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A process mining approach in big data analysis and modeling decision making risks for measuring environmental health in institutions

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ABSTRACT

This paper aimed to introduce a process-mining framework for measuring the status of environmental health in institutions. The methodology developed a new software-based index namely Institutional Environmental Health Index (IEHI) that was integrated from ontology-based Multi-Criteria Group Decision-Making models based on the principles of fuzzy modeling and consensus evaluation. Fuzzy Ordered Weighting Average (OWA) with the capability of modeling the uncertainties and decision-making risks along with Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) were employed as the computation engine. The performance of the extended index was examined through an applied example on 20 mosques as public institutions. IEHI could analyze big data collected by environmental health investigators and convert them to a single and interpretable number. The index detected the mosques with very unsuitable health conditions that should be in priority of sanitation and suitable ones as well. Due to the capability of defining the type and numbers of criteria and benefitting from specific and user-friendly software namely Group Fuzzy Decision-Making, this index is highly flexible and practical. The methodology could be used for numerating the environmental health conditions in any intended institution or occupation. The proposed index would provide e-health assessment by more efficient analysis of big data and risks that make more realistic decisions in environmental health system.

1. Introduction

Urbanization is becoming faster by passing the time specially, in medium and low income areas like developing countries and as a consequence the health deficiency is more sever in these locations due to lower earning and poor economy (Derakhshan et al., 2017; Mbuya and Humphrey, 2016; Verma et al., 2017). The correlation between physical environment, referring to buildings and public places, with human health has been one of the World Health Organization (WHO's) priorities since 1940s (Ene, 2014). Studies showed that the environmental health in a big city influences the economy as well as policy and it is an integral criterion for city planning and decision-making. Hence, the hygiene coverage is expected to be highly observed in such communities (Jenkins et al., 2014; Weingaertner and Moberg, 2014; Wolch et al., 2014).

On the other hand, it has been proved that such uncontrolled urban development has led to public health concerns such as tripled incidence of chronic disease and dwellers' mental disorders as well as inequality and increased level of violence and crime (Badland et al., 2014; Houngbo et al., 2017; Vardoulakis et al., 2016). In addition, inadequacy of community-based health will affect susceptible groups (Barrington et al., 2016). Therefore, a strong link between municipal governments, health experts and citizens is needed to cope with mentioned inadequacies (Lenzi et al., 2020).

Today, Health has a multifaceted definition being influenced by many different aspects among which institutional health is one of apparent and significant types (Caiaffa et al., 2014; Frumkin, 2016). Unlike many uncertainties that are present in this field, no integrated

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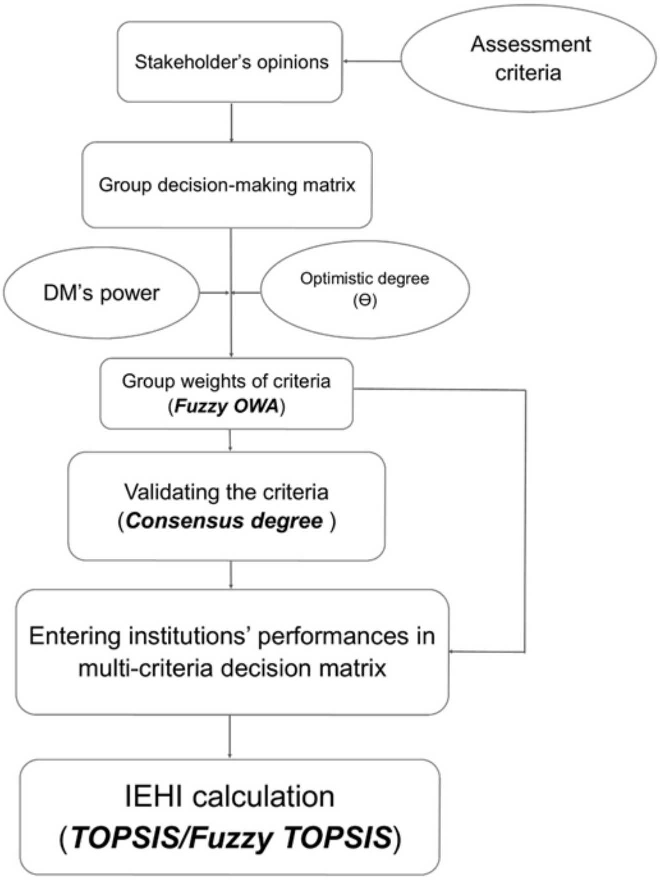

Fig. 1. The Process Mining framework of IEHI.

Table 1
Criteria used in the IEHI for mosques.

Criteria	Description	Criteria	Description
C_1	First aid box	C_{16}	Doors' and windows' lace
C_2	Cleaning	C_{17}	Shoes box existence
C_3	Carpet	C_{18}	Shoes box sanitary conditions (If existent)
C_4	Vacuum cleaner	C_{19}	Washroom floors
C_5	Prayer seal	C_{20}	Washroom walls and roofs
C_6	Health card for janitor	C_{21}	Washroom doors
C_7	Scarf distribution	C_{22}	Washroom ventilation
C_8	Trash bin	C_{23}	Washroom flush tanks
C_9	Floors' sanitary conditions	C_{24}	Washroom toilets
C_{10}	Walls' sanitary conditions	C_{25}	Water taps and gates
C_{11}	Roof's sanitary conditions	C_{26}	Liquid soap
C_{12}	Yard sanitation	C_{27}	Access to hot water
C_{13}	Cooling system	C_{28}	Pantry sanitary conditions (If existent)
C_{14}	Heating system	C_{29}	Pantry existence
C_{15}	Doors and windows	C_{30}	Sanitary discharge of sewage

effort has been taken into account for institutional environmental health big data analysis and most of these studies were too general or do not show the real conditions of these places (Bounit et al., 2016). For instance, some studies surveyed the institutional health status in mosques like the one conducted by Abdel Hameed and Habeeballah (2013). They investigated the microbial air contamination in Masjid al-Haram, Mecca. The results of their study further indicated the greater impact of human activities on the air contamination compared to the atmospheric effects (Hameed and Habeeballah, 2013). In another study, Das et al. (2012) indicated that insufficient light and ventilation, and unsuitable restrooms were the most obvious sanitary defects in both old and new buildings in Bangladesh. Hassan (2010) studied the traditional mosques in Malaysia. He found out that access to enough light, rainwater disposal, and ventilation had been three hygiene factors considered in building the mosques.

Rothenberg et al. (2014) believes that indices are useful metrics for measuring the level of community health because they have the advantage of reporting the current health status as a single interpretable number. The first efforts for quantifying the community health by using metrics were done by European Union in 2006, which led to introducing the Urban Health Index (UHI) (Pope et al., 2017). As another example, US Centers for Disease Control (CDC) set Environmental Public Health Indicators (EPHI). In 2013 for comprehensive assessment of environmental hazards and risk factors. Rothenberg et al. (2014) developed an UHI using the weighted geometric mean from nine standardized demographic indicators.

Frumkin (2016) rightly clings to the idea that now is a time to follow new methods of urban development known as "smart growth". This view in a true way boils down to having knowledge-based approach in which existing data and related standards (benchmarks) are considered in assessments (Yigitcanlar and Lönnqvist, 2013). This is while, as Makelarski et al. (2013) mentioned, for lack of having a comprehensive perspective, assessment of the health conditions in urban areas may be limited. A significant percent of a city is comprised from institutions and public places. These places play a major role in urban health (Woolthuis et al., 2013). Misapprehensions in environmental health in work places or other public places will cause mental health problems and social anomalies like increasing rate of violence, family breakdown, divorce or even suicide that in turn affects well-being of billions of people living in cities (Barbiero, 2014). It is in a way attributed to how health condition in public places and institutions where people communicate with each other during the day is observed. Since people spend a significant daytime at work, institutions and other public places, it seems that observing the health status in these places is a key value for health care system evaluation in urban communities. This is while this part is left blind and no similar research was found discussing on this aspect of urban environmental health by developing metrics such as an index for this section.

All these challenges together bring about a complex process encountering with a big data environment which highlight the need for using computerized planning support systems to analyze the health performance by employing new modeling methodologies and frameworks (Frumkin, 2016; Quan et al., 2013).

Information Technology (IT) helps systematic analysis of Health data be materialized which leads to more confident urban health policymaking (Castrucci et al., 2015). In this regard, there are two definitions that are known as hot topics in the field of IT. One is ontology which is "A formal naming of variables that are conceptual to computers" and the other process mining that refers to a set of techniques making the real process modeling be "Accomplished in an organization which has now been turned into worth disclosure in business process management" (Lee et al., 2014; Niaraki and Kim, 2009; Van Der Aalst et al., 2011; Derakhshan et al., 2019). These two definitions could help better measuring of environmental health performance in institutions and cope with conceptual obstacles in the modeling process.

Multi-criteria decision support systems have been used as ontology-based process mining algorithms in engineering software for solving complex process planning. These models have been successful because they could analyze big data. Therefore, their capability could be evaluated for urban health assessment as well.

According to the lack of quantitative research in this field, this paper aimed to present a new software-based index by using Multi-Criteria Decision Making (MCDM) framework based on the principles of fuzzy modeling and consensus evaluation for measuring the environmental health status in institutions and public places, which was applied on

Table 2
Group decision-making matrix and final weight of criteria in the IEHI for mosques.

Criteria	DM								Criteria's group weight
	Islamic advertising organization	department of Islamic culture	governor	mobilization of doctors	University experts	university professor 1	university professor 2	mosque affairs organization	
	DM's power								
	SH	H	M	M	VH	SH	SH	VH	
	DM's opinion								
C_1	M[1]	M	SL	SH	M	M	H	SH	0.3348
C_2	SH[2]	M	M	H	H	VH	H	SH	0.4262
C_3	M	M	M	H	H	VH	SH	SH	0.3979
C_4	SH	SH	M	H	SH	VH	L	M	0.3537
C_5	SH	SL	SL	H	H	VH	M	H	0.3696
C_6	SH	M	M	M	M	SH	M	VH	0.3517
C_7	H[3]	SL	SL	SH	SH	VH	VL	H	0.3074
C_8	SH	M	M	SH	H	VH	VH	H	0.4296
C_9	SL[4]	M	M	SL	SH	H	M	L	0.2683
C_{10}	SL	M	M	M	M	H	SH	SL	0.3097
C_{11}	H	M	M	M	SH	H	SL	SL	0.3245
C_{12}	H	M	M	M	SH	H	SL	SL	0.3245
C_{13}	VH[5]	SL	SH	SH	SH	SH	SH	SL	0.3612
C_{14}	VH	SL	SL	SH	SH	SH	SH	M	0.3473
C_{15}	M	M	M	SH	M	H	M	M	0.3445
C_{16}	M	L[6]	SL	M	SH	H	M	M	0.2826
C_{17}	M	VL[7]	SH	M	SH	H	L	SH	0.2626
C_{18}	M	SL	SH	M	VL	SH	M	M	0.2595
C_{19}	M	SL	M	H	SH	VH	SH	H	0.3772
C_{20}	M	SL	M	H	SH	VH	SH	H	0.3772
C_{21}	M	SL	M	H	H	VH	M	H	0.3728
C_{22}	SL	SL	M	H	H	VH	VH	H	0.3879
C_{23}	M	L	SL	SH	SH	VH	VH	H	0.3478
C_{24}	M	SL	M	SH	VL	VH	SH	H	0.2887
C_{25}	SH	SL	SL	SH	SH	M	M	H	0.3243
C_{26}	M	SL	SL	H	SH	H	H	H	0.3650
C_{27}	M	SL	SL	H	M	H	SL	SH	0.3091
C_{28}	SH	SL	M	M	H	VH	M	H	0.3623
C_{29}	SH	SL	SH	M	H	M	SH	H	0.3598
C_{30}	M	M	SH	SH	VH	VH	SL	H	0.3806

1 Medium, 2 Slightly High, 3 High, 4 Slightly Low, 5 Very High, 6 Low, 7 Very Low.

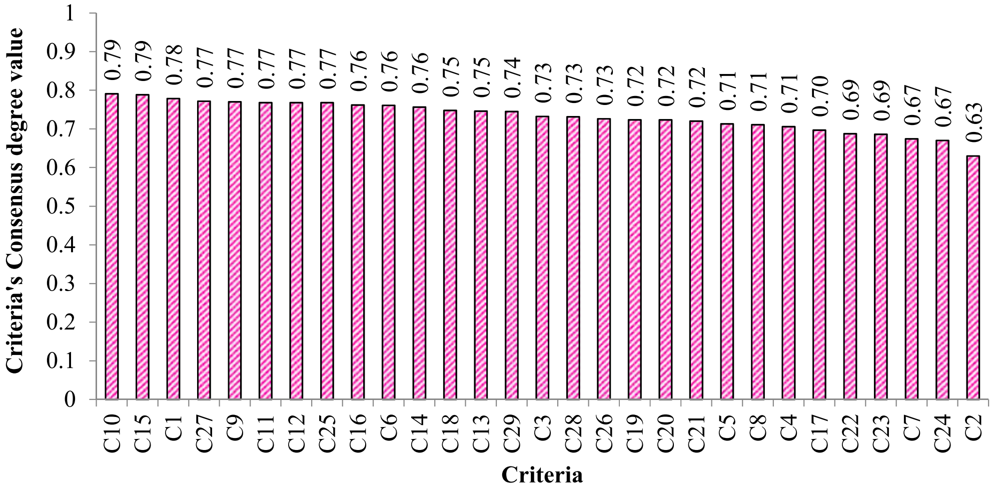

Fig. 2. Consensus degrees of criteria used in mosques' IEHI.

mosques as numerical examples.

2. Materials & methods

2.1. IEHI calculation

The proposed index namely Institutional Environmental Health Index (IEHI) was established based on fuzzy group-MCDM methods. The steps of developing this index are shown in Fig. 1. Two well-known decision-making models including Fuzzy Ordered Weighting Average (FOWA) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)/fuzzy TOPSIS make the structure of IEHI.

The first step was choosing assessment criteria and professional Decision-Maker (DMs) who are expert in the field of institutional health. They were separately asked to give their opinions on each criterion's importance for each, the importance was considered in seven ranks

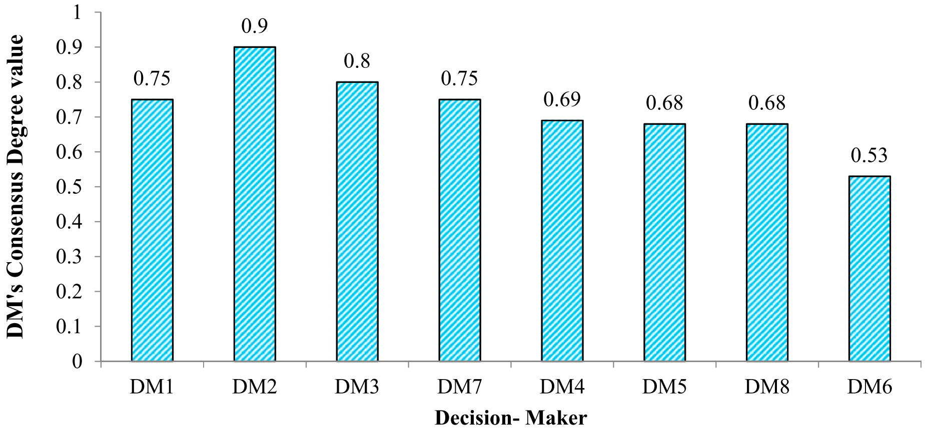

Fig. 3. DMs' consensus degree used in mosques' IEHI.

(Very Low, Low, Slightly Low, Medium, Slightly High, High, and Very High) and each DM selected the importance of each criterion from the mentioned options when filling the weighting questionnaire. The nature and number of criteria varies depend on the intended institution or public place. However, they could be extracted from health inspection checklists for a specific institution.

In the second stage, each criterion was weighted using FOWA. Yager (1988) developed this model and afterwards, using the fuzzy theory provided more accurate modeling of DMs' opinions and risks in-group decision-making process (Eq. (1)).

$$F_{OWA} : R^n \rightarrow R$$

$$F_i(r_{i1}, r_{i2}, \dots, r_{in}) = \sum_{j=1}^{n} w_j b_j = w_1 b_1 + w_2 b_2 + \dots w_n b_n \tag{1}$$

b_j is the jth criterion weight, n represents the number of DMs, and w_j is the order weights under the following conditions:

$$\sum_{j=1}^{n} w_j = 1, \quad w_j \geq 0 \tag{2}$$

The advantage of this operator is modeling the risks and uncertainties like DMs' risk aversion or risk prone attitude through measuring the optimistic degree (θ) and applying the DMs' power.

In the next step, after weighting the criteria and just before using them in the index, they were validated by determining the criteria's and DMs' consensus degrees. Criteria's consensus degree indicates that each criterion, regardless having high or low weight should achieve the minimum required consensus from the viewpoint of DMs in order to be used in the index. According to Ashton, the minimum consensus threshold for accepting the group comments is 0.6 (Ashton, 1992). Detailed information of mathematical functions of FOWA operator and the mentioned measures are adoptable from the following reference (Baghapour and Shooshtarian, 2017).

In the last step, the observed data of each institution's performance from the aspect of their health status were entered to the multi-criteria decision matrix to calculate the index value in the range of 0–100. TOPSIS functions as the aggregation operator and the computation engine of the index. This model was introduced by Yoon and Hwang in 1981 (Olson, 2004; Zarghami et al., 2015). This model measures how far is an alternative from the ideal solution (s^*) and non-ideal solution (s^-). A multi-criteria decision-making matrix of TOPSIS with m alternatives and n criteria is defined as bellow:

$$G = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{bmatrix} C_1 & C_2 & \cdots & C_n \\ G_{11} & G_{12} & \cdots & G_{1n} \\ G_{21} & G_{22} & \cdots & G_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ G_{m1} & G_{m2} & \cdots & G_{mn} \end{bmatrix}$$

$$W = [W_1, \ W_2, \dots, W_n]$$

In this matrix, (A_1, A_2, …, A_m) are the alternatives which in IEHI are the institutions or public places under estimation and (C_2, C_1, …, C_n) are the criteria; G_{ij} is the performance of alternative A_i from the viewpoint of the criterion C_j (the observation data of an institution or public place from the viewpoint of jth criteria) and W_j is the weight of the criterion C_j.

Note that if input data consist fuzzy numbers (for data that are ambiguous or linguistic data) the fuzzy mode of TOPSIS is used while if all the input data are crisp numbers then the process mining uses the classical mode of the model to calculate the IEHI number. The mathematical information of TOPSIS is presented in supplementary material (S).

IEHI is based on soft computing using specific software GFDM and this software does the whole calculation process. The software specification is provided in supplementary material (S).

3. Result and discussion

The current study has set out intending to present an innovative index for data analyzing and modeling the risks in assessing the environmental health conditions in institutions and public places.

This index represents the CEP (Complex Event Processing) and CPM (Corporate Performance Management) techniques of process mining in which the health experts' observations through their inspections serve as the Starting Point, fuzzy MCDM (Multi-Criteria Decision-Making) models are considered as Discovery Techniques, and the index value that shows the institutional health status (process performance) is the Decision Rules (Van Der Aalst et al., 2011).

In this study, on order to indicate the process of extending the methodology, IEHI was examined on mosques. Twenty mosques were considered the data of which were taken from Shiraz University of Medical Sciences. The criteria used in the IEHI for mosques were 30 adopted from the environmental health inspection checklist as shown in Table 1.

In the present study, eight professional DMs were chosen to give their opinions on each criterion's importance. These experts comprised from two university professors, an environmental health inspector from Shiraz University of Medical Sciences, Department of Islamic Culture, the Islamic Advertising Organization, the governor of Fars province, mobilization of doctors, and Mosque Affairs Organization. In this study, DMs had a relatively risk prone attitude about the mosque's health issue;

Table 3
Multi-criteria decision matrix of IEHI for considered mosques.

Performance	Mosque																				
	s^*	s^-	M_1	M_2	M_3	M_4	M_5	M_6	M_7	M_8	M_9	M_{10}	M_{11}	M_{12}	M_{13}	M_{14}	M_{15}	M_{16}	M_{17}	M_{18}	M_{19}	M_{20}
x_{iC1}	1	0	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
x_{iC2}	1	0	1	1	1	0	0	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1
x_{iC3}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	1	1	1	1	0	1
x_{iC4}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	0	1
x_{iC5}	1	0	1	1	1	0	0	0	0	1	0	1	1	1	0	0	1	0	1	1	1	0
x_{iC6}	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
x_{iC7}	1	0	1	1	1	0	0	0	1	1	0	1	1	0	1	0	1	0	0	1	0	0
x_{iC8}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	1	1
x_{iC9}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	1	1	1	0	1	1
x_{iC10}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	0	1	1	0	1	1
x_{iC11}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	0	1	1
x_{iC12}	1	0	1	1	1	0	1	0	1	1	1	0	1	1	0	0	1	1	1	1	0	1
x_{iC13}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1
x_{iC14}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1
x_{iC15}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	0	1	1	1	1	1
x_{iC16}	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
x_{iC17}	1	0	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1	0	0	1	1
x_{iC18}	1	0	1	1	1	0	0	0	0	1	1	1	0	1	0	0	0	1	0	0	0	1
x_{iC19}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1	0	0	1
x_{iC20}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1	1	0	1
x_{iC21}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	1	1	1	1	0	1
x_{iC22}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	0	0	1	0	0	1
x_{iC23}	1	0	1	1	1	0	0	0	0	1	1	0	1	1	0	0	0	1	1	0	0	1
x_{iC24}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	1	1	1	0	0	1
x_{iC25}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	1	1	1	1	0	1
x_{iC26}	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1
x_{iC27}	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1	0	1
x_{iC28}	1	0	1	1	1	0	0	0	0	1	1	1	1	1	0	0	1	1	1	0	0	1
x_{iC29}	1	0	1	1	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1
x_{iC30}	1	0	1	1	1	0	0	0	1	1	1	0	1	1	0	0	1	1	1	1	1	1

Table 4
IEHI values for mosques.

Mosque	M1	M12	M2	M3	M11	M8	M20	M17	M9	M16	M7	M15	M18	M10	M19	M6	M5	M4	M14	M13
Index value	82.4	81.1	78.9	74.2	73.6	68.6	65.6	62.5	62.5	59.0	56.1	48.1	47.6	42.6	38.7	19.6	17.7	14.5	12.0	10.4

thus, the optimistic degree equal to 0.091 (relatively pessimistic attitude) was selected (See Table 1 in reference No. 33 to get informed of the different status of optimistic degree values in FOWA model). The DMs' idea, DMs' power, and criteria's group weight, which were calculated by GFDM, are reported in Table 2.

According to DMs and Table 2, Trash bin, Cleaning, Carpet, washroom ventilation, and sanitary discharge of sewage have had the most importance in the developed index. As it is observed, all these criteria are cases whose observation has the most direct impact on the outward health of a mosque and the prayers. In contrast, Shoebox existence, Shoebox sanitary conditions, washroom floors, and Doors and windows' lace have played the minimal role in this index. These criteria are rarely the cause of direct damage to the mosque or prayers' health. The second stage was verifying the eligibility of each criterion, which was evaluated by calculating the consensus degree of the criteria and DMs. The results are presented in Fig. 2 and Fig. 3, respectively.

As shown in Fig. 2, from the criteria used by the index, walls' sanitary conditions, doors and windows, and first aid box are from the criteria with the greatest consensus degree values that means DMs have had the most agreement about them and in contrast, scarf distribution, washroom toilets, washroom flush tanks have had the least consensus degree values and the least agreement among the decision-making group. As it was referred to in the methodology, according to Ashton (1992), the minimum required consensus is 0.6. regarding this threshold, all criteria have received the minimum consensus; thus, there is no need of renegotiations for modifying the comments of any of them and all 30 criteria were allowed to be used in calculating the index. Determining this measure ensures the reasonableness of the DMs' views and correct use of each criterion and this is considered as one of the accuracy and innovative aspects of IEHI.

According to Fig. 2, the most and least values of DMs' consensus degrees have been respectively related to DM2 and DM6. These values can be interpreted such that, regarding the weights of criteria, these two DMs have respectively had the closest and the farthest view from the group's idea. Nevertheless, with comparing the values with the consensus threshold of Ashton, it can be found that DM6 with 0.53 did not achieve the minimum consensus and therefore her/his view was omitted from the weighting process.

In the next stage, the performance values of mosques from the viewpoint of the criteria were entered the GFDM. These data formed the multi-criteria decision matrix as shown in Table 3. In this table, the second and third columns show the ideal and non-ideal performances in assessing the mosques' environmental health, respectively. In the developed index, all criteria had benefit nature so that the score 1 was allocated to the favorable performance and zero to the unfavorable performance of each mosque from the viewpoint of each criterion.

In analyzing the model used in aggregating the mosques' data, it should be stated that by measuring the performance distance of each mosque from the ideal status, TOPSIS considers the best and worst possible performances in the aggregation and this makes the results of assessment more realistic and judgment on the health conditions of these places will be more reliable.

In the final stage, the observed data from the mosques were then aggregated by TOPSIS and the IEHI value for each of the studied mosques was calculated. Index values are presented in Table 4.

As the values of IEHI for mosques were reported in Table 4, 11 mosques showed numbers higher than 50 for their index values and have benefitted from a health condition higher than average level; among them, mosques M1 and M12 respectively with the indices of 82.84 and 81.15 reached the highest score and thus the best health conditions. On the contrary, 9 mosques had the index number less than 50 and the health conditions below the average level which among them, the index values of 10.4 and 12.02 have been respectively related to M13 and M14 which were very inappropriate. According to Table 3, mosque M13 only was favorable in terms of scarf distribution while it was unfavorable in terms of all other 29 criteria. In addition, the mosque M14 has only been favorable in terms of pantry existence, but it has been assessed unfavorable in terms of all other 29 criteria. This indicates that in judging the health condition in an institution or public health, many criteria play role like the 30 ones used for mosques in this paper and they should be considered in such an assessment. This is while as surveyed in the literature, all performed studies in this field such as Hameed and Habeeballah (2013), Hassan (2010), and Das et al. (2012) have discussed the reasons and health defects of their studied mosques by investigating only one or few factors separately and it seems that they have not had a comprehensive approach in health assessment of these places. Therefore, to our knowledge, no similar study was found having such a holistic approach in this field and this is one of the innovative points of the present study.

Maroufi et al. (2014), in their study have accurately emphasized on the role of socio-cultural components in mosques' performance and this is while the presence of sanitary conditions in mosques is absolutely as important as the other factors. Thus, compared to other studies, it seems that this research was the first comprehensive one in the assessment of institutional health having the modeling outlook and indexation having different approach from others.

US CDC presented EPHI as an index for evaluating the environmental health impacts on urban health. However, this index has somehow different approach from IEHI. EPHI by US CDC does not pursue data gathering, analyzing, or judgment. Besides, the one provided by California Department of Health Services involved 18 indicators; each gives a meaningful judgment of the current status but not the index as a whole (Rothenberg et al., 2015). These two indices have the same approach which is environmental hazard's evaluation while the one presented in this context evaluates the institutional health as one of the influential indicators in urban areas.

Additionally, flexibility of the extended IEHI causes the index be useable for any institution and public place which is another outstanding feature of this index. Therefore, this study is concurrent with Rothenberg et al. (2014). Those researchers believe that using indices, like UHI in their case, are highly depended on local conditions therefore; while indices could have the uniform structure they should be modified in their determinants in order to make the local decision-makers have more realistic understanding of health status of their own city.

4. Conclusion

In health care systems, due to economical limitations, the simultaneous improvement of the health conditions in public places is often impossible and performing this process in multiple stages is more reasonable for the managers. In the first step, the places with the lowest sanitary level should be identified by doing a comprehensive assessment and then they should be prioritized for optimization and improvement. This study has aimed to present a process mining framework of a numerical index for data analyzing and risk modeling in environmental health assessment in urban institutions and public places. Developed index indicated that some of the studied places had very unsuitable conditions and they should be prioritized for sanitation. This index is a useful indicator to measure institutional health status and it detects the weak points and the origins of health problems of them well.

Declaration of competing interest

The author declares no conflict of interest in the study.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envres.2021.111804.

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Author contribution

M. Dehghani, Z. Derakhshan: Conceptualization, Validation, Supervision, M.R. Shooshtarian: Methodology, Formal analysis, P. Moosavi: Resources, F. Zare, M. Ferrante, G.O. Conti: Writing - Review & Editing.

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