



Factors Affecting Medical Equipment Management in the COVID-19 Pandemic Crisis: A Mixed Qualitative and Quantitative Study

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Abstract

Background: Medical equipment plays an important role in community health in critical situations such as the COVID-19 pandemic.

Objectives: This study was conducted to determine and identify the factors affecting the management of medical equipment in crisis situations.

Methods: The present study was conducted as a mixed qualitative and quantitative study in 2020. In the qualitative section using the targeted sampling method, ten medical equipment management experts and in the quantitative section using available sampling method, 200 managers and experts active in this field from hospitals and related companies were selected for this study. The qualitative part was conducted in two stages of reviewing texts and interviewing experts and in the quantitative part we evaluated the validity of the structure and the reliability of the questionnaire.

Results: The validity of the structure was assessed using heuristic factor analysis. KMO index was 0.971 and Bartlett test was significant ($P < 0.05$). All six approved components in the content validity section, based on the mathematical model, explain and determine more than 77% of the variance related to the purpose of the study which is the management of medical equipment in COVID-19 pandemic situations.

Conclusion: The results showed that the instructions, management, information technology, equipment, manpower, and physical space components had the highest and lowest priority in the management of medical equipment in critical situations, respectively. In this regard, appropriate instructions should be provided first and localized protocols should be communicated from the same source at the same time.

Keywords: Equipment and Supplies, Risk Management, COVID-19

1. Background

A crisis is an event that occurs suddenly and sometimes increasingly and leads to a dangerous and unstable situation for an individual, group, or community¹ and causes a situation that requires fundamental and extraordinary measures to resolve. Crises are usually unpredictable, but usually not unexpected, except for natural disasters that cause crises; they are more of an emergency and a moment to become a permanent state.²⁻⁴

Although the timing of crises is not completely predictable, it can be managed using previous experience. In fact, if the critical situation is already researched and its critical problems and challenges are evaluated and analyzed, some problems would not occur in future crises. Although crises are not the same, the nature of their management is similar. Therefore, if the conditions of a

crisis such as the COVID-19 pandemic and all its relevant challenges are evaluated and examined, these results can be used in subsequent crises.^{5,6}

There are different types of crises, including personal crisis, social crisis, economic crisis, political crisis, international crisis and environmental crisis.⁷ What is most evaluated in this study are the crises that often challenge health systems, although it should be noted that most of the crises that have occurred in the world have not been ineffective on health systems. Among the previously mentioned crises, we can mention the latest crisis in the world, the COVID-19 pandemic. COVID-19 is a pandemic that has challenged the world in all aspects of economics, medicine, medicine, equipment, etc.⁸

COVID-19 started as an environmental crisis in Wuhan, China, in 2020 and affected the entire world in less than

six months. Patients with COVID-19 needed special units with assisted equipment due to respiratory problems. It should be noted that due to the rapid spread of this disease, the capacity of consumer equipment, capital, and even active special wards of the hospital did not respond to the need for crisis and the crisis has become more severe.⁹⁻¹⁴

To deal with this epidemic in terms of medical equipment, the management of two groups is required. The first group was medical equipment used as personal protection for medical personnel and members of the community to prevent the transmission of the virus¹⁵⁻¹⁹ and the second group was related to medical equipment and adjuvant therapy that was used to treat patients. Among these equipment, we can mention various types of ventilators, monitors, thermometers, and all equipment of the intensive care unit, etc.²⁰

2. Objectives

The onset of an epidemic in the world will affect all manufacturers and distributors of medical equipment and lead to problems such as shortages, significant price increases, the formation of groups or profiteers, etc.²¹ This study, therefore, aims to collect information from all hospitals, health centers, manufacturing companies, distributors, and all institutions involved in the management of medical equipment and analyze this information to create a management strategy to control the crisis of medical equipment in future crises and resolve the previous problems occurred.

3. Methods

3.1. Study Design

The present study is an analytical-applied and cross-sectional study conducted as a mixed qualitative and quantitative study in Iran in 2020.

3.2. Study Population

The target community of the quality department includes all university professors and experts with teaching experience or activity of more than ten years in the field of accident management and medical equipment engineering with specialized education in the field of medical engineering and its quantity counterpart consisted of a small number of managers and experts active in hospitals and public and private medical equipment companies.

3.3. Sampling Size

In the qualitative part, using purposive sampling method and snowball until saturation of opinions, and in the quantitative part, using the available sampling method and based on Krejcie & Morgan sample size determination table,²² 10 and 200 people were respectively selected to enter the study.

3.4. Method of Implementation (Qualitative Part)

The qualitative part of the present study was conducted in two stages. In the first stage, the method of library study

and systematic review was used. Persian and English articles and books from domestic and foreign databases such as Elsevier, Scopus, PubMed, Medline, IranMedex, IranDoc with the help of Google Scholar search engines and search for official reports in information sources of national and international organizations such as AHRO, WHO, NHS, ICAHO was thoroughly evaluated. After ensuring the complete search and saturation of the collected information, the content analysis method was used to encode, classify, and conclude the obtained information.

Finally, the variables affecting the management of medical equipment in critical situations were identified as a conceptual model in the form of six components of manpower, physical space, equipment, management, information technology, and instructions. In the second stage, to determine the status of each component in the COVID-19 pandemic crisis, the Delphi technique and interviews with experts were used. In this way, a conceptual model was provided to the experts for evaluation. Experts' opinions on adding, modifying, and reviewing various components and sections and determining the variables affecting them in the context of the COVID-19 pandemic crisis were collected in three round-trip stages. A questionnaire was provided to the experts to evaluate the content validity using content validity ratio (CVR) and content validity index (CVI) indicators. The CVR index in all items was higher than 0.8 and the CVI index in all components, as well as the whole questionnaire, was higher than 0.9. Finally, the content validity of the researcher-made questionnaire for the management of medical equipment in the COVID-19 pandemic crisis was confirmed (Table 1).

3.5. Method of Implementation (Quantitative Part)

Due to the fact that the researcher-made questionnaire was approved by experts in terms of content validity, it is necessary to evaluate the construct validity and reliability. To this end, 200 members of the target community were selected using the available sampling method and completed a questionnaire. Cronbach's alpha index was used to determine the reliability and an exploratory factor analysis technique was employed to determine the construct validity.

3.6. Data Collection Tools

The researcher-made questionnaire in this study includes 24 items in 6 structures (dimension) in which the measurement scale of each item was determined by five-choice Likert scale (very low=1, very high=5). The dimensions of the questionnaire also included manpower, physical space, equipment, management, information technology, and instructions.

3.7. Statistical Analysis

After collecting the questionnaires, exploratory factor analysis was used to evaluate the construct validity and Cronbach's alpha index was used to determine the reliability

Table 1. Researcher-Made Questionnaire After Confirming the Content Validity

Component	Factors
Manpower	Manpower training, how to use the equipment properly, matching the number of equipment with the number of patients, commitment to the device
Physical space	Equipment storage location, equipment layout, suitable trolleys for transporting equipment, the existence of suitable physical facilities and infrastructure, keeping the device clean
Management	Supply or purchase management, price management, resource distribution management, liabilities, producer management
Equipment	High precision equipment (calibrated), standard equipment
Instructions	Types of instructions and protocols, method of notification, time of notification, notifying authority, unity of instructions
Information technology	Integrated communication systems, online equipment registration system, information

of the dimensions and that of the whole questionnaire. All statistical analyses were performed by SPSS software version 21. The significance level of statistical tests was considered to be 5%.

4. Results

In the present study, 200 people were included in the study by available methods, 60% of whom were men. Fifteen point nine percent of the participants were under 30 years old, 46.6% were in the age range of 31 to 40 years and 37.5% were over 40 years old. 47.5% of the participants had a master’s degree, 21.6% had a professional doctorate, and 16.6% had a PhD (Table 2).

In performing exploratory factor analysis, first, the KMO index or the adequacy index of sampling and Bartlett’s test was evaluated. The KMO index is used to check small partial correlations between variables. In this study, the KMO index of 0.971 was obtained, which indicates the appropriateness of the information as well as the number of variables of each structure for exploratory factor analysis. Bartlett’s test was also obtained in this study ($P < 0.05$) showing that heuristic factor analysis is suitable for identifying the structure (factor model) (Table 3).

The results showed that the constructs designed in the researcher-made questionnaire from library studies and systematic review, as well as the opinion of experts based on the mathematical model, justify more than 77% of the variance related to the purpose of the study, i.e. medical equipment management in COVID-19 crisis. In other words, the questionnaire has the necessary capability to evaluate the management of medical equipment in the event of a COVID-19 crisis and can be cited. Therefore, this result confirms the validity of the structure (Table 4). According to the obtained results, manpower and information technology showed the most and the least amount of variance in the structure of medical equipment management in COVID-19 crisis conditions, respectively (Table 4).

Reliability evaluation showed that all constructs and the whole questionnaire had a Cronbach’s alpha greater than 0.7. In other words, reliability in the target population shows that the researcher-made questionnaire has good reliability, stability, accuracy, and reliability (Table 5).

Finally, in the target population, the study prioritized each of the factors affecting the management of medical equipment in the COVID-19 pandemic crisis. According

to the answers to the questions, the instruction component and then the management component had higher priority and the physical space component had the lowest priority in the management of medical equipment in critical situations (Table 6).

5. Discussion

With the outbreak of the COVID-19 pandemic in the world, the health sector is facing many challenges, which is one of the important areas of medical equipment. In addition to the fact that the virus persists on surfaces and can be transmitted to another person, the lack of equipment in various areas, from small consumables such as masks to heavy equipment such as ventilators has become more important.

The findings of the present study showed that the instruction component, management component, information technology component, equipment component, manpower component, and physical space component had the highest and lowest priority in managing medical equipment in critical situations, respectively. Based on this, the components of each of these factors were categorized as follows:

Managing factors affecting the management of medical

Table 2. Frequency Distribution of Study Participants

Demographic Characteristics		Frequency	Percent
Sex	Female	48	40
	Male	72	60
Age	Less than 30 years	19	15.9
	30 to 40 years	56	46.6
	More than 40 years	45	37.5
Education	B.Sc.	10	8.3
	M.Sc.	57	47.5
	M.D.	26	21.6
	Ph.D.	20	16.6
	Specialist	7	6

Table 3. Summary of Bartlett’s Test Results and KMO Index

KMO Measure of Sampling Adequacy	Bartlett’s Test of Sphericity		
	Chi-Square Statistic	df	P Value
0.971	48596.28	149	0.001

Table 4. Summary of the Results of Exploratory Factor Analysis With Varimax Rotation

Questions	Manpower	Physical Space	Management	Equipment	Instructions	Information Technology
To what extent is manpower training effective in managing medical equipment in times of crisis?	0.681					
To what extent does the proper use of equipment affect the management of medical equipment in times of crisis?	0.682					
To what extent does matching the number of equipment with the number of patients affect the management of medical equipment in times of crisis?	0.635					
To what extent does a sense of commitment to the device affect the management of medical equipment in times of crisis?	0.627					
To what extent does the existence of appropriate physical facilities and infrastructure affect the management of medical equipment in times of crisis?		0.591				
To what extent is equipment arrangement effective in managing medical equipment in times of crisis?		0.582				
To what extent is equipment storage effective in managing medical equipment in times of crisis?		0.577				
To what extent do proper equipment transport trolleys affect the management of medical equipment in times of crisis?		0.573				
To what extent does keeping the device clean affect the management of medical equipment in times of crisis?		0.567				
To what extent does supply or purchase management affect the management of medical equipment in times of crisis?			0.532			
To what extent do commitments affect the management of medical equipment in times of crisis?			0.528			
To what extent does resource distribution management affect medical equipment management in times of crisis?			0.529			
To what extent does price management affect the management of medical equipment in times of crisis?			0.530			
To what extent does manufacturer management affect medical equipment management in crisis situations?			0.527			
To what extent is high-calibration equipment effective in managing medical equipment in crisis situations?				0.509		
To what extent is standard consumer equipment effective in managing medical equipment in times of crisis?				0.504		
To what extent does the unity of guidelines affect the management of medical equipment in times of crisis?					0.631	
To what extent do all kinds of instructions and protocols affect the management of medical equipment in times of crisis?					0.619	
To what extent does notification time affect the management of medical equipment in crisis situations?					0.598	
To what extent does the notifying authority affect the management of medical equipment in times of crisis?					0.554	
To what extent does the communication method affect the management of medical equipment in crisis situations?					0.542	
To what extent does information affect the management of medical equipment in times of crisis?						0.758
To what extent do integrated communication systems affect the management of medical equipment in times of crisis?						0.596
To what extent does the online equipment registration system affect the management of medical equipment in times of crisis?						0.552
Cumulative Variance Percent	21.309	39.299	53.926	66.291	72.901	77.346
Exploratory factor analysis with varimax rotation						

Table 5. Summary of Reliability Assessment Results

Component	Number of Questions	Cronbach's Alpha Index
Manpower	4	0.791
Physical Space	5	0.731
Management	5	0.839
Equipment	2	0.855
Instructions	5	0.786
Information Technology	3	0.801
Questionnaire	24	0.890

Table 6. Summary of Friedman Test Prioritization Results

Component	Average Rating	Priority	P Value*
Instructions	4.2	1	0.001
Management	3.6	2	
Information technology	3.1	3	
Equipment	2.3	4	
Manpower	1.4	5	
Physical space	1.2	6	

* Friedman test

equipment in critical situations include management of supply or purchase of medical equipment, management of resource distribution in hospitals and medical centers, price management, management of manufacturers, equipment approvers, and acceleration of manufacturers and obligations.

Factors affecting the management of medical equipment in critical situations include types of instructions and protocols, how and when to communicate these instructions, the notifying authority, and the unity of instructions.

Factors of physical space affecting the management of medical equipment in critical situations include equipment storage, equipment layout, suitable trolleys for transporting equipment, the existence of appropriate physical facilities and infrastructure, and keeping the device clean.

Manpower factors affecting the management of medical equipment in critical situations include training of manpower courses, how to use the equipment properly, matching the number of equipment with the number of patients, and a sense of commitment to the device.

IT factors affecting the management of medical equipment in critical situations include integrated communication systems, online equipment registration system, and information.

Factors of efficient equipment on the management of medical equipment in critical situations include high-precision (calibrated) equipment and standard equipment. In this regard, strong and coherent information systems should be provided using the latest technology, so that all equipment are systematically tracked (for maintenance and calibration).

Research Highlights

What Is Already Known?

With the outbreak of the coronavirus in the world, the health sector is facing many challenges, of which medical equipment is one of the most important areas. In addition, the lack of equipment in various sectors, from small consumer equipment such as masks to heavy equipment such as ventilators has become increasingly important.

What Does This Study Add?

The present study showed that the components instruction, management, information technology, equipment, manpower, and physical space had the highest and lowest priority in managing medical equipment in critical situations, respectively.

6. Conclusion

According to the research findings, the instructions, management, information technology, equipment, manpower, and physical space component had the most and the least impact on the management of medical equipment in the COVID-19 crisis, respectively. In this regard, appropriate instructions should be prepared in advance, and in case of a crisis, the Crisis Management Committee should plan and announce the management of all matters. It is suggested to use the ideas of interested students and the capabilities of knowledge-based companies in this situation. Also, the use of technology solutions such as cloud computing can be useful in using the information of medical devices and equipment.

Authors' Contributions

Study design: VK; Data collection: AB; Data analysis: VK & MV; Manuscript writing: AB & MV; Critical revisions: VK.

Conflict of Interest Disclosures

There was no conflict of interest in this research.

Ethical Approval

The current study was approved by Isfahan University of Medical Sciences Ethics Committee.

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