1278 (24.4) | 1170 (22.3) | 704 (13.4) | 775 (14.8) | 769 (14.7) | 541 (10.3) |
| Gender | | | | | | | |
| Male | 1177 (22.5) | 297 (5.7) | 288 (5.5) | 157 (3.0) | 169 (3.2) | 152 (2.9) | 114 (2.2) |
| Female | 4060 (77.5) | 981 (18.7) | 882 (16.8) | 547 (10.4) | 606 (11.6) | 617 (11.8) | 427 (8.2) |
| Age Structure | | | | | | | |
| < 17 | 281 (5.4) | 77 (1.5) | 52 (1.0) | 42 (0.8) | 30 (0.6) | 43 (0.8) | 37 (0.7) |
| 18-22 | 1394 (26.6) | 311 (5.9) | 249 (4.8) | 186 (3.6) | 207 (4.0) | 235 (4.5) | 206 (3.9) |
| 23-29 | 1040 (19.9) | 244 (4.7) | 175 (3.3) | 150 (2.9) | 206 (3.9) | 161 (3.1) | 104 (2.0) |
| 30-39 | 1078 (20.6) | 237 (4.5) | 282 (5.4) | 146 (2.8) | 143 (2.7) | 157 (3.0) | 113 (2.2) |
| 40-49 | 871 (16.6) | 217 (4.1) | 264 (5.0) | 116 (2.2) | 83 (1.6) | 119 (2.3) | 72 (1.4) |
| 50-59 | 501 (9.6) | 167 (3.2) | 124 (2.4) | 60 (1.1) | 96 (1.8) | 49 (0.9) | 5 (0.1) |
| > 60 | 72 (1.4) | 25 (0.5) | 24 (0.5) | 4 (0.1) | 10 (0.2) | 5 (0.1) | 4 (0.1) |
| Education level | | | | | | | |
| Below secondary school | 222 (4.2) | 52 (1.0) | 32 (0.6) | 31 (0.6) | 39 (0.7) | 35 (0.7) | 33 (0.6) |
| Secondary school | 664 (12.7) | 136 (2.6) | 122 (2.3) | 92 (1.8) | 97 (1.9) | 119 (2.3) | 98 (1.9) |
| College diploma | 896 (17.1) | 188 (3.6) | 213 (4.1) | 123 (2.3) | 155 (3.0) | 147 (2.8) | 70 (1.3) |
| Bachelor's degree | 3088 (59.0) | 802 (15.3) | 690 (13.2) | 412 (7.9) | 437 (8.3) | 429 (8.2) | 318 (6.1) |
| Graduate degree | 367 (7.0) | 100 (1.9) | 113 (2.2) | 46 (0.9) | 47 (0.9) | 39 (0.7) | 22 (0.4) |

Table 2. Use of different types of lamps in houses of Kuwait

| Options to be selected by the participants | Frequency ^b | Percentage (%) | Pearson Chi-Square | P |
|--------------------------------------------|------------------------|----------------|--------------------|---------------------|
| Incandescent lamps | 580 | 11.1 | 49.7 | <0.001 ^a |
| Fluorescent lamps | 2012 | 38.4 | | |
| Both types of lamps | 2645 | 50.5 | | |
| Total | 5237 | 100.0 | | |

^aAppendix 2.1a; ^bSignificant differences among the categories (Post hoc test with Bonferroni adjustment, Appendix 2.1b)

Knowledge patterns towards mercury presence and transport

The core question in the questionnaire was whether the respondents knew that fluorescent lamps contained mercury or not. Surprisingly, most respondents (81.6%) were unaware that mercury was present in fluorescent lamps (Table 4). One would assume that higher levels of education (83% of the study sample) would indicate better knowledge towards mercury presence. However, this did not prove to be the case because certain types of information might require special awareness. Dun-

mire *et al.* (2003) and Jang, Hong, and Park (2005) indicated that fluorescent lamps contain mercury, which could injure human health if necessary care is not observed.

The survey participants were asked two questions regarding mercury's impact on human health and the environment. For both questions, the number of people who were not aware of the impacts of mercury was higher (Table 4). For the question, "Do you have any idea about the mercury impact on human health" 2355 respondents (45%) answered yes, and 2882 respond-

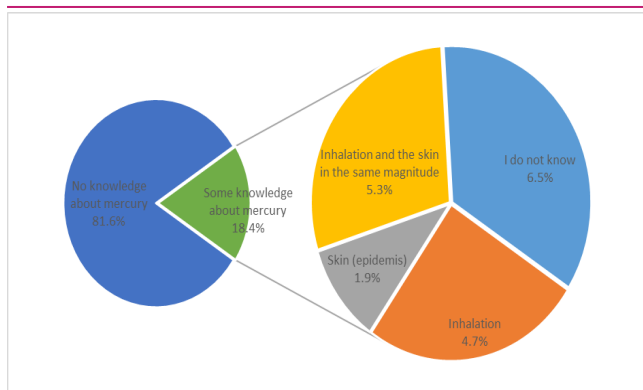


Fig. 3. Participants' view about the transmittance of mercury to humans after the breakage of a fluorescent lamp

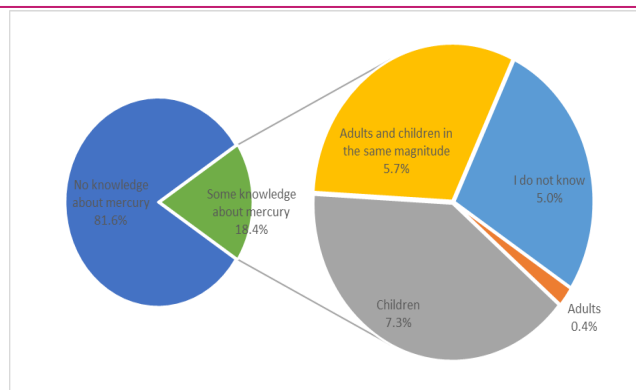


Fig. 4. Opinion of participants regarding the susceptibility of mercury to various groups of the population

ents (55%) answered no. Regarding the second question, "Do you have any idea about the mercury impact on the environment" 1919 participants (36.6%) answered yes, while the vast majority, numbering 3318 (63.4%), answered no. Thus, the majority of the communities may be affected unknowingly because, after exposure, mercury can move and accumulate to various body tissues like the kidneys and can even cross the blood-brain barrier, resulting in neurotoxicity (IARC, 2018, Li *et al.*, 2021).

The survey respondents also answered two questions, one about the routes of human exposure to mercury in case of lamp's breakage and the other about the indi-

viduals at-risk. The responses of participants were through inhalation (25.6%), through the epidermis (10.3%), through both; inhalation and epidermis (28.29%), whereas the rest (35.81%) had no idea regarding the transmission of mercury to humans (Fig. 3). According to literature, the primary route of mercury exposure in humans is through the ingestion of mercury, for example consuming contaminated fish (methyl mercury). Humans may be exposed to mercury vapor and compounds through inhalation and skin contact (Yang and Massey, 2019, Aucott *et al.*, 2003). As for the at-risk individuals, 39.8% of the respondents chose children, 2.0% chose adults, 28.9% chose both children

Table 3. Reasons for using fluorescent lamps in houses of Kuwait

| Options to be selected by the participants | Frequency ^b | Percentage (%) | Pearson Chi-Square | P |
|-------------------------------------------------------|------------------------|----------------|--------------------|---------------------|
| Fluorescent lamps are not used | 580 | 11.1 | 7490.2 | <0.001 ^a |
| Fluorescent lamps save energy | 2529 | 48.3 | | |
| Fluorescent lamps have a long life | 3066 | 58.5 | | |
| Fluorescent lamps are readily available in the market | 776 | 14.8 | | |
| Fluorescent lamps are well priced | 511 | 9.6 | | |

Participants could select multiple answers. ^aAppendix 2.2a); ^bPost hoc test with Bonferroni adjustment (Appendix 2.2b)

Table 4. Awareness about the presence of mercury in fluorescent lamps and its impact on human health and the environment

| Options to be selected by the participants | Frequency (Numbers n) | | | Percentage (%) | | | Pearson Chi-Square | P |
|--------------------------------------------------|-----------------------|------|-------|----------------|------|-------|--------------------|---------------------|
| | Yes | No | Total | Yes | No | Total | | |
| Awareness that Florescent lamps contain mercury | 961 | 4276 | 5237 | 18.4 | 81.6 | 100.0 | 874.1 | <0.001 ^a |
| Knowledge of mercury risk on human health | 2355 | 2882 | 5237 | 45.0 | 55.0 | 100.0 | | |
| Knowledge of mercury risk on the environment | 1919 | 3318 | 5237 | 36.6 | 63.4 | 100.0 | | |
| Means of frequencies for the above three options | 1745 | 3492 | 5237 | 17.9 | 82.1 | 100.0 | | |

^aAppendix 2.3

Table 5. Awareness of participants regarding immediate actions required after a fluorescent lamp is broken

| Options to be selected by the participants | Frequency (Numbers n) | | | Percentage (%) | | | Pearson Chi-Square | P |
|-------------------------------------------------------|-----------------------|---------|-------|----------------|------|-------|--------------------|---------------------|
| | Yes | No | Total | Yes | No | Total | | |
| Evacuation of the room from all people | 1668 | 3569 | 5237 | 31.9 | 68.1 | 100.0 | 1132.1 | <0.001 ^a |
| Aeration of the room by opening the windows and doors | 765 | 4472 | 5237 | 14.6 | 85.4 | 100.0 | | |
| Turn off the air conditioning system | 382 | 4855 | 5237 | 7.3 | 92.7 | 100.0 | | |
| Means of frequencies for the above three options | 938.33 | 4298.67 | 5237 | 17.9 | 82.1 | 100.0 | | |

^aAppendix 2.4

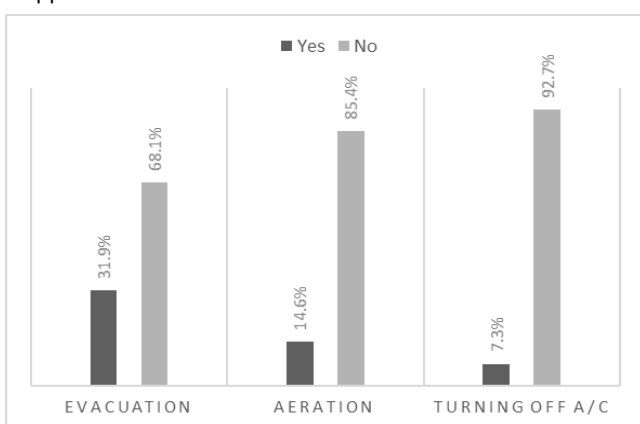


Fig. 5. Fluorescent lamps breakage response scenarios

and adults equally, while the rest had no idea and children are at a higher risk of mercury as exposure may impair the developing nervous system (Nance *et al.*, 2011, Counter and Buchman, 2004).

Knowledge patterns towards breakage, cleanup, and disposal of CFLs

Most of the literature on fluorescent lamps focused on their components, composition, environmental impact, and disposal (Jang *et al.*, 2005, ATSDR, 2011, Nance *et al.*, 2011). Very few studies focused on the human response towards its breakage and cleaned up. This survey addressed these topics in a series of "if-then" questions (Fig. 4). Respondents who answered yes to these questions chose the proper response scenario since most of the mercury released after breakage is in the form of elemental vapor. Much of this release is during the first 8 hours (Nance *et al.*, 2011). Under normal usage, fluorescent lamps remain intact. However, accidents happen, and sometimes they bust for no apparent reason. Almost 31.9% of participants indicated that they would evacuate the room versus 68.1% who do not act upon this practice after the breakage of fluorescent lamps (Table 5, Fig. 5). As for aerating the rooms by opening the doors and windows, 14.6 per-

cent indicated they would aerate the affected room, while 85.4% of them will not do that, which might be due to the lack of awareness. Only 7.3% would turn off the air conditioning system, whereas 92.7% are of the view of keeping it running. The participants selecting the negative answer may not be well-versed in the urgency and benefits of turning the AC system off. There is a real need to educate them that mercury particles may be recycled in the room if the air conditioning system is running, and these particles could be dangerous for the room's inhabitants (Hill, 2020).

The respondents were then asked how they would collect the broken pieces, and their responses were; by a broom or bare hands (44.5%), a vacuum cleaner (35.6%), damp cloth (8.3%), whereas the rest did not know how to do it (Fig. 6). These answers represent the lack of knowledge in dealing with lamp breakage as neither a broom nor a vacuum cleaner is recommended in cleaning the broken lamp fragments. Instead, the Health Protection Agency (2009) suggests refraining from using vacuum cleaners and household cleaning

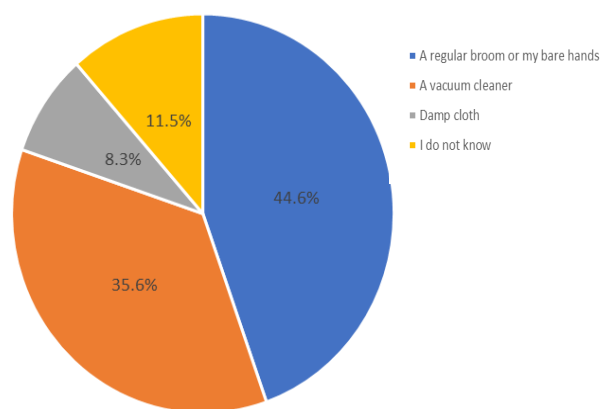


Fig. 6. Opinion of the participants of the survey regarding the cleanup method of the broken pieces of the fluorescent lamps

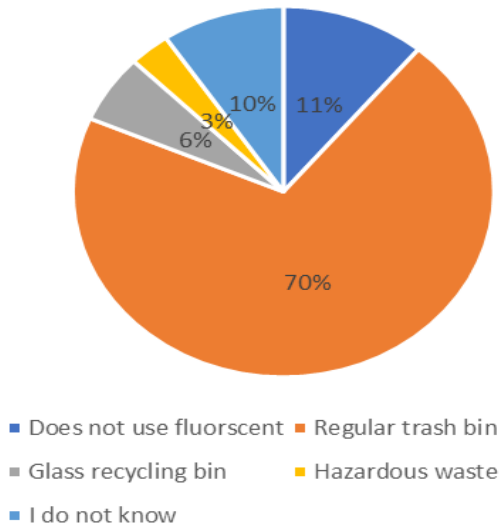


Fig. 7. Opinion assessment of participants regarding disposal of used fluorescent lamp

products, wearing rubber gloves for cleanup, cleaning by small pieces of cardboard, and finally using sticky tape to remove the fragments and powder. All the items must be disposed of in a sealed and double wrapped plastic bag, which should be dropped in a local hazardous waste drop-off location.

The last question was related to the disposal of the spent fluorescent lamps. This question excluded 11.1% of the respondents who do not use fluorescent lamps in their households (Fig. 7). The results showed that 79% of the respondents would discard the spent fluorescent lamps in general waste bins, 6.7% would discard them in glass recycling bins, 3.5% in hazardous waste bins, and the rest did not know the proper disposal route. This shows that a tiny segment of society (3.5%) is aware of the proper disposal of fluorescent lamp waste, which is dropping a local hazardous waste drop-off location (Health Protection Agency, 2009). Finally, on inquiring whether respondents knew of any establishments in Kuwait that accept fluorescent lamps, the vast

Appendix 1. Chi-Square analysis of different tables

Appendix 1.1a. Chi-Square test results of the use of different types of lamps in houses of Kuwait

| | Value | Df | P |
|------------------------------|--------|----|------|
| Pearson Chi-Square | 49.698 | 2 | .000 |
| Likelihood Ratio | 49.923 | 2 | .000 |
| Linear-by-Linear Association | 4.686 | 1 | .030 |
| N of Valid Cases | 5237 | | |

Appendix 1.1b. Posthoc test (after Chi-Square test) results of the use of different types of lamps in houses of Kuwait

| | | Type of lamps are used in household | | | Total | |
|---------------------------------------------------------------------------|-------------------|-------------------------------------|-------------|-----------|--------|------|
| | | Incandescent | Fluorescent | Both | | |
| Do you know the difference between the types of lamps sold in the market? | Yes | Count | 228 | 1122 | 1343 | 2693 |
| | Percent | 8.5% | 41.7% | 49.9% | 100.0% | |
| | Adjusted Residual | -6.2 | 5.0 | -.9 | | |
| | P* | 0.0000000 | 0.0000007 | 0.3435859 | | |
| | No | Count | 352 | 890 | 1302 | 2544 |
| Percent | 13.8% | 35.0% | 51.2% | 100.0% | | |
| Adjusted Residual | 6.2 | -5.0 | .9 | | | |
| P* | 0.0000000 | 0.0000007 | 0.3435859 | | | |
| Total | Count | 580 | 2012 | 2645 | 5237 | |
| Percent | 11.1% | 38.4% | 50.5% | 100.0% | | |

*Bonferroni corrected/adjusted p value

Appendix 1.2a. Chi-Square test results of the reasons for using fluorescent lamps in houses of Kuwait

| | Value | Df | P |
|--------------------|-----------------------|----|-------|
| Pearson Chi-Square | 7490.150 ^a | 8 | 0.000 |
| Likelihood Ratio | 4103.393 | 8 | 0.000 |
| N of Valid Cases | 7462 | | |

Appendix 1.2b. Posthoc test (after Chi-Square test) results of the reasons for using fluorescent lamps in houses of Kuwait

| | | | Reasons of using fluorescent lamps | | | | | Total |
|--------------------------------------------|--------------|-------------------|------------------------------------|--------------------|---------------------------------------|-------------------|-----------------|-------|
| | | | Does not use fluorescent | It has a long life | It is readily available in the market | It is well priced | It saves energy | |
| Options to be selected by the participants | Both | Count | 0 | 1756 | 451 | 340 | 1378 | 3925 |
| | | Adjusted Residual | -26.4 | 6.8 | 3.3 | 6.5 | 2.3 | |
| | | P* | 0.0000000 | 0.0000000 | 0.0011435 | 0.0000 | 0.01934 | |
| | Fluorescent | Count | 0 | 1310 | 325 | 171 | 1151 | 2957 |
| | | Adjusted Residual | -20.3 | 4.6 | 1.4 | -3.0 | 7.4 | |
| | | P* | 0.0000000 | 0.0000049 | 0.1750483 | 0.0031 | 0.00000 | |
| | Incandescent | Count | 580 | 0 | 0 | 0 | 0 | 580 |
| | | Adjusted Residual | 86.4 | -20.9 | -8.5 | -6.8 | -18.0 | |
| | | P* | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000 | 0.00000 | |
| | Total | Count | 580 | 3066 | 776 | 511 | 2529 | 7462 |

*Bonferroni corrected/adjusted p value

Appendix 1.3. Chi-Square test results on awareness of the presence of mercury in fluorescent lamps and its impact on human health and the environment

| | Value | Df | P |
|--------------------|----------------------|----|-------|
| Pearson Chi-Square | 874.073 ^a | 2 | 0.000 |
| Likelihood Ratio | 916.590 | 2 | 0.000 |
| N of Valid Cases | 15711 | | |

Appendix 1.4. Chi-Square test results on awareness of immediate actions required after a fluorescent lamp is broken

| | Value | Df | P |
|--------------------|-----------------------|----|-------|
| Pearson Chi-Square | 1132.115 ^a | 2 | 0.000 |
| Likelihood Ratio | 1127.557 | 2 | 0.000 |
| N of Valid Cases | 15711 | | |

majority (95.6%) of them were unaware of any place that accepts used fluorescent lamps.

Conclusion

Mercury is an essential component of fluorescent lamps, which can prove harmful to humans and the environment. The focus of this study was to assess the awareness of the community for this problem and raise public awareness regarding proper usage, disposal, and recycling of fluorescent lamps. The opinion survey indicated that 50.5 % of the respondents used both incandescent and fluorescent lamps, while 38.4% used only fluorescent lamps due to long lifespan (65.8%) or energy-saving properties (53.3%), yet 81.6% of them were not aware of the presence of mercury in fluores-

cent lamps and its consequences. Only 45% have an idea about mercury's impact on human health, while 36.6% suspected it would affect the environment. About 35.8% of participants were unaware of possible transmission mechanisms of mercury into the human body through inhalation or the epidermis. The lack of awareness in the community of Kuwait regarding fluorescent lamps could be due to the poor acquaintance of suitable actions for proper disposal of pieces if a fluorescent lamp accidentally breaks or when it completes its life. These probable consequences necessitate arranging appropriate awareness and training campaigns of communities by health organizations, environmental organizations, and government entities to avoid possible health and environmental shortfalls in Kuwait. Large furniture and electronics retailers can initiate nationwide CFL take-back programs to increase the number of recycled lamps and reduce the quantity that would eventually be discarded. It is recommended that these programs be at no additional cost to the consumer to increase the participation rate.

ACKNOWLEDGEMENTS

The authors of this study would like to thank the 38 collectors who helped gather the data and complete this large-scale survey, Kuwait University for providing the statistical software package, Muhammad Islam for proofreading this manuscript, and all the survey participants.

Conflict of interest

The authors declare that they have no conflict of interest.

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