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A survey of Knowledge, attitudes, and practices of Tehran residents regarding solid waste management in the COVID-19 era

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ABSTRACT

This study aimed to investigate the knowledge, attitude, and practice (KAP) of residents in Tehran City towards municipal solid waste management (MSWM) after the Corona Virus Disease 2019 caused by SARS-CoV-2 (COVID-19) epidemic, which has been tended for the first time in this research. The study was conducted in Tehran, Iran from August 2021 to March 2022. The study population consisted of 385 participants drawn from 22 urban areas in Tehran. In order to collect the data, self-administered questionnaires containing 20 questions in 3 subject areas were used. Testing for associations between variables was conducted using Chi-square (χ2) and Pearson correlation analyses. Despite the fact that 64.9% and 56.6% of residents had adequate knowledge and attitude regarding MSW management during the COVID-19 pandemic, only 33.1% performed moderate practice. Obtained results highlighted the correlation between education, employment, gender, and age of respondents with KAP levels on (MSWM) (P<0.05). The training was found to be an important tool to enhance residents’ awareness and attitude, but strict MSW legislation must also be implemented to restart appropriate separation, recycling, and composting programs during the pandemic. The findings of this study in turn can serve as a basis for experts and decision-makers to develop pragmatic waste management strategies during the COVID-19 pandemic, which rely on the participation of the general public.

1. Introduction

As of October 1, 2022, there had been 7549,186 confirmed cases and 144,429 deaths in Iran as a result of the COVID-19 outbreak (WHO, 2022). A new Coronavirus outbreak was officially classified as a pandemic by the World Health Organization (WHO) on March 11, 2020, owing to its rapid spread (Zareie et al., 2020). Coronavirus is a type of virus having single-stranded RNA as well as a crown on its surface. In humans, these viruses commonly cause illnesses ranging from the common cold to severe respiratory illnesses (Bhawal Mukherji et al., 2016; Wan et al., 2020; Zhou et al., 2020). Various cases of pneumonia of unknown etiology have been reported in Wuhan City, China, following the discovery of the new Coronavirus Disease 2019 caused by SARS-CoV-2 (COVID-19) in December. Consequently, COVID-19 has spread around the world rapidly (Rothan and Byrareddy, 2020). Fig. 1 provides data on recent COVID-19 infected cases and deaths in Iran. Iran experienced a rapid increase in the number of infections from 894 new cases on 9 July 2022 up to 11,035 new cases on 26 July 2022, which was primarily due to the reopening of several businesses and jobs, unsafe travel during the COVID-19 pandemic, and a lack of public awareness regarding social distancing measures.

Most aspects of people’s lives have been affected by the outbreak of COVID-19, and every day new environmental concerns are being enumerated worldwide. MSWM in developing countries has long been considered a critical environmental problem. In general, solid wastes in Iran tend to be disposed of or buried in poorly managed landfills where waste pickers without proper personal protective equipment (PPEs) can scavenge for recyclable materials. With 81 million people, Iran is the 18th most populous country in the world; it produces annually over 18 million tons of municipal solid waste.

The Source separation of solid wastes in large cities is a key prerequisite for safe handling and disposal of wastes in COVID-19 outbreak. In most parts of Iran, source separation and reduction programs are poorly implemented, with only 8% of solid wastes being recycled legally (Rupani et al., 2019) substantially due to poor public awareness and participation. The sorting of wastes from the origin and disposal sites ceased as a result of the new Coronavirus outbreak in large cities of Iran, including Tehran. Electronic and medical wastes, which are
hazardous household wastes, are now mixed with household wastes in Tehran and collected as part of general MSW. Coronavirus might be further spread through improper management of MSW.

Despite the outbreak of Coronavirus in Tehran, the legal separation and recycling of urban wastes has been suspended, while illegal separation and recycling has continued. There is a need for a strict regulatory regime to prevent waste pickers from separating MSW from recycling materials in a manner that aggravates the health risks associated with illegal separation and recycling during the pandemic. A reliable method for the destruction of viruses, including the new Coronavirus, would be the incineration of wastes. Tehran’s collected MSW is currently being buried or disposed at the Aradkouh disposal site without further processing (Zand and Heir, 2020). Since the outbreak of Coronavirus, the amount of waste being disposed of in Tehran has increased by 34.7%. Environmental problems in Tehran during COVID-19 pandemic are mainly caused by MSW management. It is more vulnerable to Coronavirus propagation through waste management practices if wastes are not handled in a sustainable manner. With an increase in infectious or suspected litter, MSW may pose a greater risk of disease transmission and public health threats (Zand and Heir, 2021).

People participation in a given community is a crucial factor affecting urban solid waste management systems. Any health scheme cannot be guaranteed to succeed without an acceptable public attitude and engagement. Research on people’s knowledge, attitudes, and practices (KAP) regarding solid waste management programs is one of the best tools for evaluating public attitude and involvement towards waste management issues (Gaiani et al., 2018). In a previous study, 36.7% of the residents in Mazandaran Province, Iran, showed satisfactory knowledge of household hazardous wastes, while only 6.3% of them participated well in solid waste management (SWM) programs (Amouei et al., 2016). On the other hand, more than 80 percent of respondents in Wyoming, USA, were knowledgeable about waste reduction programs and motivated to participate, mostly due to their concern for the environment regarding proper waste disposal (Rom et al., 2017).

The results of a questionnaire study in Delhi revealed that 60% of the residents don’t know the difference between biodegradable and non-biodegradable waste. Only 2% of the residents separate MSW from its origin (Bhawal Mukherji et al., 2016). Providing regular training in the rapidly urbanizing areas of Thailand was reported to be able to promote the participation of residents in solid waste recycling (Yukalang et al., 2018). A large portion of the citizens in developing countries do not participate in decision-making regarding waste management, which reduces their concern, attitude, and responsibility (Essuman, 2017).

Besides establishing the required MSW infrastructures, achieving a sustainable SWM during the COVID-19 pandemic requires understanding public environmental concerns, knowledge, and behavior. The citizens’ participation in source separation programs during the COVID-19 outbreak may have a determining role in the establishment of safe recycling programs. The degree of propagation of the viral disease through waste management practices in developing countries with non-adaptive MSW management infrastructure would be more affected by public behavior rather than developed nations. In other words, it will hardly be possible to tackle the COVID-19 outbreak without involvement of residents’ KAP in decision-making on MSW management. To date, KAP of people regarding MSW management during the COVID-19 pandemic has rarely been investigated. The purpose of this research is to evaluate the level of Tehranian KAP compared to SWM during the outbreak of Covid-19, which has been identified for the first time in this study. Pragmatic remarks to promote participation of people in order to support proper MSW management are also provided, which can be used as a basis for developing proper waste management policies in developing countries during the COVID-19 pandemic. We hope that the paper will supplement the published literature and provide a reference for the decision-maker and environmental planners to raise the level of residents’ KAP in the field of solid waste management from the origin by stating the benefits of proper SWM; also, it is important to consider the economic and social consequences of inefficient SWM that directly affect people in this context.

2. Materials and methods

2.1. Study area

In this survey, Tehran City was selected as the study area as it is Iran’s capital and its most urbanized city. Based on the 2010 census conducted by the Sociology Department of the University of Tehran, in many districts of Tehran across various socioeconomic classes in proportion to population sizes of each district and socioeconomic class, 63% of the people were born in Tehran, 98% knew Persian, 75% identified themselves as ethnic Persian, and 13% had some degree of proficiency in a
Table 1
The Structure of questions.

| No. | Question description                                                                 | Type of people opinion on SWM during the pandemic | Component                           |
|-----|--------------------------------------------------------------------------------------|---------------------------------------------------|-------------------------------------|
| 1   | I am aware of Tehran SWM practices and services during the pandemic                  | Knowledge                                         | The importance of                        |
|     | Improper management and disposal of municipal solid wastes may cause a serious threat| Knowledge                                         | residents awareness about SWM          |
|     | during the COVID-19 outbreak                                                        |                                                   | in Tehran during                      |
| 2   | Household medical wastes are collected separate from the general wastes             | Knowledge                                         | COVID-19                              |
| 3   | As a resident, I have social responsibility to dispose my wastes properly to prevent | Knowledge                                         |                                                    |
|     | spread of the viral disease                                                         |                                                   | Tehran during                         |
| 4   | I produce more packaging wastes during the pandemic                                 | Practice                                           | COVID-19                              |
| 5   | Solid waste recycling programs has been ceased during the COVID-19 pandemic         | Knowledge                                         |                                                    |
| 7   | Awareness about methods for disposing of used facemask, single-use plastic gloves  | Knowledge                                         |                                                    |
|     | to prevent spread of the viral disease among waste collection teams                 |                                                   |                                                    |
| 8   | I put my used facemask, gloves and tissues in a tightly-closed bag, separate from  | Practice                                           | Residents’ role in                     |
|     | regular trash at home                                                               |                                                   | proper SWM during                     |
| 9   | Willingness to participate in short-term SWM educational courses and transfer the   | Practice                                           | COVID-19                              |
|     | gained knowledge to family members and acquaintances                                 |                                                   |                                                    |
| 10  | People discard the household medical wastes together with general wastes since the  | Practice                                           |                                                    |
|     | responsible authorities have not declared any separation and collection scheme       |                                                   |                                                    |
| 11  | I purchase my packed food, groceries and other items online during the Coronavirus   | Practice                                           |                                                    |
|     | pandemic                                                                            |                                                   |                                                    |
| 12  | I use the recommended PPEs in crowded places and discard them in trash bins          | Practice                                           |                                                    |
| 13  | Willingness to care for patients and take care of the produced medical waste at     | Attitude                                           | Role of training                       |
|     | home                                                                                |                                                   | programs during                       |
| 14  | People’s participation affects the proper collection and disposal of contaminated   | Knowledge                                         | COVID-19                              |
|     | PPEs                                                                                |                                                   |                                                    |
| 15  | Training is important for the proper handling of contaminated PPEs both at home and  | Attitude                                           |                                                    |
|     | public places                                                                       |                                                   |                                                    |
| 16  | Employer’s requirement is a reason for proper use and disposal of PPEs at my        | Attitude                                           |                                                    |
|     | workplace                                                                           |                                                   |                                                    |
| 17  | I use the PPEs at my workplace and discard them as recommended                       | Practice                                           | COVID-19                              |
| 18  | Used facemasks and gloves should not be recycled during the COVID-19 pandemic       | Knowledge                                         |                                                    |
| 19  | National and social media have promoted me to dispose my household wastes and PPEs  | Attitude                                           |                                                    |
|     | safely during the COVID-19 pandemic                                                  |                                                   |                                                    |
| 20  | Responsible organizations have effectively distributed household waste management   | Knowledge                                         |                                                    |
|     | guidelines and provided sufficient educational resources for all residents           |                                                   |                                                    |

European language. The area of Tehran is 730 km². It is located at longitude and latitude of 51.4215° E and 35.6944°N, respectively. Tehran City has an estimated population of 8693,706 making it the 21st largest city in the world. The metropolis of Tehran is divided into 22 municipal districts. The total yearly precipitation is 233 mm. The elevation of Tehran City above sea level ranges from 1020 m to 1060 m, and its average annual temperature ranges from −5 °C to 40 °C. Preceding the new SWM collection system’s implementation, around 1200 solid waste centers were located along the streets and between structures and in residential areas. These points were performed in the form of a transfer station. With the new collection system’s implementation, 11 municipal solid waste transfer stations were built in Tehran. The transfer stations recirculate more than 8000 tonnes of MSW daily and transport to the final disposal site. According to statistics, one-fifth of MSW of Iran’s waste is produced in Tehran. Tehran’s main waste disposal site, Arakdokh, is located 40 km south of the city and has been the principal waste disposal site of Tehran for several decades. The Arakdokh complex is primarily responsible for the separation, incineration, composting, and landfilling of Tehran’s MSW. Tehran is the most economically, socially, and environmentally affected city in Iran by the COVID-19 pandemic. There are many confirmed cases of COVID-19 infection in Tehran, but the Ministry of Health and Medical Education (MOHME) in Iran decided to announce only the total number of COVID-19 infected deaths and cases in Iran, and prevented releasing province-by-province details since mid-April.

2.2. Data collection

A survey questionnaire was created to assess the KAP of Tehranian residents regarding the MSWM in Tehran during the Coronavirus pandemic. There were open-ended and closed-ended questions in the questionnaire. During the survey, residents were asked to answer questions about their knowledge, attitudes, and practices regarding solid waste management. Participants under the age of 15 were not included in the survey. According to the type of data, the questions were categorized into two sections. In the first section, Tehranian residents were asked to provide socio-demographic information, including education level, age, marital status, occupation received education and its source, and types of the used PPEs. Socio-demographic information was collected to assess their effect on the KAP of respondents towards the MSW management during the outbreak of Coronavirus. The second part of the questions consisted of 20 closed questions involving: eight questions in knowledge, six questions in attitude, and six questions in practice. A five-point Likert scale is used to create this section of the questionnaire. The scale ranges from very slightly (=1) to extremely (=5). The questions were divided into three categories:

- Seven questions on the importance of residents’ awareness about SWM in Tehran during the COVID-19 pandemic
- Six questions concerning the importance of training in MSW management during the COVID-19 outbreak, as presented in Table 1.

The interviewees were asked to complete the questionnaire after clarifying their questions face to face. The designed questionnaire was examined by ten environmental experts and faculty members of the Department of Environment of Iran based on the research objectives in order to assess its validity. Using Cronbach’s alpha, the reliability of the questionnaire was also examined. According to the standard scale, the Cronbach’s alpha was 0.82, which was considered acceptable (George and Mallery 2003).

2.3. Sample selection method

This cross-sectional study carried out in Tehran City. Respondents were randomly chosen from the 22 urban district of Tehran City. Size of the population in this study was 7771,000. Cochran’s sampling theory was applied to determine the sample size using the following equation (Cochran, 1977):

$$n = \frac{N \cdot Z^2 \cdot \sigma^2}{(N - 1)c^2 + Z^2 \cdot \sigma^2}$$

(1)

When N and n demonstrate the population size and volume of the sample, respectively; $Z^2$ is the desired confidence level (95%), $\sigma^2$ is the
The variance of an attribute in the population (1.06) and e is the desired level of precision (0.05). According to Cochran’s formula, the maximum value of e can be chosen equal to 0.05 in order to have the highest level of precision. It was specified that there would be 385 participants in the study. A representative sample of the community was selected based on the community’s population. Using a simple random technique, samples were selected from five different geographical locations within the city: North, South, East, West, and the center. Face-to-face interviews were conducted at the door of the houses in order to collect data. Studies have shown that face-to-face interviews are more effective than other methods such as electronic mail, telephone, etc. Zhuang et al. (2008) reported an efficiency of response of 95%. The participation rate in surveys conducted via email has been reported to be low in studies. In addition, participants were justified in terms of the methodology, confidentiality of information, and study goals, and they all agreed to participate (Zhuang et al., 2008).

2.4. Statistical analysis

SPSS software (IBM SPSS Statistics, version 23) was used to analyze the collected data. An analysis of the relationship between knowledge, attitude, and practice based on demographic characteristics used descriptive statistics including mean and inferential statistics such as Pearson test at a significance level of p<0.05 and Chi-square.

3. Results and discussion

Daily more than 7500 tonnes of solid wastes are collected from 22 municipal districts of Tehran City. As a consequence of the prevalence of COVID-19 in Iran, the amount and composition of SW has changed in most regions of the country. The MSW composition in Tehran is shown in Fig. 2. After the outbreak of COVID-19, the amount of hospital waste generated in Tehran has increased by 22–42 tonnes per day.

Medical wastes generated by non-hospital sources (e.g. small healthcare centers) are collected with other MSW. The World Health Organization and other national disease control centers have issued guidelines in order to limit the spread of Coronavirus. Iran’s National Headquarters for Managing Coronavirus (INHMC) has recommended the use of personal protective equipment (PPE) (such as facemasks) in Iran. These recommendations have resulted in many of these personal protective equipments being used on a daily basis in Tehran during the COVID-19 outbreak. The majority of residents dispose of their used personal protective equipment (PPE) in the street or sewers, which could promote the spread of the disease and endanger public health, primarily for waste collectors and street sweepers.

Additionally, people tend to spend more time in their homes during COVID-19, resulting in increased waste production. As an example, residents of Tehran have generated more food waste since the prevalence of Coronavirus. Moreover, food delivery and online shopping have expanded in Tehran City. There has been an increase in packaging wastes, including HDPE and PET, in Tehran City’s waste stream during the COVID-19 outbreak. Consequently, single-use plastic is preferred as a safe alternative. In the meantime, discarded materials, including household medical wastes and personal protective equipment, may further exacerbate environmental and health problems if improperly managed. These threats would be much greater in developing countries with inadequate SWM strategies. Public participation for proper SWM is more critical than ever during the outbreak of COVID-19 in large cities of developing countries such as Tehran. Therefore, KAP of people regarding SWM during the COVID-19 outbreak has been provided for the first time in this study.

3.1. Respondents’ demographic profile

Table 2 shows demographic data concerning marital status, gender, age, occupation, education level, source of education, and types of PPE used by respondents.

Table 2 indicates that the majority of respondents was aged between 31 and 45 years (54.6%), and married (74.8%). Among the Tehranian residents 69.6% of the respondents were employed, 36.4% of them hold a diploma degree, while only 12.4% has post-graduate degree. Among the respondents, 142 (36.9%) were female and 243 (63.1%) were male. Most of the participants had received some education about the Coronavirus (70.6%). Those who had received education were asked about the source of education. Choices were “Public TV”, “Social media”, “National guidelines”, and “Others”. The highest rate among sources belonged to public TV with 34.6%, followed by the National guidelines (30.9%). Residents were also asked about their favored type of PPEs during the COVID-19 pandemic. They were given only one choice to choose the most frequently used type of PPEs. Among the respondents, 22.9% had never used any kind of PPEs during the COVID-19 pandemic. The most favored types of PPEs among Tehranian residents were face-mask (29.9%) and single-use gloves (26.5%), respectively.

3.2. The importance of residents’ awareness about SWM in Tehran during the coronavirus crisis

Table 3 shows the descriptive findings of this research. Demographic characteristics such as marital status, age, occupation, and education affected the level of KAP regarding SWM in Tehran in the COVID-19
prevalence. 62.8% of the higher-educated residents were aware of appropriate management of their generated wastes during the Coronavirus outbreak.

A significant correlation was found between education level, marital status, occupation, age, and gender of the Tehranian residents with awareness about SWM during the COVID-19 pandemic (p<0.05). For instance, the correlation between marital status (p<0.05, chi square=10.242), education level (p<0.05, chi square=14.234), and occupation (p<0.05, chi square=11.354) with awareness of people about SWM during the pandemic was considerable. That is consistent with the findings from Bhawal Mukherji et al. (2016) who concluded that the

occupation and education of people in Delhi, India play a significant role in their awareness of MSWM (Bhawal Mukherji et al., 2016). It is also reported that access to the internet and the education level of the residents in Bogota, Columbia, contribute significantly to the attitudes of individuals toward SWM programs (Kampf et al., 2020).

Employed residents had higher knowledge on SWM management during the pandemic. Based on the results and interviews, it seems that employed people in Tehran are more sensitive to protect their health than unemployed residents. Employed residents had also better knowledge regarding a safe disposal of the used PPEs compared to the unemployed respondents. Gender was also found to be an important factor affecting awareness of Tehranian residents about SWM. The Tehranian women were 67.4% aware of the importance of the safe disposal of PPEs as well as the methods for their proper disposal, while only 34.2% of the respondent men had satisfactory knowledge in this regard. Previous investigations have indicated that women usually have better environmental knowledge than men (Ahmadi, 2018; Padilla and Trujillo, 2018). Married Tehranian residents were also found to have more satisfactory knowledge on SWM during the viral disease outbreak compared to single residents. A major fraction of single residents did not have sufficient awareness on their responsibility towards a safe disposal of solid wastes such as used PPEs during the COVID-19 pandemic. Residents over 45 years were more knowledgeable about the proper disposal methods for solid wastes during the pandemic.

The results demonstrated that respondents who were married and employed, as well as possessed a higher educational level, were more knowledgeable about SWM during the COVID-19 outbreak than others.

### Table 2
Demographic characteristics of the studied inhabitants.

| Profile          | Categories               | Respondents’ number and percentage | Total |
|------------------|--------------------------|------------------------------------|-------|
| **Gender**       | Female                   | 142 (36.9%)                        | 385 (100%) |
|                  | Male                     | 243 (63.1%)                        | 385 (100%) |
| **Age bracket**  | 15–30                    | 35 (9.1%)                          | 385 (100%) |
|                  | 31–45                    | 210 (54.6%)                        | 385 (100%) |
|                  | 46–60                    | 98 (25.4%)                         | 385 (100%) |
|                  | >60                      | 42 (10.9%)                         | 385 (100%) |
| **Marital status**| Single                   | 97 (25.2%)                         | 385 (100%) |
|                  | Married                  | 288 (74.8%)                        | 385 (100%) |
| **Education**    | Pre-diploma              | 58 (15.1%)                         | 385 (100%) |
|                  | Diploma                  | 140 (36.4%)                        | 385 (100%) |
|                  | B.A or B.S.              | 139 (36.1%)                        | 385 (100%) |
|                  | M.A or M.S.              | 40 (10.3%)                         | 385 (100%) |
|                  | Ph.D.                    | 8 (2.1%)                           | 385 (100%) |
| **Occupation**   | Employed                 | 268 (69.6%)                        | 385 (100%) |
|                  | Unemployed               | 117 (30.4%)                        | 385 (100%) |
| **Received education** | Yes                    | 272 (70.6%)                        | 385 (100%) |
|                  | No                       | 152 (29.4%)                        | 385 (100%) |
| **Source of education** | Public TV          | 94 (34.6%)                         | 272 (100%) |
|                  | Social media             | 67 (28.6%)                         | 272 (100%) |
|                  | National guidelines      | 84 (39.9%)                         | 272 (100%) |
|                  | Others                   | 27 (9.9%)                          | 272 (100%) |
| **Personal protection equipment (PPE)** | Facemask             | 115 (29.5%)                        | 385 (100%) |
|                  | Single-use gloves        | 102 (26.5%)                        | 385 (100%) |
|                  | Face shields             | 22 (5.7%)                          | 385 (100%) |
|                  | Tissues                  | 58 (15%)                           | 385 (100%) |
|                  | None                     | 88 (22.9%)                         | 385 (100%) |

### Table 3
Participants answering to the survey questions based on demographic characteristics.

| Question | Demographic information | Agree (%) | Disagree (%) | p-value | Chi-square |
|----------|--------------------------|-----------|--------------|---------|------------|
| Q7       | Education (Pre-) Diploma| 40.3      | 59.7         | <0.001  | 14.234     |
|          | Higher Education         | 62.8      | 37.2         |         |            |
|          | Occupation                | 63.3      | 36.7         | <0.001  | 11.354     |
|          | Employed                 | 38.1      | 61.9         |         |            |
|          | Unemployed                | 36.7      | 63.3         | 0.001   | 10.242     |
|          | Marital                   | 59.4      | 40.6         |         |            |
|          | Single                    | 32.6      | 65.8         | 0.003   | 8.845      |
|          | Married                   | 34.2      | 65.8         |         |            |
|          | Age                       | 57.4      | 42.6         | <0.001  | 11.424     |
|          | >45                       | 41.0      | 59.0         |         |            |
|          | <45                       | 29.3      | 70.7         |         |            |
| Q8       | Education (Pre-) Diploma| 32.3      | 67.7         | <0.001  | 14.538     |
|          | Higher Education          | 48.0      | 52.0         |         |            |
|          | Age                       | 39.0      | 61.0         | 0.001   | 10.785     |
|          | >45                       | 29.3      | 70.7         |         |            |
|          | <45                       | 23.1      | 76.9         | 0.002   | 9.122      |
|          | Gender                    | 52.0      | 48.0         |         |            |
|          | Female                    | 52.0      | 48.0         |         |            |
|          | Male                      | 23.1      | 76.9         | 0.007   | 7.325      |
|          | Occupation                | 42.0      | 58.0         |         |            |
|          | Employed                 | 22.2      | 77.8         |         |            |
|          | Unemployed                | 22.2      | 77.8         |         |            |
| Q15      | Education (Pre-) Diploma| 57.5      | 42.5         | <0.001  | 11.268     |
|          | Higher Education          | 69.9      | 30.1         |         |            |
|          | Occupation                | 70.3      | 29.7         | 0.005   | 7.755      |
|          | Employed                 | 42.6      | 57.4         |         |            |
|          | Age                       | 62.3      | 37.7         | <0.001  | 12.351     |
|          | >45                       | 51.3      | 48.7         |         |            |
|          | <45                       | 23.1      | 76.9         | 0.007   | 7.325      |
which may be attributed to the higher attitude of women in gaining relevant educational information from different sources to face with the Coronavirus outbreak. Tehranian women also showed more willingness to transfer the gained knowledge on safe disposal of household wastes to their family member and acquaintances, compared to men during the Coronavirus outbreak (question 9). Previous studies also suggested that women can usually complete pro-environmental behaviors better than men (Ahmadi, 2018). The Significant correlation between the employment status of respondents with participation in SWM programs during the COVID-19 pandemic was also found (P<0.05). Employed residents had significantly higher practice towards safe management of wastes during the pandemic (42.0%), compared to the unemployed people (22.2%). This may be attributed to their higher knowledge and attitude about the SWM as well as the employers’ requirements for proper use and disposal of wastes at workplaces.

3.4. Role of training programs in MSW management during the outbreak of coronavirus

Failure to collaborate in separation and proper management of solid wastes during the COVID-19 pandemic can be attributed to the lack of efficient training programs, selective collection plans, and appropriate guidelines (De Feo and De Gisi, 2010). In order to attract residents’ collaboration in any management program for MSW during the pandemic, they are required to receive effective training to become aware of the serious environmental and health issues associated with improper SWM. Training programs may also enable residents to apply appropriate methods for separating, storing, and disposing of suspicious household wastes, involving medical wastes and PPEs. The Results of this study indicate that there have not been any robust motivation and legislation regarding proper separation and management of household wastes in Tehran during the Coronavirus outbreak. So far, most of the training programs have focused on encouraging the use of PPEs, which has increased the quantity of plastic wastes in Tehran. Insufficient training programs in SWM have been identified as a major problem by many developing countries (Deus et al., 2020; Fernando, 2019; Guerrero et al., 2013). The provision of public training to promote the contribution of residents in SWM programs could significantly affect MSW management during the COVID-19 outbreak.

If appropriate education programs are not provided, it is possible that SWM plans, particularly complicated programs, may not be well understood by some people (Purell and Magette, 2010). Education level, employment and age of respondents were found to be significantly correlated with KAP of Tehranian residents towards MSW training programs during the COVID-19 pandemic. Residents with higher education levels were more interested to receive education regarding MSW management during the pandemic and realized the necessity of relevant training programs more than residents with lower levels of education (P<0.05). Residents with higher education also emphasized on the importance of training to face with contaminated wastes e.g. PPEs during the COVID-19 outbreak. In the meantime, significant correlation between the employment situation of the respondents and their attitude towards the necessity of MSW training programs during the pandemic was found (P<0.05, chi square=7.775). As an example, responses to the questions 16 and 17 indicate that the availability of guidelines and requirements in workplaces have positively increased proper management of generated wastes such as PPEs.

National and social media have also positively affected people attitude towards SWM, but residents believed that responsible organizations had not effectively distributed household waste management guidelines or other educational resources for all Tehranian residents. 70.6% of respondents received education from various sources such TV channels and social media. Public TV and national guidelines were the main sources of gaining information on COVID-19 pandemic among Tehranian residents. There may be a significant role for different media in the formation and promotion of people’s attitudes and behavior toward SWM programs, as suggested by the literature (Mallick and Bajpai, 2019; Saunders and Goddard, 2002; Sujata et al., 2019). The correlation between residents age with willingness to receive SWM-related training programs during the pandemic was also significant (P<0.05). Interestingly, participation of older residents (>45 years) in recommended SWM programs such as proper disposal of PPEs at workplaces was more than younger residents, which may be attributed to the fact that different sources of education such as national TV have more emphasized on the susceptibility of the elderly people to the viral disease, which in turn promote their willingness to participate in proper usage and disposal of the PPEs.

3.5. Perspective of SWM in the era of COVID-19

The amount of produced waste in Tehran as a model of a large city in a developing country has risen since the outbreak of Coronavirus, due to the growing volume of plastic and medical waste as well as the change in people’s habits. Because of the lack of public participation and the non-sustainable handling of waste in many developing countries, these countries are more susceptible to Coronavirus transmission through SWM practices. In the era of COVID-19, management of municipal solid wastes in large cities of developing countries has no longer been possible without effective promotion of public KAP towards systematic SWM. Based on the obtained results, overall, 64.9% of respondents had a high level of knowledge, and 56.6% of respondents showed a satisfactory attitude towards SWM during the COVID-19 outbreak. But, only 33.1% of respondents practiced MSW management adequately during the pandemic.

Lack of consistency among practice and knowledge on MSW management was also reported in the literature (Giani et al., 2018; Mattar et al., 2018). In a previous study, 73% of respondents in Northern Thailand demonstrated a high level of knowledge about MSWM, but only 59% practiced it adequately (Laor et al., 2018). According to the results of this study, there are inconsistencies in Tehranian practice, attitude, and knowledge, which are due to weaknesses in the Tehran Solid Waste Management System, financial barriers, nonexistent comprehensive plans for the effective management of solid wastes during the pandemic, and inadequate cultural and technical infrastructures. It may also be inferred from the results that Tehran residents need to be more motivated to improve their environmental performance. The intrinsic or extrinsic motivations of individuals are among the most critical factors in determining the success of recycling programs (Nguyen and Watanabe, 2020; REMR, 2019). The intrinsic motivation of people in developing nations, such as Iran, is usually less evident than in developed countries. Extrinsic motivation, which is mainly associated with economic incentives, might be an influential factor affecting people’s practice regarding promoting SWM in Iran, which is suggested to be further studied. However, during the COVID-19 pandemic, urgent legislation accompanying training programs regarding SWM seems to be necessary, at least for short-term planning. In addition, most of the respondents did not separate household medical wastes from general wastes due to the lack of appropriate guidelines regarding the separation and collection of household medical wastes during Coronavirus pandemic. In general, 7% of Tehran’s municipal solid waste is legally separated (from the source 3%, Ardakouh 4%), whereas 10% is illegally separated by waste keepers for recycling. After the COVID-19 outbreak, legal separation and recycling of MSW have been completely suspended. However, illegal separation and recycling of wastes has continued. Intensive separation of MSW by waste pickers due to inadequate regulations could exacerbate the health impacts of illegal recycling and separation of materials during COVID-19. Tehran has suspended its waste separation and recycling program due to the possibility of spreading the new Coronavirus at solid waste transfer stations and recycling facilities. The separation of waste is more critical than ever during COVID-19 outbreaks, and only households that have infected or suspicious members should be exempted. Italy, for example, prohibits the separation of wastes at the source for
only infected residents (Zambrano-Monserrate et al., 2020). Currently, all the household wastes, including medical wastes, are being collected together and transported to the Ardakouh disposal site. Wastes are then landfilled/ buried without undergoing any processes or treatments. A major fraction of the residents expected the responsible authorities to provide more educational programs or resources regarding proper separation, storage, collection, and management of household wastes during the COVID-19 pandemic. For example, results indicated that 38.4% of the residents discard the used PPEs such as facemasks and single-use gloves in a tightly-closed bag, but finally, these bags are collected in accompany with general household wastes by waste collection teams. Separation of wastes, selective collection, and safe recycling and disposal programs should be established as soon as possible; otherwise, the emerging environmental and health outcomes pertained to improper SWM during the pandemic might be turned into complicated problems, which cannot be resolved conventionally. Residents are also not participating in waste separation programs because of poor communication between the municipality and them. As well as that, there are insufficient infrastructures, a lack of strategic planning, a lack of staff capacity, weak information systems, low engagement with programs, and unorganized waste management and fee collection methods. The situation could, however, be improved with external government support.

4. Conclusions and remarks

This research deals with some critical concerns about Tehranian residents’ knowledge, attitude, and behavior towards SWM during the COVID-19 pandemic. Only around one-third of residents of Tehran have practiced satisfactory towards SWM during the pandemic, though two-thirds of them were found to have some relevant knowledge. Having an adequate level of knowledge does not necessarily guarantee a high level of participation in SWM programs during the COVID-19 pandemic, as shown in this study, implying the exigency of implementing urgent training programs and as well as robust legislation during the pandemic to ensure acceptable levels of public participation in such a critical situation. As a result of the COVID-19 pandemic, SWM has faced logistical challenges in Tehran. Other environmental, financial, and technical concerns have also taken a back seat during this new crisis. Waste burial/landfilling has increased by more than 30% after the COVID-19 outbreak in Tehran. As a consequence of improper management of MSW in developing countries, such as Iran, secondary contagion is probable, unless they can establish integrated approaches for proper SWM during the pandemic. A few necessary, pragmatic statements are prioritized to enhance residents KAP and to upgrade proper SWM during the COVID-19 pandemic:

- Enhancing residents’ KAP towards proper SWM during the pandemic through regular training programs. District municipalities should hold free training programs for both residents and waste management workers on a regular basis.
- socioeconomic incentives such as partial tax exemptions can motivate residents to participate in SWM programs more effectively.
- Separate collection and transportation of (potentially) infectious wastes produced at medical centers and suspected homes to avoid mixing general wastes with COVID-19-contaminated wastes. Used gloves, facemasks, tissues and other suspicious wastes are required to be double-bagged, well tied and stored for 72 hr before being collected.
- Allocation of sufficient budget to promote source separation, recycling and “definite” incineration programs.
- Providing and extensive distribution of appropriate guidelines and protocols for separation, storage, collection and disposal of MSW including medical waste, used personal protective equipment, etc.
- Strict, urgent legislation for a “definite time” for residents and all commercial, institutional and industrial sectors to follow SWM guidelines during the pandemic.

- Special waste buckets should be prepared in public places such as metro stations, healthcare centers, and enormous buildings to discard used personal protective equipment.
- Devising long-term integrated SWM plans according to various plausible scenarios for the pandemic in the upcoming years, incorporating uncertainties and socioeconomic factors.

Providing public education and training programs is a must in such a situation, but enforceable legislation is also urgently required in developing countries to effectively promote residents KAP levels towards proper SWM during the pandemic. In developing countries, ignoring the impacts of the COVID-19 pandemic on solid waste management systems and public behavior would lead to more challenging and long-lasting environmental and health outcomes. In planning SWM procedures for the upcoming years, consideration of the effects of the COVID-19 pandemic on the environment and human health is unavoidable.

Authors’ contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Ali Daryabeigi Zand, Azar Vaezi Heir and Hamidreza Khodaei. The first draft of the manuscript was written by Ali Daryabeigi Zand and Azar Vaezi Heir and Hamidreza Khodaei commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability

All data generated or analysed during this study are included in this published article.

Availability of data and materials

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