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Original Article

Acceptance and Willingness to Pay for COVID-19 Vaccination by Iranian Society Using the Health Belief Model and Contingent Valuation

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Abstract

Introduction: Owing to the widespread COVID-19 pandemic, it has been introduced as an emergency problem for global health by the World Health Organization (WHO). Thus, policymaking to enhance public awareness and preparedness for successful vaccination should be a priority in the health policies of a country. In the present study, we examined the factors affecting the acceptance, intention, and willingness of Iranian society to pay for COVID-19 vaccination.

Methods: This cross-sectional study was conducted in Iran for six months in 2020. It was conducted by distributing a questionnaire in cyberspace. After distributing it, the respondents were asked to send the relevant link to some of their friends after answering its questions (snowball method). In this study, the constructs of the health belief model were used to identify the acceptance and intention of vaccination and evaluate the individuals' maximum willingness to pay for each dose of vaccine using questions based on the contingent valuation method.

Results: Most of the participants in the present study were 18-35 years old (50.8%), female (57.3%), and married (64.9%); most of them lived in urban areas (91.4%), had a bachelor's degree (38.4%), and had monthly income between 40 and 60 million Rials (26.8%). In terms of health status, only a small percentage reported their general health status at a poor level (2.8%), and 22% reported one chronic disease.

A total of 323 (81.5%) participants responded positively to the intention of vaccinating, while only 73 (18.5%) answered negatively. The majority of participants (68%) were not willing to pay for vaccination. The mean and standard deviation for the amount the participants were willing to pay was 36742426488349.30 Rials.

Conclusion: Since the outbreak of coronavirus disease, governmental measures to reduce mortality or morbidity such as public education, social distancing policies, and screening tests have been helpful, but the most effective way to control this disease was a widespread implementation of general vaccination. To implement it, preparedness and acceptance of vaccination by society will play an effective role.

Keywords: Health Belief Model, Willingness to Pay, Vaccination, COVID-19

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Introduction

The COVID-19 outbreak is an emerging phenomenon in the world that has affected all aspects of the lives of billions of people (1, 2). COVID-19 is a serious threat to world health and is a natural phenomenon. It causes respiratory and deadly infections in humans (3). Uncontrolled COVID-19 has affected the lives of millions of people and put severe pressure on the healthcare systems around the world. Governments have made great efforts to control and suppress COVID-19 disease, including public education, social distancing, screening tests, and vaccination (4). In this disease, control measures such as physical distance can help reduce the prevalence of the disease, but these measures will

be associated with high economic and social costs.

Efforts to make vaccines against human spherical virus infections such as MERS and SARS have not been effective for decades, and there is no approved vaccine for these diseases. Although few vaccines have been effective in the laboratory, they have not been tested in human or animal samples. Currently, there is no vaccine or drug with direct action against human spherical virus infections. It is widely agreed that vaccines have a particular importance (5). When a vaccine is introduced to the general population, doubts may arise regarding its efficacy and safety. Concerns about contamination, uncertainties related to the safety and reliability of the vaccination service system, ease of access to services, and costs exceeding expectations can all reduce the likelihood of vaccine acceptance (6). At the time of this study (2020), no vaccine for COVID-19 was available, and it was estimated that it would be available by the end of 2021 (7). However, sooner than expected, in December 2020, the FDA licensed the Pfizer-BioNTech vaccine (8), other vaccines, such as Moderna, AstraZeneca / Oxford, and Jansen, were quickly licensed, and vaccination was done all around the word (9). Even with the COVID-19 vaccination, not all people were expected to get vaccinated and refused to be vaccinated due to a phenomenon called hesitation (6).

Vaccination has started in Iran, but not all members of the society have been vaccinated so far, and there is still a high risk of death due to this disease. Since there is currently no definitive treatment for this emerging disease and its mortality is increasing all over the world, including in Iran, and since various mutations have been found in some countries, the only solution to create immunity of people in society against this disease is to vaccinate against this disease. Thus, policymaking to enhance public awareness and preparedness for successful vaccination should be a priority in the health policies of a country, and part of this planning process is to examine the demand and willingness of people to pay to receive the vaccine. Thus, this study aimed to examine the factors affecting vaccine acceptance and intention, as well as the willingness of the Iranian society to receive the coronavirus vaccine.

Methods

This cross-sectional study was conducted for six months (from October 2020 to early April 2021) before the implementation of the official vaccination program in Iran. The questionnaire of this research was distributed in cyberspace (email, telegram, Instagram, and WhatsApp), and each respondent was asked to send the relevant link to some of his/her friends after answering its questions (snowball method). The inclusion criteria were Iranian citizens and an age range of 18 to 70 years. Before using the questionnaire, the experts confirmed its content (face validity). The questionnaire was published experimentally and distributed among a large number of the Iranian population and more than 500 people received it and answered. A total of 396 respondents over the age of 18 were surveyed to assess their willingness to pay for vaccination (Figure 1).

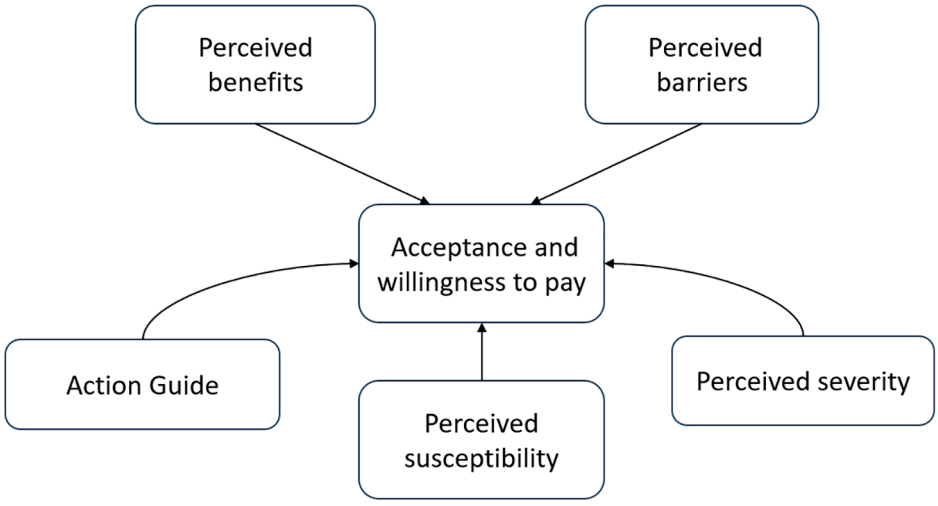

Figure 1: Hypothetical model of the relationship between the constructs of the health belief model and acceptance and willingness to pay (Authors)

Demographic Information, Health Status, and COVID-19 Experience

The first part of the questionnaire included demographic information, health status, and experience of COVID-19. In this section, personal information such as age, gender, residence, level of education, marital status, job, and average monthly household income were collected. Participants were also asked if they had a chronic disease (or a history of heart, lung, kidney, asthma, etc. diseases) and whether they had problems with anxiety and depression. Also, they were asked questions to assess their general health status, as well as a history of coronavirus disease or possible death among family or friends of the respondents. They were also asked how they obtained information about coronavirus disease. Their opinions about the disease and COVID-19 vaccination (perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and action guide) were inquired.

The Health Belief Model (HBM) was used to predict a wide range of health behaviors among a wide range of populations. Three broad areas were identified for the application of this model, including 1) preventive and health-threatening behaviors as well as vaccination and disinfection practices, 2) patient behaviors, and 3) the use of clinics that are for physician visits for various reasons (10).

In this study, the constructs of the Health Belief Model (HBM) were used to measure the participants' opinions about COVID-19 vaccination. In this model, there are four important factors. Based on this model, the second part of this questionnaire including 2 questions to identify the level of awareness of the disease and 5 questions to find out the perceived severity of coronavirus disease was developed. The third part of this questionnaire included 4 questions to assess the perceived susceptibility of individuals, 4 questions related to the perceived benefits of the vaccination, the fourth part included 8 questions to assess the perceived barriers to vaccination, and 4 questions used to assess the action guide. In this part, individuals' willingness to accept vaccination was assessed with a question that had four options "definitely yes, maybe yes, definitely no, and maybe no". In one question, the respondents were asked, if they did not want to be vaccinated, to state their reasons based on the options of "I am not sure about the effectiveness of the vaccination, I am not sure about the duration of the vaccination, I disagree vaccination, and I will only receive the vaccine if it is free". Respondents were also asked if their families would like to be vaccinated. If they answered "no", they were asked if their families would like to be covered by the vaccination program if it was free. Among HBM constructs, self-efficacy is not necessary to perceive simple health behavior, so it was not evaluated in this study (11, 12).

Willingness to Pay (WTP)

Willingness to pay is a monetary measure used to evaluate the value of a consumer good or program. It reflects the amount of money a person is willing to pay to purchase a good or benefit from a program (13). People's willingness to pay for a vaccine is derived from the CVM model, which is used to determine individual choices and estimate the monetary value of hypothetical vaccines (14). In the fifth part of this questionnaire, questions related to the willingness to pay are asked; to find out the maximum level of willingness to pay, two questions are used. The first question asks if they are willing to pay an amount equal to 10 million Rials for one dose of vaccine in the case of the availability of a vaccine in the market. If the respondents answered yes, they were asked whether they could pay 20 million Rials, and finally, what was the maximum amount they were willing to pay. If the respondents answered no to the first question, they were asked if they were willing to pay 5 million Rials for vaccination, and if they answered no, the reason was asked. If they answered yes, the maximum amount they were willing to pay was asked. The research questionnaire was designed based on the Guttman spectrum and the options for answering the questions including yes or no options (Figure 2).

Results

Examining the Demographic Characteristics

As shown in Table 1, the majority of participants were 18-35 years old (50.8%), female (57.3%), married (64.9%); most of them lived in urban areas (91.4%), had a bachelor's degree (38.4%), and had a monthly income between 40 and 60 million Rials (26.8%). In terms of health status, only a small percentage reported their general health status at a poor level (2.8%) and 22% reported one chronic disease.

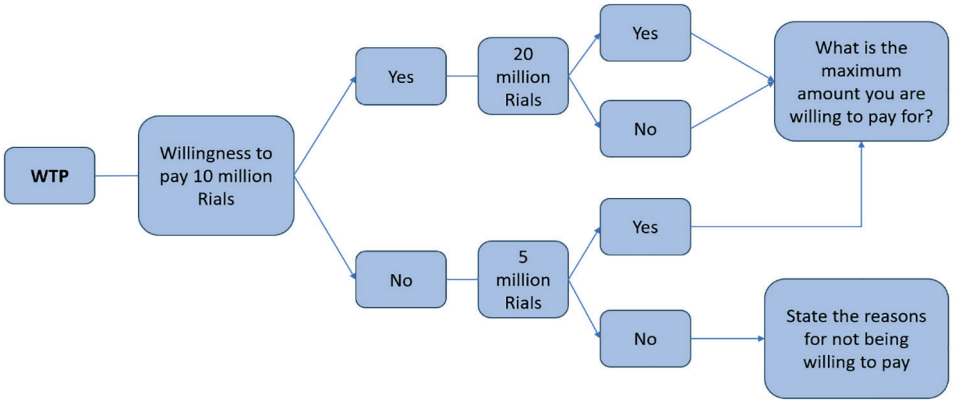

Figure 2: Steps of willingness to pay in this study

Table 1: Demographics and COVID-19 intention for vaccination (N=396)

	Overall N (%)	Intend n=323	Do not intend n=73
Age group (years)			
<18	4 (%1)	2 (%0.6)	2 (%2.7)
18-35	201 (%50.8)	161 (%49.8)	40 (%54.8)
36-55	161 (%40.7)	135 (%41.8)	26 (%35.6)
56-75	26 (%6.6)	24 (%7.4)	2 (%2.7)
>75	4 (%1)	1 (%0.3)	3 (%4.1)
Gender			
Female	227 (%57.3)	182 (%56.3)	45 (%61.6)
Male	169 (%42.7)	141 (%43.7)	28 (%38.4)
Marital status			
Married	257 (%64.9)	206 (%63.8)	51 (%69.9)
Single	130 (%32.8)	109 (%33.7)	21 (%28.8)
Other	9 (%2.3)	8 (%2.5)	1 (%1.4)
Living area			
Urban	362 (%91.4)	297 (%92)	65 (%89)
Rural	34 (%8.6)	26 (%8)	8 (%11)
Level of education			
<High school diploma	56 (%14.1)	46 (%14.2)	10 (%13.7)
Associate	36 (%9.1)	25 (%7.7)	11 (%15.1)
Bachelor	152 (%38.4)	126 (%39)	26 (%35.6)
Master	119 (%30.1)	99 (%30.7)	20 (%27.4)
PhD degree	33 (%8.3)	27 (%8.4)	6 (%8.2)
Monthly income (Iranian Rial)			
Without monthly income	105 (%26.5)	83 (%25.7)	22 (%30.1)
<20000000	37 (%9.3)	29 (%9)	8 (%11)
20000000-40000000	94 (%23.7)	75 (%23.2)	19 (%26)
40000000-60000000	106 (%26.8)	90 (%27.9)	16 (%21.9)
>60000000	54 (%13.6)	46 (%14.2)	8 (%11)
Diagnosed with chronic diseases			
Yes	87 (%22)	69 (%21.4)	18 (%24.7)
No	309 (%78)	254 (%78.6)	55 (%75.3)
Perceived overall health			
Very good	158 (%39.9	131 (%40.6)	27 (%37)
Good	162 (%40.9)	137 (%42.4)	25 (%34.2)
Mediocre	65 (%16.4)	49 (%15.2)	16 (%21.9)
Fair/poor	11 (%2.8)	6 (%1.9)	5 (%6.8)
Known any friends, neighbors, and colleagues infected by COVID-19			
Yes	241 (%60.9)	199 (%61.6)	42 (%57.5)
No	155 (%39.1)	124 (%38.4)	31 (%42.5)

Also, among friends, neighbors, and colleagues, 60.9% of the respondents had a history of COVID-19 disease.

Examining the Constructs of Health Belief Model and Willingness to Pay

In the perceived susceptibility part, only 25.8% believed that Covid-19 disease was fatal and that there was no treatment for it. The majority of participants (73%) believed that the disease was very serious but not fatal. Also, 54.5% considered the disease non-fatal and treatable, and 58.3% were worried about the serious effects after being infected with Covid-19. In this study, the perceived severity of the disease was at a high level. Also, 40.9% of the participants considered their chances of being infected with this disease at a high level and 60.1% estimated the chances of being infected with this disease in the next few months at a high level. Also, 92.90% believed that everyone could be infected with this disease and 87.1% considered vaccination necessary. The results also showed the participants had a high level of perceived benefits. In this regard, 75% said that vaccination would reduce their anxiety about Covid-19 disease, and 84.3% stated that vaccination would reduce the chances of being infected. Also, 64.9% considered vaccination as the most effective way to prevent and protect against COVID-19, and 83.3% stated that vaccination strengthened the immune system against the COVID-19 virus.

Regarding perceived barriers, 75.3% of the participants were worried about the effectiveness of the vaccine, and 60.4% were worried about the cost and price of the vaccine. Only 8.3% stated that they did not have enough time for vaccination, 33.6% were worried about the side effects, and 40.4% were doubtful about vaccine immunization and immunity. Also, 77.5% stated that they would be vaccinated if they had enough information about it, and finally, 34.8% stated that they would be vaccinated only if many people were vaccinated. The action guide also showed a high level in this study. In this regard, 80.6% of the participants responded positively to vaccination if there was a vaccination program and 74.7% showed willingness about the vaccination of their family members. Also, 75.5% stated that their family and friends should receive the vaccine, and 82.3% were willing to receive the vaccine if recommended by physicians.

Figure 3 shows the response ratio of willingness to receive the COVID-19 vaccine. A total of 323 patients (81.5%) among the participants responded positively to the vaccination and intended to be vaccinated, while only 73 patients (18.5%) responded negatively. It can be stated that the majority of the participants (46.7%) answered "definitely yes" to vaccination, 34.8% answered "maybe yes", 10.4% answered "maybe no", and 8.1% answered "definitely no". Figure 4 shows the different percentages of people responding to the constructs of the health belief model.

Table 2 presents the univariate and multivariate analyses of factors associated with the response "definitely yes". The results indicate that none of the demographic characteristics significantly influenced the intention to be vaccinated. In the perceived susceptibility part, those worried about the serious effects of COVID-19 (OR=0.655, 95% CI 0.437-0.980) showed the greatest willingness to be vaccinated.

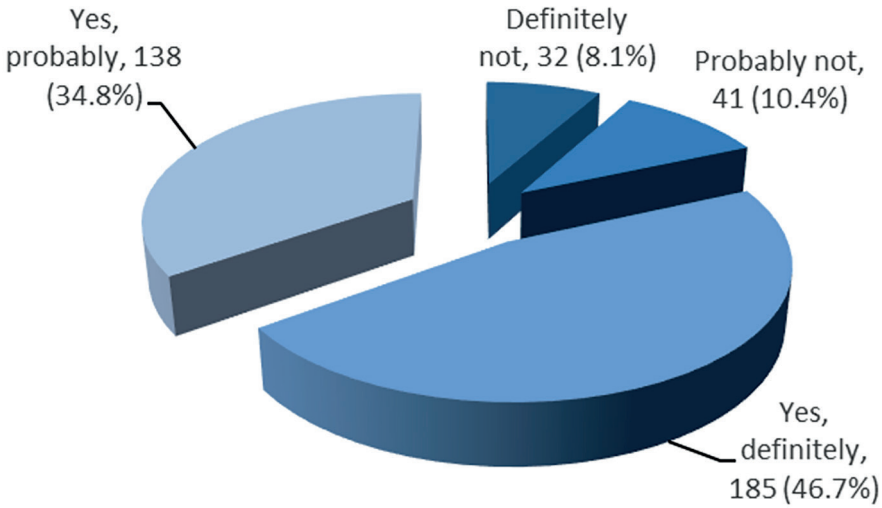

Figure 3: COVID-19 vacciation intention (N=395)

Perceived severity affected the willingness to be vaccinated, and those who had higher odds of being infected with the disease (OR=0.595, 95% CI 0.398-0.892) and thought that they would be more likely to be infected in the coming months (OR=0.578, 95% CI 0.017-0.183) and those who considered vaccination necessary (OR=0.056, 95% CI 0.017-0.183), respectively, were more willing to be vaccinated.

All perceived benefit items affected the willingness to be vaccinated. The most important part was related to the perceived barriers that showed the greatest odds for vaccination. In this part, respondents who were not doubtful on the immunity and safety of the vaccine (OR=5.210, 95% CI 3.367-8.061), were not worried about the side effects of vaccination (OR=3.895, 95% CI 2.498- 6.074), had trust in the vaccination (OR=3.844, 95% CI 2.310-6.532), were willing to be vaccinated if they had enough information about the vaccination (OR=2.438, 95% CI 1.509-3.939), respondents who reported that the number of people vaccinated had no effect on their decision to be vaccinated (IR=1.602, 95% CI 1.057-2.428), respectively, showed the highest willingness to be vaccinated.

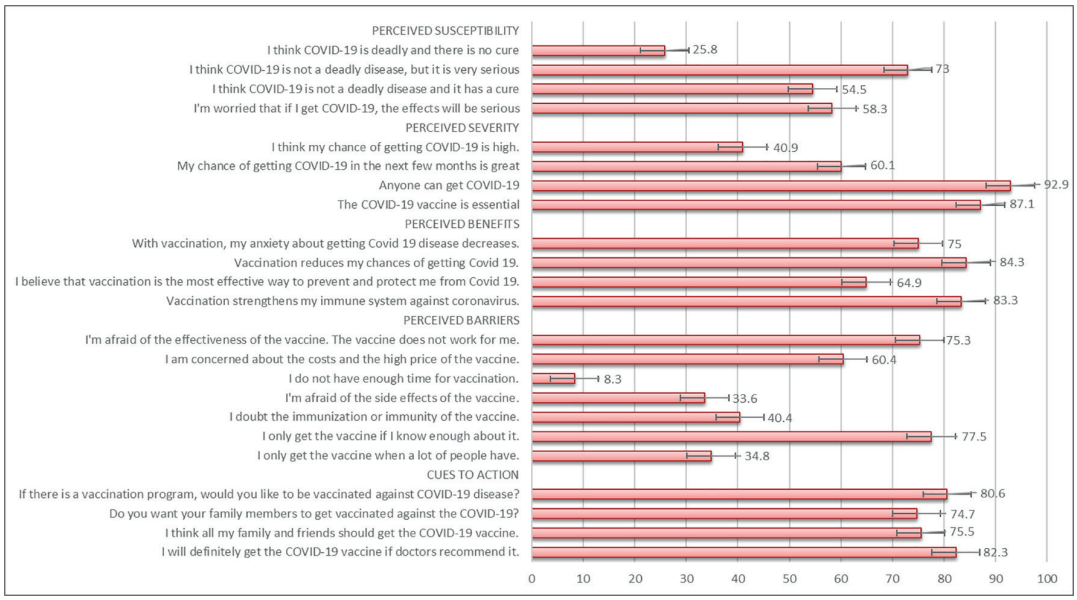

Figure 4: Proportion of positive responses to health belief model constructs (N=396)

Table 2: Multivariable logistic analysis of the factors associated with a definite intention to take the COVID-19 vaccine (N=396)

	Overall N (%)	**Univariate analysis**			**Multivariable logistic regression**
		Yes, Definitely (n = 185)	**Yes, probably/possibly, and definitely/probably not (n = 211)**	**P value**	**Yes, definitely vs. Yes, probably/possibly, and definitely/probably not OR (95% CI)**
Demographics					
Age group (years)					
<18	4 (%1)	1 (%25)	3 (%75)	0.853	
18-35	201 (%50.8)	96 (%47.76)	105 (%52.24)		
36-55	161 (%40.7)	73 (%45.34)	88 (%54.66)		
56-75	26 (%6.6)	15 (%57.69)	11 (%42.31)		
>75	4 (%1)	0 (%0)	4 (%100)		
Gender					
Female	227 (%57.3)	94 (%41.41)	133 (%58.59)	0.014	1.651 (1.105-2.466)
Male	169 (%42.7)	91 (%53.85)	78 (%46.15)		Reference
Marital status					
Married	257 (%64.9)	118 (%45.91)	139 (%54.9)	0.870	
Single	130 (%32.8)	64 (%49.23)	66 (%50.77)		
Other	9 (%2.3)	3 (%33.33)	6 (%66.67)		
Living area					

	Overall N (%)	Univariate analysis			Multivariable logistic regression
		Yes, Definitely (n = 185)	Yes, probably/possibly, and definitely/probably not (n = 211)	P value	Yes, definitely vs. Yes, probably/possibly, and definitely/probably not OR (95% CI)
Urban	362 (%91.4)	170 (%46.96)	192 (%53.04)	0.751	
Rural	34 (%8.6)	15 (%44.12)	19 (%55.88)		
Level of education					
<High school diploma	56 (%14.1)	17 (%30.36)	39 (%69.64)	0.035	2.159 (0.887-5.253)
Associate	36 (%9.1)	14 (%38.89)	22 (%61.11)		1.479 (0.568-3.856)
Bachelor	152 (%38.4)	81 (%53.29)	71 (%46.71)		0.825 (0.388-1.752)
Master	119 (%30.1)	57 (%47.90)	62 (%52.10)		1.024 (0.473-2.215)
PhD degree	33 (%8.3)	16 (%48.49)	17 (%51.51)		Reference
Monthly income (Iranian rial)					
Without monthly income	105 (%26.5)	47 (%44.76)	58 (%55.24)	0.041	2.098 (1.070-4.112)
<200000000	37 (%9.3)	14 (%37.84)	23 (%62.16)		2.793 (1.177-6.626)
200000000-400000000	94 (%23.7)	37 (%39.36)	57 (%60.64)		2.619 (1.313-5.222)
400000000-600000000	106 (%26.8)	53 (%50)	53 (%50)		1.700 (0.869-3.325)
>600000000	54 (%13.6)	34 (%62.96)	20 (%37.04)		Reference
Diagnosed with chronic diseases					
Yes	87 (%22)	42 (%48.28)	45 (%51.72)	0.741	
No	309 (%78)	143 (%46.28)	166 (%53.72)		
Perceived overall health					
Very good	158 (%39.9	82 (%51.90)	76 (%48.10)	0.047	Reference
Good	162 (%40.9)	74 (%45.68)	88 (%54.32)		1.888 (0.532-6.707)
Mediocre	65 (%16.4)	25 (%38.46)	40 (%61.54)		1.726 (0.958-3.112)
Fair/poor	11 (%2.8)	4 (%36.36)	7 (%63.64)		1.283 (0.827-1.991)
Known any friends, neighbors and colleagues infected by COVID-19					
Yes	241 (%60.9)	112 (%46.47)	129 (%53.53)	0.903	
No	155 (%39.1)	73 (%47.10)	82 (%52.90)		
Health belief					
Perceived susceptibility					
I think COVID-19 is deadly and there is no cure					
Agree	102 (%25.8)	51 (%50)	51 (%50)	0.441	
Disagree	294 (%74.2)	134 (%45.58)	160 (%54.42)		
I think COVID-19 is not a deadly disease, but it is very serious					
Agree	289 (%73)	130 (%44.98)	159 (%55.02)	0.256	
Disagree	107 (%27)	55 (%51.40)	52 (%48.60)		
I think COVID-19 is not a deadly disease and it has a cure					
Agree	216 (%54.5)	87 (%40.28)	129 (%59.72)	0.005	1.772 (1.188-2.644)
Disagree	180 (%45.5)	98 (%54.44)	82 (%45.56)		Reference
I'm worried that if I get COVID-19, the effects will be serious					
Agree	231 (%58.3)	118 (%51.08)	113 (%48.92)	0.039	0.655 (0.437-0.980) *
Disagree	165 (%47.1)	67 (%40.61)	98 (%59.39)		Reference
Perceived severity					
I think my chance of getting COVID-19 is high.					
Agree	162 (%40.9)	88 (%54.32)	74 (%45.68)	0.012	0.595 (0.398-892) *
Disagree	234 (%59.1)	97 (%41.45)	137 (%58.55)		Reference
My chance of getting COVID-19 in the next few months is great					
Agree	238 (%60.1)	124 (%52.10)	114 (%47.90)	0.008	0.578 (0.384-870) **
Disagree	158 (%39.9)	61 (%38.61)	97 (%61.39)		Reference
Anyone can get COVID-19					
Agree	368 (%92.9)	176 (%47.83)	192 (%52.17)	0.109	
Disagree	28 (%7.1)	9 (%32.14)	28 (%68.86)		
The COVID-19 vaccine is essential					

	Overall N (%)	Univariate analysis			Multivariable logistic regression
		Yes, Definitely (n = 185)	Yes, probably/possibly, and definitely/probably not (n = 211)	P value	Yes, definitely vs. Yes, probably/possibly, and definitely/probably not OR (95% CI)
Agree	345 (%87.1)	182 (%52.75)	163 (%47.25)	0.000	0.056 (0.017-0.183) ***
Disagree	51 (%12.9)	3 (%5.88)	48 (%94.12)		Reference
Perceived benefits					
With vaccination, my anxiety about getting COVID-19 disease decreases.					
Agree	297 (%75)	176 (%59.26)	121 (%40.74)	0.000	0.069 (0.033-0.142) ***
Disagree	99 (%25)	9 (%9.09)	90 (%90.91)		Reference
Vaccination reduces my chances of getting COVID-19					
Agree	334 (%84.3)	181 (%54.19)	153 (%45.81)	0.000	0.058 (0.021-0.164) ***
Disagree	62 (%15.7)	4 (%6.45)	58 (%93.55)		Reference
I believe that vaccination is the most effective way to prevent and protect me from Covid 19.					
Agree	257 (%64.9)	160 (%62.26)	97 (%37.74)	0.000	0.133 (0.081-0.219) ***
Disagree	139 (%35.1)	25 (%17.99)	114 (%82.01)		Reference
Vaccination strengthens my immune system against coronavirus.					
Agree	330 (%83.3)	177 (%53.64)	153 (%46.36)	0.000	0.119 (0.055-0.258) ***
Disagree	66 (%16.7)	8 (%12.12)	58 (%87.88)		Reference
Perceived barriers					
I'm afraid of the effectiveness of the vaccine. The vaccine does not work for me.					
Agree	298 (%75.3)	162 (%68.35)	75 (%31.65)	0.000	Reference
Disagree	98 (%24.7)	23 (%14.46)	136 (%85.54)		3.884 (2.310-6.532) ***
I am concerned about the costs and the high price of the vaccine.					
Agree	239 (%60.4)	112 (%46.86)	127 (%53.13)	0.943	
Disagree	157 (%39.6)	73 (%46.50)	84 (%53.50)		
I do not have enough time for vaccination.					
Agree	33 (%8.3)	9 (%27.27)	24 (%72.73)	0.019	Reference
Disagree	363 (%91.7)	176 (%48.48)	187(%51.52)		2.510 (1.135-5.548) *
I'm afraid of the side effects of the vaccine.					
Agree	133 (%33.6)	91 (%68.42)	42 (%31.58)	0.000	Reference
Disagree	263 (%66.4)	94 (%35.74)	169 (%64.26)		3.895 (2.498-6.074) ***
I doubt the immunization or immunity of the vaccine.					
Agree	160 (%40.4)	112 (%70)	48 (%30)	0.000	Reference
Disagree	236 (%59.6)	73 (%30.93)	163 (%69.07)		5.210 (3.367-8.061) ***
I only get the vaccine if I know enough about it.					
Agree	307 (%77.5)	126 (%41.04)	181 (%58.96)	0.000	2.438 (1.509-3.939) **
Disagree	89 (%22.5)	59 (%66.29)	30 (%33.71)		Reference
I only get the vaccine when a lot of people have.					
Agree	138 (%34.8)	75 (%54.35)	63 (%45.65)	0.026	Reference
Disagree	258 (%65.2)	110 (%42.64)	148 (%57.36)		1.602 (1.057-2.428) *
Cues to action					
If there is a vaccination program, would you like to be vaccinated against COVID-19 disease?					
Agree	319 (%80.6)	181 (%56.74)	138 (%43.26)	0.000	0.042 (0.015-0.117) ***
Disagree	77 (%19.4)	4 (%5.19)	73 (%94.81)		Reference
Do you want your family members to get vaccinated against COVID-19?					
Agree	296 (%74.7)	180 (%60.81)	116 (%39.19)	0.000	0.034 (0.013-0.086) ***
Disagree	100 (%25.3)	5 (%5)	95 (%95)		Reference
I think all my family and friends should get the COVID-19 vaccine.					
Agree	299 (%75.5)	182 (%60.87)	117 (%39.13)	0.000	0.021 (0.006-0.066) ***
Disagree	97 (%24.5)	3 (%3.09)	94 (%96.91)		Reference
I will get the COVID-19 vaccine if doctors recommend it.					
Agree	326 (%82.3)	181 (%55.52)	145 (%44.48)	0.000	0.049 (0.017-0.136)
Disagree	70 (%17.7)	4 (%5.71)	66 (94.29)		Reference

*P<0.05; **P<0.01; ***P<0.001; Hosmer–Lemeshow test, chi-square: 6.090, *p*-value: 0.637; Nagelkerke R^2: 0.605

Figure 5 shows that most participants (68%) were willing to pay for vaccination. The mean and standard deviation for the amount that the participants were willing to pay was 3674242.42±6488349.30. Given the household income, the willingness to pay for vaccination was obtained according to Figure 5.

Figure 5 shows the results of willingness to pay for vaccination for COVID-19 with the options of "not willing to pay for", "willing to pay 5 million Rials ($ 16), 10 million Rials ($ 32), and 20 million Rials ($ 66). The results showed that participants with an income of 40-60 million Rials and people who did not consider their odds of being infected with the disease high in the next few months were not willing to pay for vaccinations. Figure 6 shows the participant's willingness to pay based on their mean income. The highest willingness to pay was related to those with an income of more than 60 million Rials and these people had accepted the highest amount for vaccination.

Discussion

COVID-19 vaccination has greatly reduced the number of deaths due to this disease around the world. However, despite the development of some vaccines and vaccinations in various countries, one of the worrying factors for governments is still the vaccine effectiveness against new strains and mutations found in this virus. Few studies have been conducted so far on WTP for vaccination against COVID-19, including the studies conducted by Garcia and Sardar in Chile, Harapan et al. in Indonesia, Wong et al. in Malaysia, and Sarasti et al. in Ecuador, and Adeli et al. in Iran (15-19). In most of these studies,

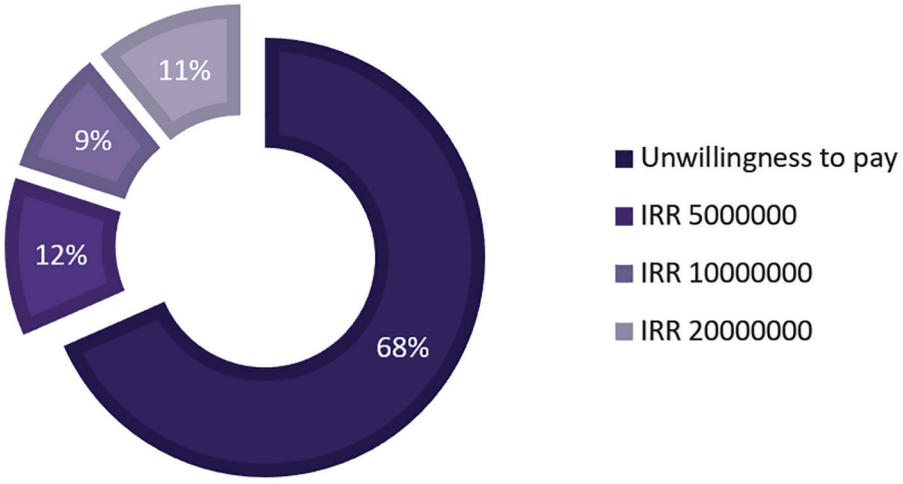

Figure 5: Overall willingness to pay (WTP) for the COVID-19 vaccine (N=396)

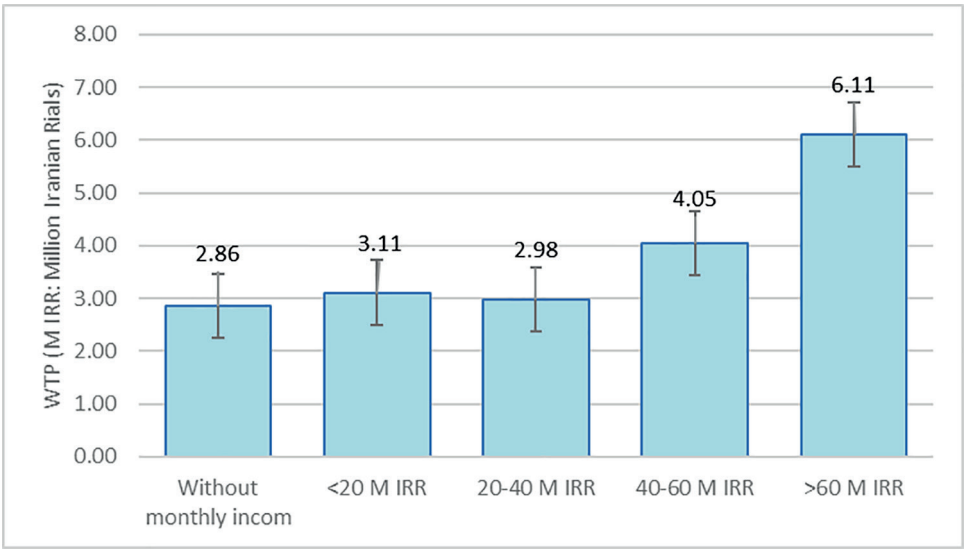

Figure 6: WTP by average household income groups (N=396)

only the willingness to pay for society has been studied. Also, studies have been conducted to identify the intention to be vaccinated against infectious diseases using the health belief model method (20, 21).

In these studies, only the factors affecting the acceptance of vaccination in society have been studied, but in the present study, the intention of Iranians to receive the COVID-19 vaccine and their willingness to pay possible costs in the future were examined. Also, according to the predictors of health behaviors and different demographic types and using a combination of HBM and WTP models, the target population was assessed. The results revealed that the majority of those present in the study were willing to receive the COVID-19 vaccine, which is in line with other similar studies (9, 22, 23). Also, respondents who were not worried about the side effects of vaccination and those who were willing to be vaccinated if they had enough information about the immunization showed the highest willingness to be vaccinated, which is in line with the study conducted by Yulan Lin et al. (24).

In the present study, the results revealed that participants with a monthly income of more than 60 million Rials were willing to pay the highest cost for vaccination, indicating the role of economic factors on the maximum amount they were willing to pay. In the research conducted by Sarsati et al., regression results also showed that WTP for vaccination was related to income, job, probability of need for hospitalization if infected with the COVID-19 virus, and residence (18). In other contingent valuation studies, a significant number of participants were willing to accept a lower price for the proposed policy, even if it meant an increase in the suggested cost. However, in this study, people were willing to pay for vaccination if it was not free, which is consistent with the study conducted by Adeli et al. (19). In this study, the mean and standard deviation of the amount that participants were willing to pay was 3674242.42±64.88349.30 (approximately equivalent to US $ 23.23) for one dose; this amount was lower compared to the mean willingness to pay in the study conducted by Wong et al. in Malaysia (US $ 18.12) and the mean willingness to pay in the study conducted in China (US $ 28). However, the maximum willingness to pay in the present study (US $ 66.66) was higher than that in a study conducted in Malaysia (US $ 23) (18, 17).

Although the majority of those who participated in the study were willing to perform and accept vaccination in the present study, more than half of them (68%) including people who did not consider the high odds of developing the disease in the next few months were not willing to pay for the vaccination. Also, based on the results of this study, none of the demographic characteristics affected the intention to accept the vaccination, which could indicate the importance of vaccination from the point of view of Iranian society, since a high perceived severity of the subject was received in this study. People who considered high odds of development of the disease in the coming months as well as those who thought it was necessary to be vaccinated were more likely to accept vaccination, indicating the role and effect of perceived severity of the disease on vaccination.

Research Limitations

The present study started when there was no official vaccination program for the Iranian population and it was conducted during a period of the coronavirus pandemic in which most of the provinces of Iran were in the red situation and the incidence of this disease was relatively high. It can cause bias in the response of people to the maximum amount of willingness to pay. Also, the questionnaire of this research was published in cyberspace and used in Iranian society, which has led to limitations in the method of using the questionnaire.

Conclusion

The emergence of diseases such as Covid-19 has caused great worry for people and governments around the world and has affected human life in many aspects. Thus, governments and the World Health Organization have made great efforts to control and suppress this disease. Implementing some control measures such as physical distancing has helped reduce the prevalence of COVID-19, but such measures have imposed high economic and social costs. Hence, the only effective way to eradicate the disease globally is general vaccination, and it is considered effective among the people of a society. To help policymakers at the global and local levels and to prioritize health interventions, we need to recognize the preferences of the people in the

society, and willingness to pay for them will be one of the most important issues for health policy adoption.

Ethical Consideration

There are no ethical considerations to be considered in this research.

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Conflict of Interest

None declared.

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Appendix: Multinomial logic regression of factors associated with marginal willingness to pay (WTP) for COVID-19 vaccine (N=396).

	Overall N (%)	Univariate analysis				P value	Multinomial logistic regression		
		Unwillingness to pay (n=271)	IRR5000000 (n=46)	IRR10000000 (n=36)	IRR20000000 (n=43)		Unwillingness to pay OR (95% CI)	IRR5000000 OR (95% CI)	IRR10000000 OR (95% CI)
Demographics									
Age group (years)									
<18	4 (%1)	3 (%75)	0 (%0)	1 (%25)	0 (%0)	P>0.05			
18-35	201 (%50.8)	139 (%69.15)	25 (%12.44)	19 (%9.45)	18 (%8.96)				
36-55	161 (%40.7)	110 (%68.32)	18 (%11.18)	15 (%9.32)	18 (%11.18)				
56-75	26 (%6.6)	16 (%61.54)	3 (%11.54)	1 (%3.85)	6 (%23.08)				
>75	4 (%1)	3 (%75)	0 (%0)	0 (%0)	1 (%25)				
Gender									
Female	227 (%57.3)	165 (%72.69)	22 (%9.69)	21 (%9.21)	19 (%8.37)	P>0.05			
Male	169 (%42.7)	106 (%56.08)	24 (%12.70)	15 (%7.94)	44 (%23.28)				
Marital status									
Married	257 (%64.9)	173 (%67.32)	30 (%11.67)	20 (%7.78)	34 (%13.23)	P>0.05			
Single	130 (%32.8)	90 (%69.23)	16 (%12.31)	15 (%11.54)	9 (%6.92)				
Other	9 (%2.3)	8 (%88.89)	0 (%0)	1 (%11.11)	0 (%0)				
Living area									
Urban	362 (%91.4)	247 (%68.23)	43 (%11.88)	34 (%9.39)	38 (%10.50)	P>0.05			
Rural	34 (%8.6)	24 (%70.59)	3 (%8.82)	2 (%5.88)	5 (%14.71)				
Level of education									
<High school diploma	56 (%14.1)	34 (%60.75	10 (%17.86)	5 (%8.93)	7 (%12.50)	P>0.05			
Associate	36 (%9.1)	27 (%75)	3 (%8.33)	3 (%8.33)	3 (%8.33)				
Bachelor	152 (%38.4)	99 (%65.13)	17 (%11.18)	15 (%9.87)	21 (%13.82)				
Master	119 (%30.1)	88 (%73.95)	12 (%10.08)	9 (%7.56)	10 (%8.40)				
PhD degree	33 (%8.3)	23 (%69.70)	4 (%12.12)	4 (%12.12)	2 (%6.06)				
Monthly income (Iranian rial)									
Without monthly income	105 (%26.5)	82 (%78.10)	8 (%7.62)	10 (%9.52)	5 (%4.76)	P<0.05	1.093 (0.250-4.788)	1.200 (0.185-7.770)	3.000 (0.372-24.171)
< 200000000	37 (%9.3)	22 (%59.46)	7 (%18.92)	3 (%8.11)	5 (%13.51)		0.293 (0.064-1.340)	1.050 (0.159-6.924)	0.900 (0.091-8.899)
200000000-400000000	94 (%23.7)	57 (%60.64)	16 (%17.02)	9 (%9.57)	12 (%12.77)		0.317 (0.084-1.190)	1.000 (0.188-5.332)	1.125 (0.154-8.205)
400000000-600000000	106 (%26.8)	65 (%61.32)	11 (%10.38)	12 (%11.32)	18 (%16.98)		0.241 (0.067-0.866)*	0.458 (0.086-2.445)	1.000 (0.145-6.907)
> 600000000	54 (%13.6)	45 (%83.33)	4 (%7.41)	2 (%3.70)	3 (%5.56)		Reference	Reference	Reference
Diagnosed with chronic diseases									
Yes	87 (%22)	70 (%80.46)	5 (%5.75)	4 (%4.60)	8 (%9.20)	P<0.05	1.524 (0.675-3.442)	0.534 (0.160-1.780)	0.547 (0.150-1.991)
No	309 (%78)	201 (%65.05)	41 (%13.27)	32 (%10.36)	35 (%11.33)		Reference	Reference	Reference
Perceived overall health									
Very good	158 (%39.9	109 (%68.99)	20 (%12.66)	17 (%10.76)	12 (%7.59)	P>0.05			
Good	162 (%40.9)	105 (%64.81)	22 (%13.58)	14 (%8.64)	21 (%12.96)				
Mediocre	65 (%16.4)	48 (%73.85)	3 (%4.62)	4 (%6.15)	10 (%15.38)				
Fair/poor	11 (%2.8)	9 (%81.82)	1 (%9.09)	1 (%9.09)	0 (%0)				
Known any friends, neighbors and colleagues infected by COVID-19									
Yes	241 (%60.9)	167 (%69.29)	24 (%9.96)	24 (%9.96)	26 (%10.79)	P>0.05			
No	155 (%39.1)	104 (%67.10)	22 (%14.19)	12 (%7.74)	17 (10.79)				

	Overall N (%)	Univariate analysis				P value	Multivariable logistic regression		
		Unwillingness to pay	IRR5000000 (n=175)	IRR10000000 (n=92)	IRR20000000 (n=78)		Unwillingness to pay OR (95% CI)	IRR10000000 OR (95% CI)	IRR20000000 OR (95% CI)
Health belief									
Perceived susceptibility									
I think COVID-19 is deadly and there is no cure									
Agree	102 (%25.8)	65 (%63.73)	12 (%11.76)	8 (%7.84)	17 (%16.67)	P>0.05			
Disagree	294 (%74.2)	206 (%70.07)	34 (%11.56)	28 (%9.52)	26 (%8.84)				
I think COVID-19 is not a deadly disease, but it is very serious									
Agree	289 (%73)	195 (%67.47)	34 (%11.76)	26 (%9)	34 (%11.76)	P>0.05			
Disagree	107 (%27)	76 (%71.03)	12 (%11.21)	10 (9.35)	9 (%8.41)				
I think COVID-19 is not a deadly disease and it has a cure									
Agree	216 (%54.5)	148 (%68.52)	24 (%11.11)	20 (%9.26)	24 (%11.11)	P>0.05			
Disagree	180 (%45.5)	123 (%68.33)	22 (%12.12)	16 (%8.89)	19 (%10.56)				
I'm worried that if I get COVID-19, the effects will be serious									
Agree	231 (%58.3)	159 (%68.83)	25 (%10.82)	18 (%7.79)	29 (%12.55)	P>0.05			
Disagree	165 (%47.1)	112 (%67.88)	21 (%12.73)	18 (%10.91)	14 (%8.48)				
Perceived severity									
I think my chance of getting COVID-19 is high.									
Agree	162 (%40.9)	116 (%71.60)	15 (%9.26)	12 (%7.41)	19 (%11.73)	P>0.05			
Disagree	234 (%59.1)	155 (%66.24)	31 (%13.25)	24 (%10.26)	24 (%10.26)				
My chance of getting COVID-19 in the next few months is great									
Agree	238 (%60.1)	174 (%73.11)	22 (%9.24)	23 (%9.66)	19 (%7.98)	P<0.01	Reference	Reference	Reference
Disagree	158 (%39.9)	97 (%61.39)	24 (%15.19)	13 (%8.23)	24 (%15.19)		2.266 (1.182-4.345)*	1.158 (0.502-2.668)	2.235 (0.901-5.542)
Anyone can get COVID-19									
Agree	368 (%92.9)	249 (%67.66)	44 (%11.96)	35 (%9.51)	40 (%10.87)	P>0.05			
Disagree	28 (%7.1)	22 (%78.57)	2 (%7.14)	1 (%3.57)	3 (%10.71)				
The COVID-19 vaccine is essential									
Agree	345 (%87.1)	237 (%68.70)	39 (%11.30)	30 (%8.70)	39 (%11.30)	P>0.05			
Disagree	51 (%12.9)	34 (%66.67)	7 (%13.73)	6 (%11.76)	4 (%7.86)				
Perceived benefits									
With vaccination, my anxiety about getting Covid 19 disease decreases.									
Agree	297 (%75)	200 (%67.34)	33 (%11.11)	28 (%9.43)	36 (%12.12)	P<0.01	0.548 (0.233-1.286)	0.494 (0.176-1.387)	0.681 (0.220-2.103)
Disagree	99 (%25)	71 (%71.72)	13 (%13.13)	8 (%8.08)	7 (%7.07)		Reference	Reference	Reference
Vaccination reduces my chances of getting Covid 19.									
Agree	334 (%84.3)	229 (%68.56)	36 (%10.78)	30 (%8.98)	39 (%11.68)	P>0.05			
Disagree	62 (%15.7)	42 (%67.74)	10 (%16.13)	6 (%9.68)	4 (%6.45)				
I believe that vaccination is the most effective way to prevent and protect me from Covid 19.									
Agree	257 (%64.9)	179 (%69.65)	26 (%10.12)	23 (%8.95)	29 (%11.28)	P>0.05			
Disagree	139 (%35.1)	92 (%66.19)	20 (%14.39)	13 (%9.35)	14 (%10.07)				
Vaccination strengthens my immune system against coronavirus.									
Agree	330 (%83.3)	226 (%68.48)	35 (%10.61)	32 (%9.70)	37 (%11.21)	P>0.05			
Disagree	66 (%16.7)	45 (%68.18)	11 (%16.67)	4 (%6.06)	6 (%9.09)				
Perceived barriers									
I'm afraid of the effectiveness of the vaccine. The vaccine does not work for me.									
Agree	298 (%75.3)	206 (%69.13)	33 (%11.07)	28 (%9.40)	31 (%10.40)	P>0.05			
Disagree	98 (%24.7)	65 (%66.33)	13 (%13.27)	8 (%8.16)	12 (%12.24)				
I am concerned about the costs and the high price of the vaccine.									
Agree	239 (%60.4)	162 (%67.78)	31 (%12.97)	21 (%8.79)	25 (%10.46)	P>0.05			
Disagree	157 (%39.6)	109 (%69.43)	15 (%9.55)	15 (%9.55)	18 (%11.46)				
I do not have enough time for vaccination.									
Agree	33 (%8.3)	28 (%84.85)	3 (%9.09)	1 (%3.03)	1 (%3.03)	P>0.05			
Disagree	363 (%91.7)	243 (%66.94)	43 (11.85)	35 (%9.64)	42 (%11.57)				
I'm afraid of the side effects of the vaccine.									
Agree	133 (%33.6)	91 (%68.42)	16 (%12.03)	14 (%10.53)	12 (%9.02)	P>0.05			
Disagree	263 (%66.4)	180 (%68.44)	30 (%11.41)	22 (%8.37)	31 (%11.79)				

I doubt the immunization or immunity of the vaccine.							
Agree	160 (%40.4)	108 (%67.50)	20 (%12.50)	16 (%10)	16 (%10)	P>0.05	
Disagree	236 (%59.6)	163 (%69.07)	26 (%11.02)	20 (%8.47)	27 (%11.44)		
I only get the vaccine if I know enough about it.							
Agree	307 (%77.5)	204 (%67.33)	37 (%12.21)	29 (%9.57)	33 (%10.89)	P>0.05	
Disagree	89 (%22.5)	67 (%72.04)	9 (%9.68)	7 (%7.53)	10 (%10.75)		
I only get the vaccine when a lot of people have.							
Agree	138 (%34.8)	96 (%69.87)	16 (%11.59)	13 (%9.42)	13 (%9.42)	P>0.05	
Disagree	258 (%65.2)	175 (%67.83)	30 (%11.63)	23 (%8.91)	30 (%11.63)		
Cues to action							
If there is a vaccination program, would you like to be vaccinated against COVID-19 disease?							
Agree	319 (%80.6)	214 (%67.08)	40 (%12.54)	29 (%9.09)	36 (%11.29)	P>0.05	
Disagree	77 (%19.4)	57 (%74.03)	6 (%7.79)	7 (%9.09)	7 (%9.09)		
Do you want your family members to get vaccinated against the COVID-19?							
Agree	296 (%74.7)	203 (%68.58)	36 (%12.16)	25 (%8.45)	32 (%10.81)	P>0.05	
Disagree	100 (%25.3)	68 (%68)	10 (%10)	11 (%11)	11 (%11)		
I think all my family and friends should get the COVID-19 vaccine.							
Agree	299 (%75.5)	209 (%69.90)	35 (%11.71)	25 (%8.36)	30 (%10.03)	P>0.05	
Disagree	97 (%24.5)	62 (%63.92)	11 (%11.34)	11 (%11.34)	13 (%13.40)		
I will definitely get the COVID-19 vaccine if doctors recommend it.							
Agree	326 (%82.3)	221 (%67.79)	41(%12.58)	29 (%8.90)	35 (%10.74)	P>0.05	
Disagree	70 (%17.7)	50 (%71.43)	5 (%7.14)	7 (%10)	8 (%11.43)		

*P<0.05; Multinomial regression; Reference group: IRR 2000000. Goodness of fit; Pearson Chi square: 154.870, Significant:0.085.

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Original Article

Community-Based Disaster Management in Iran: Strengths, Challenges, and Recommendations

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Abstract

Introduction: The limitation of relief forces from various aspects and the impossibility of the presence of specialist forces in the affected area immediately after the disaster has made it a necessity to use the capacity of the people and local communities in the government's response to disasters. This article aimed to identify the strengths and challenges of community-based crisis management in Iran and provide recommendations for expanding this approach.

Methods: The present research was conducted using a qualitative method, through in-depth semi-structured interviews with 13 experts and 12 subjects who had participated in community-based disaster management activities. The selection of people for the interview was done through targeted sampling using the snowball method. Examination and extraction of data were performed using the thematic analysis method, and the obtained data were classified in the form of strengths, challenges, and recommendations for adopting a community-based approach to disaster management in Iran.

Results: As a result of reviewing and analyzing the interview texts, 567 codes were extracted. In the next step, by removing duplicate codes and merging them, research results were presented in the form of strengths and challenges of community-based disaster management in Iran, and recommendations were presented to expand this approach. The main challenges of implementing this approach included social expectations, parallel work of organizations, numerous changes in the management of organizations, multiplicity of educational content, and the goals of the executors from the implementation of community-based programs. Against these challenges, strengths such as the existence of social bases at the neighborhood level, participation of donors, and development of individual skills and capabilities were extracted.

Conclusion: The findings of this research provide a general and comprehensive view of the challenges and strengths of adopting a community-based disaster management approach in Iran. Despite the existence of many challenges such as people's priorities, social expectations, parallel work of organizations, and many managerial changes in the implementation of this approach, there are many strengths and experiences in this regard in the country that can facilitate the implementation of this approach. Factors such as the participation of benefactors and existence of different capacities and social bases in the localities are valuable components in applying the community-based disaster management approach in Iran.

Keywords: Disaster Management, Community-Based, Challenges and Strengths, Approach, Iran

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Introduction

Evidence shows that, in all countries, the programs related to the exposure of people and capital to disasters have been done much faster than the reduction of vulnerability; as a result, the damages caused by disasters have continuously increased. Therefore, it has caused severe economic, social, health, cultural, and environmental impacts in the short, medium, and long term, especially at the local and community level (1).

The latest report published by the Center for Research Epidemiology of Disasters (CRED) for 2023 shows that 399 natural disasters have occurred in the world, resulting in the death of 86,473 people. 93 million people have been affected by these disasters and more than 202 billion dollars of damages have been caused to different communities. The occurrence of this number of natural disasters, which is more than

the average of the last two decades -380 disasters, emphasizes the necessity of more preparedness of people and organizations involved in the process of disaster management (2).

Despite efforts made to create preparedness at the community level, especially in vulnerable populations and high-risk areas, many researchers report low levels of preparedness. Based on assessing the preparedness of families against disasters at the national level (2013), the level of preparedness of Iranian families was equal to 8.5%, which increased to 9.3% with the intervention and implementation of the public education program in 2014. Another study (2013) showed that 93.3 percent of the respondents had average and less than average knowledge about the necessary measures before, during, and after disasters. Also, the amount of action to learn issues related to actions before, during, and after disasters was evaluated as low (3).

During the disaster and in the first hours after the disaster, due to the delay in the transmission of information, interruption of communication routes, problems of access to the damaged area, problems related to the calling, organization and mobilization of relief forces, preparation and delivery of equipment and the like, reaching Expeditionary forces takes a lot of time in the affected area. At this time, the survivors and residents of the disaster area are the first to rush to help the injured and are considered the first group to respond. In most programs related to reducing the risk of disasters, the local community should be considered as the center of attention. However, research shows that in planning for disaster preparedness and coping, the role of people as the most important and largest group of interested groups is often neglected (4, 5).

One of the approaches that has become more prominent in the last two decades and has been emphasized in international frameworks such as Hyogo and Sendai is the community-based disaster management approach. An approach that recommends the participation of different groups of society in different phases of disaster management, as the main beneficiaries (6-8). In different countries, especially Southeast Asian countries as well as the United States of America, this approach has a longer history. By publishing the results of adopting such an approach, other countries have also understood the necessity of planning to benefit from the capacity of local communities in addition to the phase of prevention and reduction of effects and preparation in the phase of responding to disasters.

Community-based disaster management is fundamentally based on the concept of participation (7). In the developmental or community-based approach, there is an attempt to increase the ability of society to adapt to the harmful consequences of hazards through capacity building and empowering the members of the society. By attracting participation in risk reduction measures, society's ability to prevent, deal with, and respond to disasters and recovery will be improved (9).

Applying a community-based approach causes problems, challenges, and shortcomings. By participating in the efforts of local communities in analyzing the current situation, identifying environmental hazards, and determining the level of vulnerability, the existing capacities in the society can be increased. In addition, in the event of a disaster, the facilities and resources of the affected community and their cooperation should be used to return to the previous situation. In this way, local communities will not only be the creators of a part of the program, but they will also be the source of important decisions and their implementation (3).

Considering the situation in Iran and the high frequency of hazards in the country, it is very necessary to use the capacity of local forces in an organized manner to accelerate the process of disaster management and reduce the effects of disasters. Therefore, the main goal of the current research was to identify the strengths and challenges of community-based disaster management in Iran and provide recommendations for expanding this approach.

Methods

This study was conducted using a qualitative method. In-depth semi-structured interviews were conducted with 13 subject experts and 12 people involved in community-based disaster activities. Next, using the thematic analysis method, the strengths, challenges, and recommendations for adopting this approach were classified.

The participants in the research were experts in the field of disaster management and members of people's disaster management groups who were

selected by purposeful and snowball sampling. Inclusion criteria were university education, research related to disaster management, and at least 5 years of work experience. Not having any of the entry criteria, unwillingness to participate, or inability to answer some questions were the exclusion criteria in this study.

Data were collected through in-depth interviews with participants. In the interview process, semi-structured questions as well as follow-up questions were asked during the interview. The interviews lasted for about an hour each, and finally, after conducting 25 interviews, the interviews were terminated by reaching data saturation.

The thematic analysis method was used to analyze the data. In this study, the researcher used Braun and Clark's 6-step process, including 1. Acquaintance, 2. Coding, 3. Generating themes, 4. Examining themes, 5. Defining and naming themes, and 6. Writing for data analysis (10). After implementing the interview texts, by checking the data manually, meaning units were identified. By reviewing and categorizing the obtained key concepts, themes were extracted in the form of strengths, challenges, and recommendations for community-based disaster management in Iran.

Ethical Considerations

The present study was a part of the research project of the Red Crescent Society of the Islamic Republic of Iran with the code of IR.RCS.REC.1402.005. All ethical principles were considered in this article. The participants were informed about the purpose of the research and its implementation steps. They were also assured of the confidentiality of their information and possibility of their withdrawal from the study at any time.

Results

The demographic and occupational characteristics of the people who participated in the study are shown in Table 1.

Strengths, challenges, and recommendations of community-based disaster management in Iran are shown in Table 2.

Challenges

Based on the participants' viewpoints, lack of proper understanding of the existing risks and hazards, along with economic and livelihood problems, people's life priorities have changed. Many people consider the government responsible for these actions.

"Most people are in the pre-contemplation stage; that is, they have not yet understood the risks. That's why people's participation in these calls is low. You need people to come to work. That's why you need to identify people who understand the risk." (P. 22)

Some experts also pointed out that the goal of the program should not be to outsource governance activities to the people. People should feel that the activities will be useful first for themselves, their family members, and then for the neighbors.

"People's expectations from the government are high. People expect the government to take care of all their needs so that contribute less themselves. This acculturation should happen; people need to do some things themselves." (P. 8)

Table 1: Demographic and occupational characteristics of the participants

Characteristics		Number
Gender	Man	14
	Female	11
Level of Education	Ph.D.	11
	Masters	9
	Bachelor	5
Occupation	Lecturer / University Professor	12
	Employee	6
	Trainer of rescue courses	4
	Student	3
Field/Specialty	Disaster management	13
	Sociology	4
	Education	3
	Management	3
	Psychology	2

Table 2: Strengths, challenges, and recommendations of community-based disaster management in Iran extracted from interviews

	Themes	Meaning units
Challenges	Objectives of the program	The organization's goal must not be to impose its duties on the people, and the goals of program should be in line with the needs of different social groups.
	Multiplicity of educational content	Teaching various subjects and contents. the contents are sometimes opposite and contradictory.
	People's priorities	Due to the lack of understanding of the risks and the existence of economic concerns, these programs are not considered a priority by people.
	Social expectations	The majority of people believe that the government is accountable for these actions.
	Parallel work	The existence of similar plans and programs in various organizations
	Organizational changes	Changing the management causes the program to be incomplete
	Managers of the executive organization	The attitude of headquarters, provincial and city managers towards the community-based issue
	Program coaches	The competence, attitude and perspective of the trainers should be community-oriented
Strengths	Commitment and ownership creating	People's participation creates a sense of commitment and ownership to the program
	Contribution of donors	The capacity of donors to develop programs
	Existing social bases	The potential of social bases such as educational and student centers and Helal houses
	Development of skills and abilities	Participation in the program leads to learning skills and abilities. A person can save his life, family and neighbors in emergency situations.
	The capacity of virtual space and social media	The capacity of virtual space, media and various social groups to expand the scope of influence
Recommendations	Educational subjects	Paying attention to the common hazards of the region and the functions required in response to these risks
	Structure	Structures should be flexible to facilitate the formation of social participation
	Characteristics of people	Paying attention to people's innate characteristics, interests and knowledge level
	Attracting and retaining people	Identification of interested people in public courses, screening based on specific recruitment process
	Evaluation and promotion indicators	Determining indicators for the periodic evaluation of the program as well as the performance index of the members
	Identification	People should have an educational and operational ID, and based on that, their progress and promotion process will be determined
	Training managers	Managers should be familiar with or receive training on how to interact with different social groups
	Branding	Transforming activities, coverage, etc. into a social brand

Organizational changes and the impact of such programs from these changes are the next challenge. Community-oriented programs should not depend on the manager of the organization. Also, the goals and output of all actions of these programs should meet the needs of different social groups. Otherwise, people will not welcome it and participate. If the goals of the program are based on the needs of the community, the level of intervention of the organizations will also be determined. In other words, people consider themselves the owners of the process and this mentality is created for them that they do these activities for themselves, their family members, or for their neighbors. It is a big threat for organizations to want to have these social teams, manage them, and delegate organizational tasks to them.

The next issue is the parallel work of organizations and institutions. Similar plans and programs are being implemented in different organizations and bodies. To own these programs, by changing the contents and creating different structures, every organization causes confusion and discouragement for interested people. The government can organize all community-based relief and rescue activities by appointing a special organization. As a result, not only people do not receive different and sometimes contradictory contents and education, but also a unified social structure is formed for these activities. It seems that the main reason why different organizations perform this activity is that many organizations are involved in the field of disaster management and even do similar work.

"*The parallel work of organizations that work*

in the field of crisis management prevents these activities from forming. If it is formed, its people will disperse, or if it is formed, there is one person who owns several organizations." (P.19)

Strengths

According to many participants, one of the main potentials that can lead to more success in the development and expansion of community-based programs is the companionship and cooperation of benefactors and social leaders with voluntary and humanitarian activities. In this case, popular organizations such as the Red Crescent society can play an important role.

"The history of the Red Crescent Society in public works is long and this is a good potential in implementing community-based programs. The capacity of Helal Houses can also be used in the field of advertising, promoting, and informing activities." (P.3)

Undoubtedly, virtual space and media are the main tools these days for the expansion of all activities and programs. Using this capacity can significantly increase the influence of community-based activities. In addition to being very helpful in attracting the audience, this capacity can increase understanding of the risks and increase the participation of different social groups by showing successful training activities of local teams in various disasters.

In addition, it can be a potential for sharing educational content by establishing the position of virtual networks and channels in neighborhood-based relief and rescue programs. Although the restriction of Internet access can affect this aspect of activities, it should be noted that social media can also help to expand the influence of these activities.

Some experts have pointed out that it is possible to use the potential of existing social bases at the beginning of the program and even later at the neighborhood level. Even though the synchronization of the custodians of these bases, such as health centers, mosques, Basij bases, and most importantly, schools, requires precise planning. At the beginning of the work, the social bases of the Red Crescent community, such as Helal Houses, can be used to expand community-based programs in different neighborhoods. Then, the lessons learned and experiences gained in this field can be used to attract the cooperation of other organizations and institutions.

Planning for existing social organizations and associations or attending educational campaigns and attracting citizens' participation as a social duty, to turn these activities into a social campaign, can also be very effective in encouraging different social groups to participate in these activities.

"It is possible to use the capacities of different social groups, such as sports, art groups, etc., to inform, educate, and also increase the influence of education in society." (P. 5)

Recommendations

Due to the voluntary nature of neighborhood-based programs, the main capital of this program is the volunteers and participating learners. Therefore, one of the essential efforts to increase the level of social participation and sustainability of this program is to pay attention to the characteristics of people. The participation of different social groups in terms of age, gender, level of education, interests, and intrinsic and innate characteristics highlights the need for planning and special attention to this field.

Wherever there is volunteer activities, issues such as recruitment, retention, promotion, and encouragement are significant. One of the essential things that the experts stated was clarifying the recruitment process, so that interested people were identified in public courses and screened based on different functions. In selecting people for community-based activities, criteria and qualifications should be considered. These criteria can range from interest and motivation to mental, psychological, and physical preparation.

"Managing recruitment, retention, maintenance, and development of volunteers requires knowledge, but, unfortunately, our approach is not based on knowledge. Even the use of experiences has a very insignificant role." (P. 7)

Designing and compiling appropriate educational content, in addition to affecting the level and extent of people's participation in community-based programs, regardless of whether the trained person participates in social activities or not, can increase social readiness and resilience against disasters.

Training topics should be based on the needs of people in disasters, so that it teaches people how to solve and meet needs in emergencies. The main philosophy of preparing and compiling

educational content should be to create sensitivity in different communities and societies to prepare, deal with, and respond to disasters.

"Educational topics should be designed and compiled based on the needs of local communities. Then, practical and theoretical courses should be defined based on these topics." (P. 10)

Most of the participants stated that educational content should be designed and prepared based on the interests and needs of different social groups. The unattractiveness of the contents and excessive attention to a specific issue, along with the dispersion, multiplicity, and large amount of information, reduce the penetration rate and the desire of the people in the community to learn disaster-related materials and also participate in community-based programs.

"We have to prepare content based on people's taste. If people don't welcome it, the problem is with our content and management. If people are going to help, the content should be tailored to their taste. This requires study and recognition." (P. 6)

Discussion

Although the process of Community-Based Disaster Risk Management (CBDRM) has been widely used throughout the world, it should be considered that its implementation in different regions of the world, is different, based on the knowledge and awareness of local people, and economic, cultural, political conditions and other factors.

Trott believes that to turn knowledge into a norm, a macro-scale policy change is needed by recognizing the capacities of individuals to become agents of change in societies (11). According to the 2015-2030 Sendai framework, to increase the efficiency and effectiveness of disaster risk reduction activities, all stakeholders should be connected and involved in the design and implementation of policies, programs, and standards (6). In the same line with this study, khanlow also states that there is currently a "policy gap" in approaches that needs to be filled through the development and implementation of evidence-based resilience approaches (12).

What is clear is that developed countries have realized the importance of community members in better disaster management. Developing countries are also changing their approach and increasing participation with local communities in the direction of community-based disaster management with the aim of improving the resilience of local communities.

The most common elements of the participation of different social groups in community-oriented programs are cooperation, empowerment, and ownership by local people (13). Individual and social ownership, commitment, and concerted action in disaster risk reduction produce a wide range of appropriate, innovative, and feasible solutions that are cost-effective and sustainable (14). The issue that the findings of the present study have also addressed and the sense of commitment and ownership towards neighborhood-based programs is one of the important factors in increasing the participation rate and durability of this program.

As the participants in the current research emphasized the necessity of participation of individuals and different social groups in different phases of planning and implementation, Huong also in a study that investigated community-based disaster management in Japan and Vietnam emphasized the necessity of participation. The residents' activists have endorsed the community-based disaster management plan in the early stages of development and formulation (15).

The four elements that contribute to social participation in community-based disaster management programs are the social participation of non-governmental organizations, participation of donors and financial sponsors, internal factors and the organization that emphasizes the participation of volunteers in the disaster area, and, finally, the coalition and cooperation of other organizations (16). In addition, one of the measures that can play an important role in increasing the participation of different social groups in community-based disaster management programs is the spirit and culture of sacrifice in society (17), so the existence of "disaster-coping culture" and "disaster-reducing culture" in local communities are key factors in the sustainability of community-based programs (18).

The results of Amini Hosseini's research (2014) show that the information and skills presented in training courses are usually not suitable and understandable for people because most of the information is technical or theoretical and is usually presented without considering local and socio-economic conditions (19). Local groups that share similar socio-cultural and sometimes

economic characteristics and live together in adjacent neighborhoods can play an important role in reducing the risks of hazards or improving emergency response capacities, as they are the first to be affected by disasters (20).

Conclusion

The findings of this research showed that despite the existence of many challenges such as people's priorities, social expectations, parallel work of organizations, and many managerial changes in the implementation of this approach, there are many strengths and experiences in this regard in the country that can facilitate the implementation of this approach, such as participation of benefactors, capacities and social bases available in neighborhoods, which are valuable components in applying the community-based disaster management approach in Iran.

Unwillingness or access to some experts to participate in the research was one of the limitations of this study, which the researchers tried to solve by continuing the interviews until reaching data saturation. It is also suggested that to increase the generalizability of the results of this research, we should also consider the opinions of other groups and specialized fields.

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Conflict of Interest

There are no conflicts of interest

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Original Article

Automated Fetal Head Circumference Measurement by Ultrasound using V-NET and Data Augmentation

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Abstract

Introduction: One of the common methods for monitoring fetal growth is measuring its head circumference in ultrasound images taken from the mother's womb. In recent years, utilizing deep learning methods have been expanded in this application thanks to its potential in promoting the accuracy of estimating head circumference. However, the performance of deep neural networks is highly dependent on the volume of training data. On the other hand, the region of the fetal head is segmented with considerable errors, due to the presence of various types of noise in ultrasound images which leads to erroneous estimation of fetal head circumference. In this article, a new method is presented to improve fetal head circumference estimation in ultrasound images in which, by using unsupervised data augmentation, an attempt is made to increase the amount of training data of the deep network.

Methods: By utilizing an elliptical contour estimation method, an optimal contour was created to decrease the segmentation errors of the fetal head.

Results: Comparing the performance of the proposed scheme with the basic method as well as state-of-art schemes showed the improvement of fetal head circumference estimation with the help of the proposed algorithm in such way that not only the quality of fetal head circumference measurement with the Dice parameter has been improved by 0.6% and 3.24% respectively compared to the closest alternative and the basic method but also the variance of the obtained results in both types of these comparisons have improved dramatically.

Conclusion: These achievements demonstrate that the performance of the proposed method is also more focused and reliable in addition to being more accurate.

Keywords: Deep neural networks, Fetal head circumference, Ultrasound, Unsupervised data augmentation, Optimal contour estimation

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Introduction

Diagnostic ultrasound is a traditional imaging modality that utilizes either reflection or scattering of ultrasound waves to create images from soft organs. These images may provide valuable information for diagnosing and treating diseases. Thanks to the specifications of sound waves; this modality does not have an invasive and radioactive nature like CT or MRI. Therefore, it may be used in many clinical applications like in pregnancy clinics. The ultrasound images provide information about the fetus's Head Circumference (HC) and its hip joint. Obstetricians can estimate the gestational age, size, and weight from the fetus's HC and further the fetal movement in order to identify congenital diseases (1, 2).

In the first trimester of pregnancy, the doctors can measure the age of the fetus from the difference between the head and the seat of the fetus. Afterward, they estimate the fetal age from the head diameter and fetal femur length (3). The fetal situation is natural if the fetal age differs from the estimated age between one to ten days. However, if this difference is more than ten days, the obstetrician should check the health conditions of the fetus and the mother by using other examinations.

In conventional analysis, obstetricians measure the border around the fetal head manually.

Therefore, this method is highly subjective, its performance is limited by several parameters, and the most important challenge is different diagnoses by different specialists. In practice, this process requires specialized knowledge in parallel with the fact that it is tedious and time-consuming (4). As an alternative, automated image segmentation may be considered as an effective way to extract the fetal head contour (5). Unfortunately, there are some challenges that have caused automated segmentation of the fetal head to remain an open problem. Some of the above factors are the low contrast of the ultrasonic image under various conditions, its low signal-to-noise ratio, acoustic shadows, and speckle noise (5, 6).

During recent years, researchers have proposed a number of methods in order to solve the above limitations. These methods are divided into two categories: methods which are based on extracting handcrafted features and deep learning-based methods. Van den Heuvel et al. (7) propose a two-dimensional computer-aided diagnosis (CAD) to automatically measures the fetal head circumference from two dimensional images for the entire trimester of pregnancy. They extract Haar features to train a random forest classifier in order to locate the fetal skull. Finally, they estimate the fetal HC by using a combination of the Huff transform, dynamic programming, and oval fitting.

Zhang et al. (8) use a supervised learning-based approach for accurate segmentation. They use a multistep strategy for the measurement of the fetal head. In the first step, they reduce the spectral noise using a nonlinear propagation technique. Next, they utilize a multidimensional and multidirectional filter bank to extract specific features for the anatomical structure of the fetus. It is due to the assumption that brightness of the skull cross-section has an approximate Gauss-like curve. Finally, they construct a contour for the fetal head by using an oval curve fitting method. Gonzalez et al. (9) propose a fully automated approach for segmentation and measurement of the fetal head which mainly relies on tissue mapping and optimal oval recognition. They combine tissue mapping, morphological operations, and active contour with optimal oval detection. The final segmentation and measurement of the fetal skull are relatively acceptable.

Reudo et al. (10) propose a method based on distance calculation and blend-Altman measurements in order to segment the abdomen, head, and femur of the fetus in ultrasound images. Although they indicate that this approach can be used in clinical applications, it has poor performance for femur segmentation compared to the head. This weakness has two main reasons. The first is that the femur segmentation is more challenging compared to head segmentation. The second one is high dependency of this algorithm to the appearance of the femur.

Ni et al. (11) propose an automated method to detect fetal head based on the AdaBoost learning algorithm and then measure the head circumference by using the detected fetal head. To achieve significant improvement in both detection and speed, they train the AdaBoost classifier by using pseudo-rabid features. To reduce the sensitivity to spectral noise and intensity changes in ultrasound images, they identify the head boundary in the local area by utilizing a local phase-based method. Finally, they use the Hough transform in order to determine an ellipse on the contour of the head. In another research, Jatmiko et al. (12) combine the improved efficient Hough transform and boosting concept to detect the ellipse shape organs like the fetal head, abdomen, and femur.

Another family of methods for fetal head parameter estimation is the deep learning-based schemes in them; either the feature extraction or classification stages are within the network. Therefore, they are called end-to-end networks. The superior achievements of these networks in solving different problems make them popular among researchers. In the feature extraction stage, the network extracts low-level features and combines them in order to build high-level features. Next, a fully connected neural network is used for the classification stage.

Sundaresan et al. (13) propose an end-to-end convolutional neural network for detecting the fetal heart in the ultrasound video frames (echocardiography). Their purpose is detection of cardiac abnormalities and congenital heart disease. Also, Wu et al. (14) propose the cascading neural network method to fully automate the segment of the skull and abdomen of the fetus. Sinclair et al. (15) use the transfer learning technique based on VGG16 for estimation of the region of the fetal head. Unfortunately, this work has poor performance with the Dice evaluation criterion.

Sobhaninia et al. (16) propose a deep neural network based on the Link-Net for fetal skull segmentation in 2-D ultrasound images. They use a CNN for segmentation and oval estimation by minimizing a cost function. Experimental results on the fetal ultrasound dataset in different trimesters of pregnancy have been relatively consistent with the radiologist's diagnosis. Sobhaninia et al. (17) also propose another approach based on multidimensional CNN for measurement of the fetal head circumference. Although this network has fewer parameters and trains faster than conventional CNN, its results on ultrasound data sets of fetuses in different trimesters of pregnancy show some errors. Some deep learning-based methods use supervised augmentation in order to promote the quality of their training (16, 17). Also, some researchers use data augmentation that does not corrupt the image (e.g., flip) (15).

The aforementioned studies mainly indicate that deep learning methods have significant achievements for fetal HC segmentation, but the existence of sufficient data is one of the main requirements for them to work properly. Unfortunately, the accessible dataset for medical purposes in this area is limited. Therefore, data augmentation may be considered as a potential solution. Some augmentations like rotation and translation can corrupt the ultrasound images. Thus, some researchers prune the augmented images or use augmentation methods without destruction (15-17). Thus, here, this important question is raised whether the generation of fake data (We created new data by performing a series of operations on the original data, such as data augmentation, and in order not to be confused with the original data, we have called them "fake data" in our text; i.e., augmented ultrasound images), even at the cost of causing partial destruction in them, may lead to an improvement in the quality of classification and thus promote the overall results. In this study, it is shown that such a slight destruction can even have a constructive role in the generalization of the model. Accordingly, this article presents a novel method for training convolutional neural networks (CNNs) for fetal head circumference segmentation in ultrasound images using unsupervised data augmentation. The proposed approach leverages various data augmentation techniques, without the need for human supervision. The rationale behind this approach is that by carefully selecting the augmentation parameters, the generated images can still preserve the essential features of the fetal head, thereby improving the generalization ability of the deep learning model without the overhead of manual curation.

Methods

There is a trade-off between the number of training data and the model size to train a reliable convolutional neural network (CNN) model. A challenge with higher data complexity may require more complicated CNN models. These models have a large number of parameters and are prone to overfitting. Therefore, they may need massive training dataset, and collecting and preparing such a dataset is an overwhelming task. One common technique in the deep learning context is increasing the number of the training dataset by generating some fake data. Such a process may decrease the chance of overfitting. By using such fake data in training of the deep model, it may better generalize unseen data. There are some ways for generating such fake data. In computer vision, some of these techniques are based on geometric manipulation like flip, rotation, scale, crop, and translation, while others are not related to geometric manipulation like jpeg noise, Gaussian noise, changing color, and blur filters. The wise choice of these techniques is crucial. However, some methods are not suitable for some problems. For example, the jpeg noise or blur filters may negatively affect the training process for ultrasound images (e.g., our problem). Sometimes, such a fake data generation can change the image label. If these labels are not refined, they can introduce noise labels.

Some augmentation techniques like rotation and translation can remove some parts of an image. The deleted part can contain some parts of the fetus's skull. Therefore, there was human supervision for augmented images in recent research works (16, 17).In other words, a person reviews all augmented images and deletes images with a partial fetus's skull which is tedious. Block diagram of supervised image augmentation is shown in Figure 1a.

One may ask about the essence of supervision on these augmented images. To the best of our knowledge, there is no attempt to eliminate the human supervision of augmented training images. We can adjust the destructions of

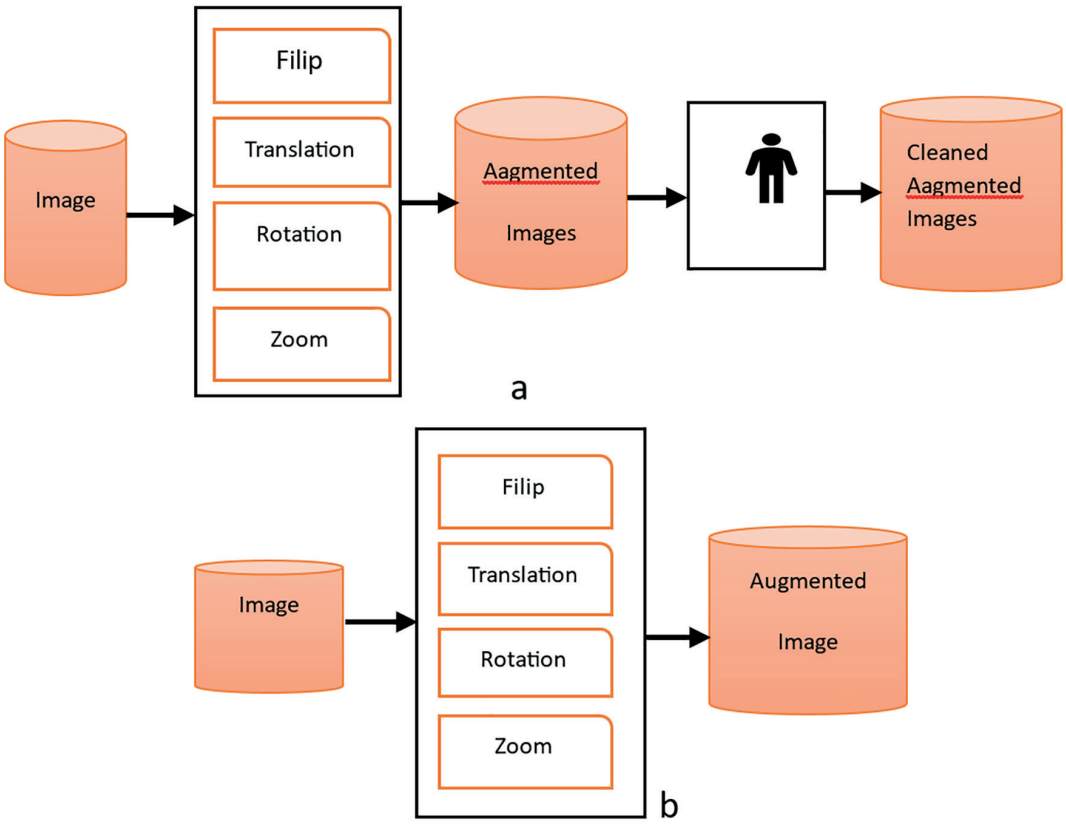

Figure 1: Supervised data-augmentation diagram (a) vs unsupervised data-augmentation diagram (b)

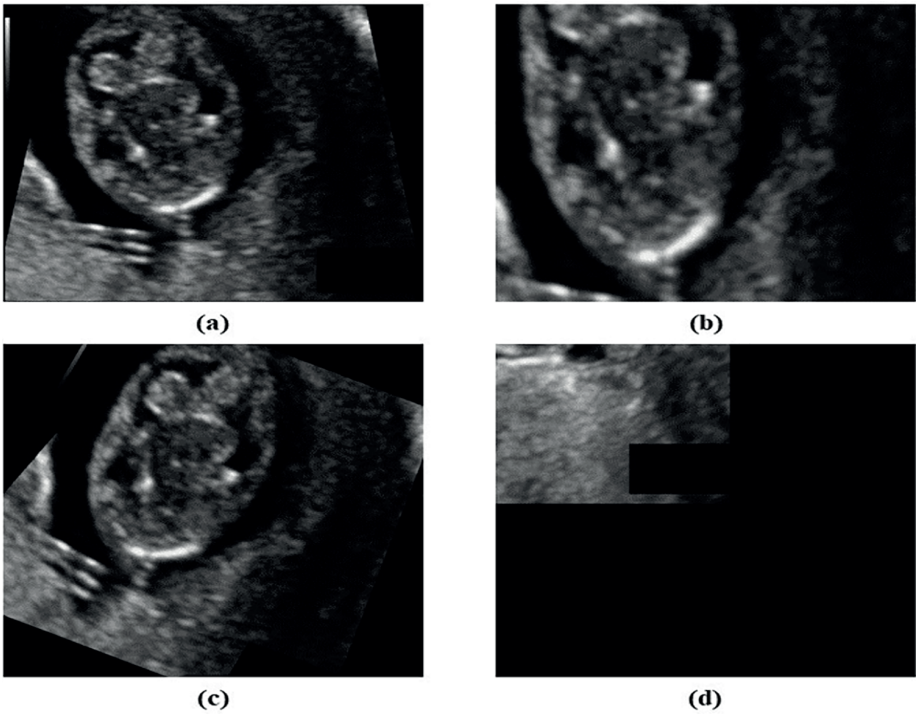

Figure 2: (a) the original image (b) corrupted image by zoom augmentation with 0.5 scale factor for height and width (c) corrupted image by rotation augmentation with 0.9 rotation factor (d) corrupted image by translation augmentation with 0.8 translation factor for height and width

an augmented image by choosing the augmentation parameters. For example, if the rotation degree sets to 45°, it may remove the major part of the fetus's skull. Therefore, we can ignore the human supervision for training images by selecting the augmentation parameters carefully. The pipeline of this unsupervised data augmentation is shown in Figure 1b. Examples of these disruptions are shown in Figure 2.

In this study, a version of fake data generation is introduced without any human monitoring for training a V-Net simultaneously. In other words, we do not save and prune the augmented training dataset and directly feed it into a V-Net. It is assumed that most of the fetus's skull is in the generated images. Therefore, some items including flip, translation, rotation, and zoom are utilized in the framework of the above idea. In Figures 3, 4 and 5, some generated images are shown in parallel with their labels. As a detailed explanation, since flip augmentation preserves the image content and its label, the images and their corresponding labels are flipped horizontally, vertically, or both. In translation technique, each pixel of an image can translate with the equation (1):

$$\begin{bmatrix}\hat{x}\\ \hat{y}\\ 1\end{bmatrix} = \begin{bmatrix}1 & 0 & x_0\\ 0 & 1 & y_0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}x\\ y\\ 1\end{bmatrix} \qquad (1)$$

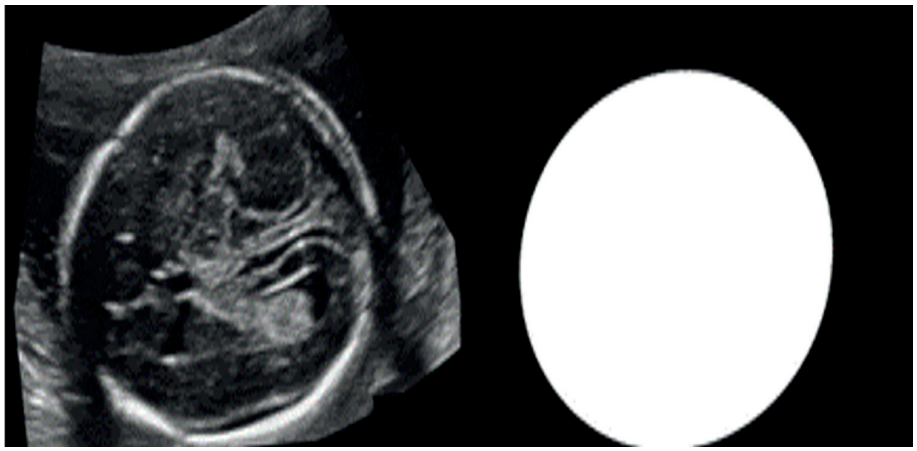

Figure 3: Corrupted image with random zoom

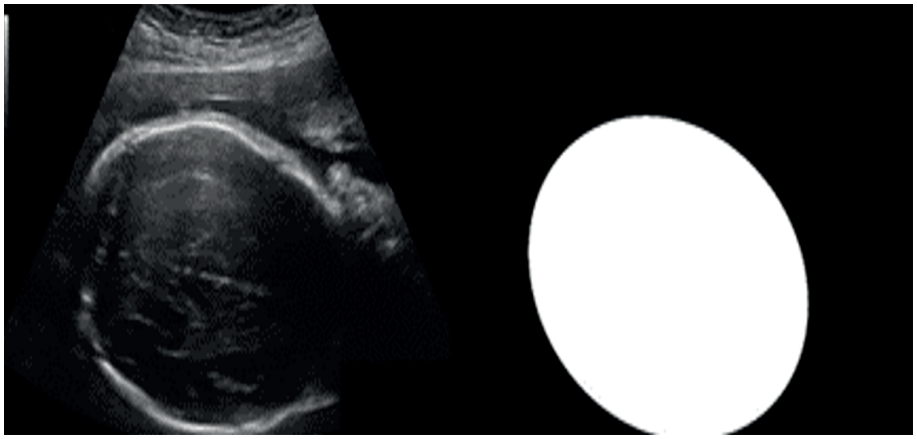

Figure 4: Corrupted image with random rotation

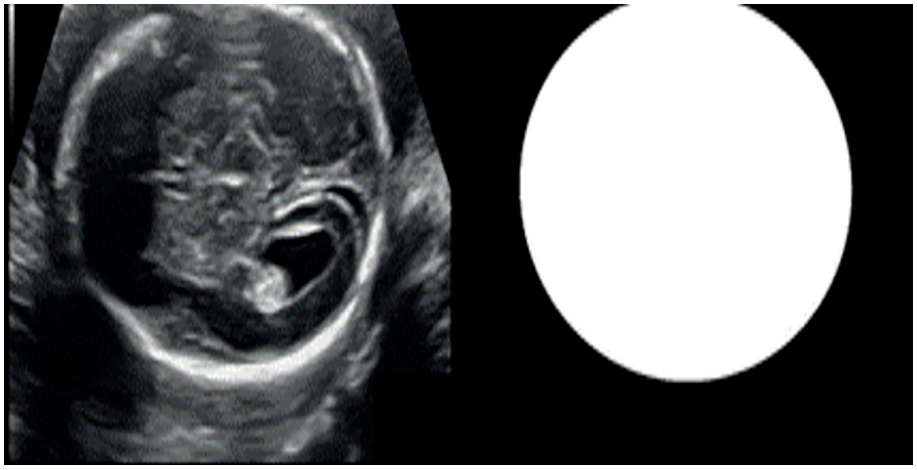

Figure 5: Corrupted image with random translation

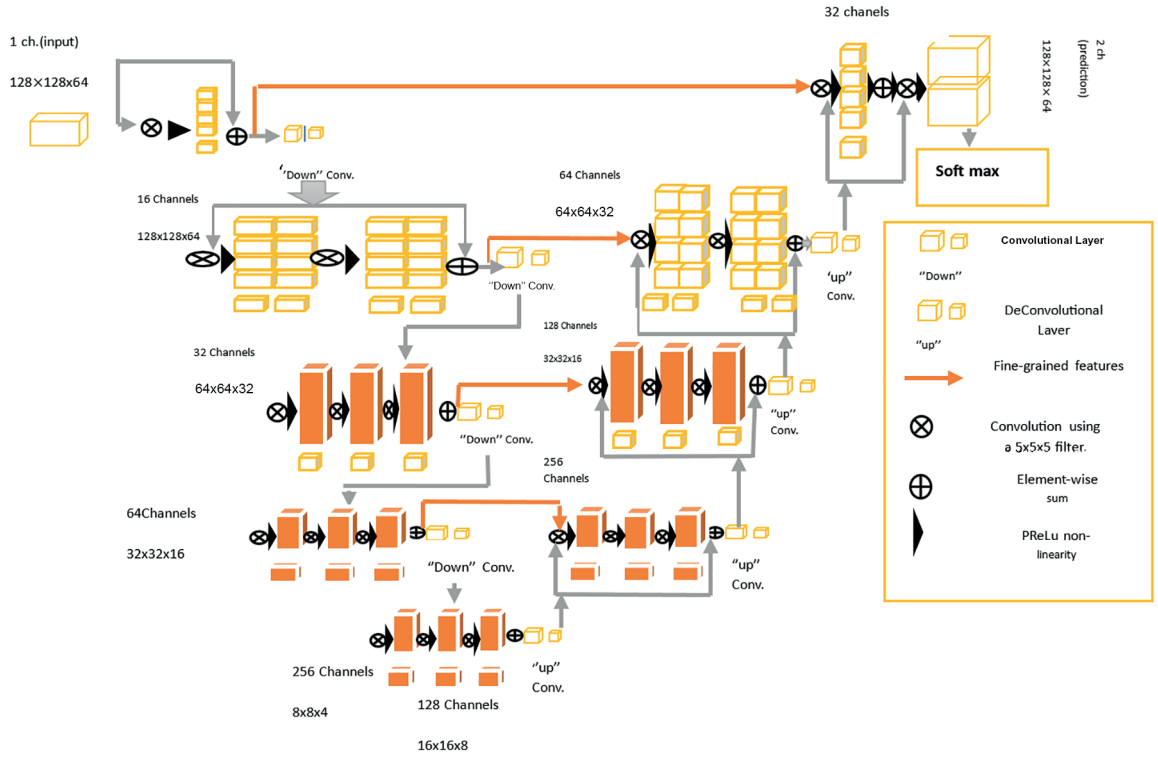

Figure 6: V-Net architecture for segmentation

where x_0 and y_0 are the translation values in x and y axes, respectively. The images are translated horizontally, vertically or both. For pixels outside the translated image, the same constant k with a value of 0.05 is applied. In rotation augmentation method, the transformation matrix of rotation is described in equation (2):

$$\begin{bmatrix}\hat{x}\\ \hat{y}\\ 1\end{bmatrix} = \begin{bmatrix}\cos(\theta) & \sin(\theta) & 0\\ -\sin(\theta) & \cos(\theta) & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}x\\ y\\ 1\end{bmatrix} \quad (2)$$

where the rotation degree is specified by θ. Each image is rotated in the range leading to 20° in either clockwise or counterclockwise directions. Finally, the scale transformation matrix of zoom augmentation technique is demonstrated in equation (3).

$$\begin{bmatrix}\hat{x}\\ \hat{y}\\ 1\end{bmatrix} = \begin{bmatrix}s_1 & 0 & 0\\ 0 & s_2 & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}x\\ y\\ 1\end{bmatrix} \quad (3)$$

In which s_1 and s_2 are the scaling factor for x and y axes. The zoom-in or zoom-out process are performed randomly on images by utilizing a zooming factor up to 0.05 for the height and width while preserving the aspect ratio. The pixels outside the zoomed image are filled with the same constant with a value of 0. The Convolutional Neural Network for Volumetric Medical Image Segmentation (i.e., V-Net) was used as the core of deep learning in this article. This structure which is demonstrated in Figure 6 tries to perform fetal head segmentation in 2D ultrasound images. Based on the architecture, this network consists of the two branches. The first branch (i.e., left part) is a compression path**,** which is divided into different levels, and in each of them residual training is performed, consisting of one to three convolutional layers.

Along this branch, resolution is reduced during convolution and stride operation. This leads to halving the size of the resulting feature maps, similar to what happens in the pooling process in standard CNN deep networks. Correspondingly, the number of feature channels doubles at each level of the branch. The second branch (i.e., right part) decompresses the signal until its original size is reached. It expands the spatial support of the lower resolution feature maps in such way that two feature maps which are computed by convolutional layer are converted to probabilistic segmentations of the foreground and background regions by applying residual learning (same as the left branch) and soft-max voxel-wise.

After training a reliable model, a post-processing technique is used to estimate the extent of the fetal head and remove unwanted parts. Accordingly, first, the segmented image

is converted into a binary image by utilizing the thresholding method. Then, different contours are fitted to the binary image. Firstly, the largest contour among the above boundaries is selected as the fetal head pixels. Finally, the algebraic distance algorithm is applied in order to fit an ellipse on it. The basis of this algorithm is the minimization of an objective function which demonstrates the distance between extracted points and constructed curve. In this article, the conic fitting algorithm is utilized in order to solve such minimization problem as described below. The main components of this approach are as follows:

(a) A set of data points $p = \{a_i\}_{i=1}^{m}$ in which $a_i = (a_i, b_i)$;

(b) A family of curves $c(n)$ parameterized by the vector n;

(c) A distance metric $\delta(c(n), a)$ which measures the distance from a point a to the curve $c(n)$;

The main purpose of this problem is to find the value of parameter n for which the error function ϵ^2 (n) which is demonstrated by equation (4), reaches its global minimum. The curve $c(n)$ is then the curve that best fits the data. This best fitting value of n is called minimizer n and in this paper is shown as n_{min}.

$$\epsilon^2(\mathrm{n}) = \sum_{i=1}^{m} \delta(c(n), a_i) \qquad (4)$$

In the approach of this paper, the curve families considered are represented in the implicit form described in equation (5):

$$c(n) = \{a | F(n; a) = 0\} \qquad (5)$$

The family that we examine are general conic sections, with the following equation (6):

$$F(n; a) = A_{aa}a^2 + A_{ab}ab + A_{bb}b^2 + A_a a + A_b b + A_0 \qquad (6)$$

This equation can be rewritten by using the concept of dot product in such a way that data points and model parameters are separated.

$$F(n; a_i) = [a_i^2 a b_i b_i^2 a_i b_i].[A_{aa}A_{ab}A_{bb}A_a A_b A_0] = a_i.n \qquad (7)$$

Based on the concept of equation (8), the algebraic distance algorithm minimizes th objective function equation (8):

$$\epsilon^2(n) = \sum_{i=1}^{m} F(n; a)^2 = \|D_n\|^2 \qquad (8)$$

subject to the constraint that $\|n\|^2 = 1$.

In which the design matrix D is the $m \times 6$ matrix with row elements of a_i. The constrained objective function is defined as:

$$E = \|D_n\|^2 - \lambda(\|n\| - 1) = n^T D^T D_n - \lambda(n^T n - 1) \qquad (9)$$

It is minimized analytically to form an eigenvector problem (18) as equation (10):

$$\nabla_n E = 0 \Leftrightarrow 2D^T D_n - 2\lambda n = 0 \qquad (10)$$

In the above equation, λ is a Lagrange multiplier. The variable n_{min} which we mentioned as best fitting value before the relation (4) is also obtained as the eigenvector of $D^T Dn$ corresponding to the smallest eigenvalue based on the result of equation (10).

Results

In order to evaluate the effectiveness of the proposed method, it is necessary to simulate it in software framework followed by testing on real ultrasound images of the fetus. These images should be such that in them the border around the fetus's head is specified both in contour and numerically. In this way, the correctness of the contour and circumference resulting from the proposed method can be evaluated. To prepare the software, it is also necessary to implement the fetal head circumference estimation algorithm once by applying the method proposed in this article regarding the production of false images and once again without such innovation. Thus, python3 and Tensorflow paradigms were utilized as the testbed for implementation of the both methods on Intel ® Core i7-10700 computer with Ubuntu 20.04 operation system, 32 GB RAM, and an NVIDIA 2080 Ti. Furthermore, the OpenCV was used as a testbed for postprocessing algorithm including thresholding, contour extraction, and ellipse fitting. As explained above, the evaluation of the proposed method and any comparison requires a dataset in which the contours and numbers of the circumference of the head are precisely known. Thus, a dataset of HC18 challenge (9) was used in this research. This dataset contains 999 2D ultrasound images of the fetal head in the standard plane. Each ultrasonic image had 800 by 540 pixels with a pixel size ranging from 0.052 to 0.326 mm. This set was randomly divided into 700 images for training and 299 to test. In the training process, the 5-fold cross-validation strategy was adopted; thus, 20% of the training images were used for validation in each round of training. In the training set, the fetal head circumference (HC) has been

manually annotated by a trained sonographer. In the next step, based on the contour drawn by the sonographer, the annotated image is divided into two white and black regions by a thresholding-based software. The area inside the contour drawn by the sonographer is indicated with white color, while the area outside the contour is marked with black background. The resultant images are used as reference for training the network and measuring the results. A pair of the ultrasound image and its annotated label are shown in Figure 7. In addition, the rotation parameter varied from 0 to 180 degrees, and the zoom parameter was changed from 0.8 to 2, in experiments. Furthermore, both the horizontal and vertical translation values were also changed from zero to 10%. By combining the above scenarios, the augmentation process was performed.

Finally, in order to carry out the comparison process correctly, it is necessary that the conventional parameters used in the field of fetal head circumference measurement are also used as a basis for comparisons in this research. However, the most concrete parameter related to the comparison is fetal HC difference which is the difference between the estimated HC and its actual size. In equation 11, the HC_s is the estimated HC, and HC_a is the actual HC.

$$DF = HC_s - HC_a \qquad (11)$$

In addition to this quantitative parameter, a visual comparison of the border drawn for the remote environment in any method with the Benchmark border can also be inspiring. Thus, in this part of the article, we make comparisons on limited results and with the help of these two parameters to get a proper sense of how the proposed method works; then, in the next part, by adding other parameters, the evaluation will be done quantitatively and based on the entire set of images.

After the tests were conducted in two scenarios without and with using fake images, the obtained results clearly indicated the superiority of the method proposed in this article against its alternative which does not make use of fake images (i.e., basic method). Figures 8 and 9 show some visual results of these tests.

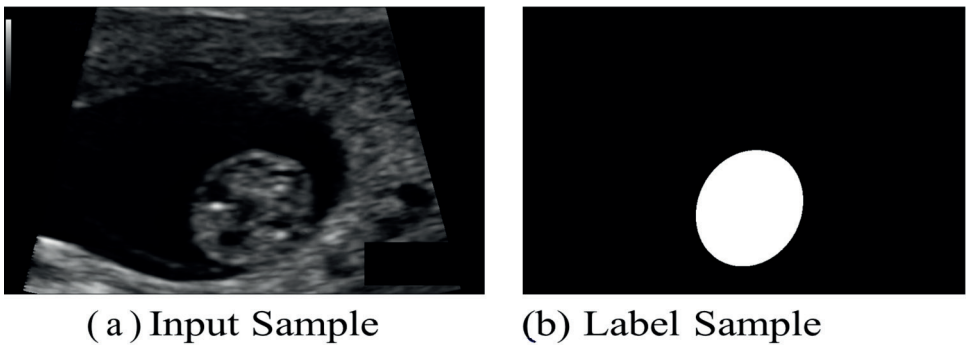

Figure 7: A sample image and its label

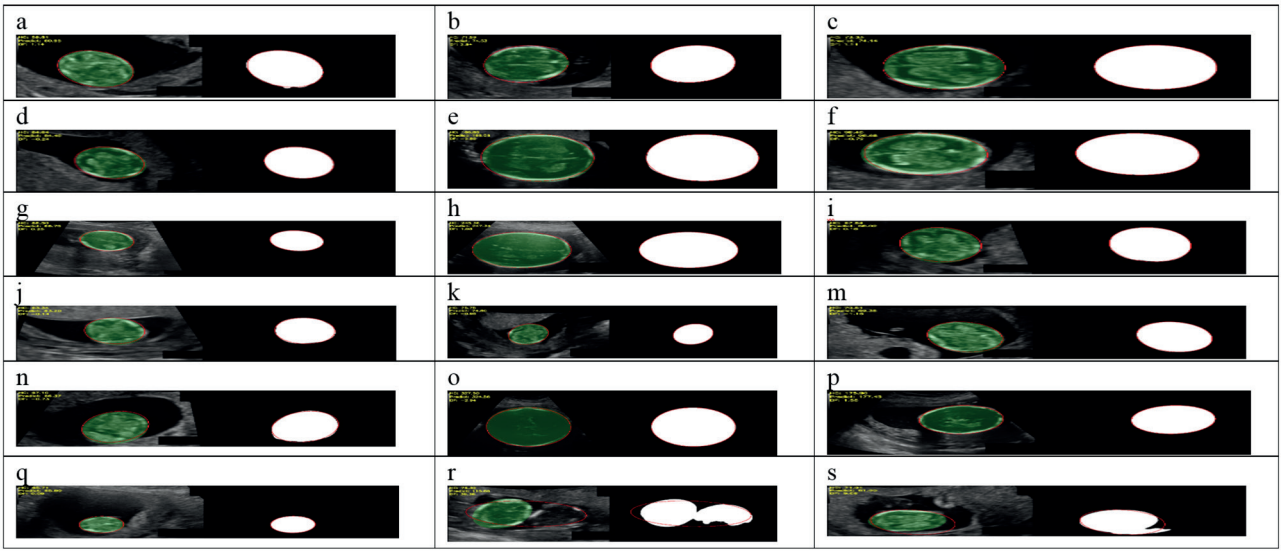

Figure 8: Some results obtained from the proposed method in parallel with their labeled references

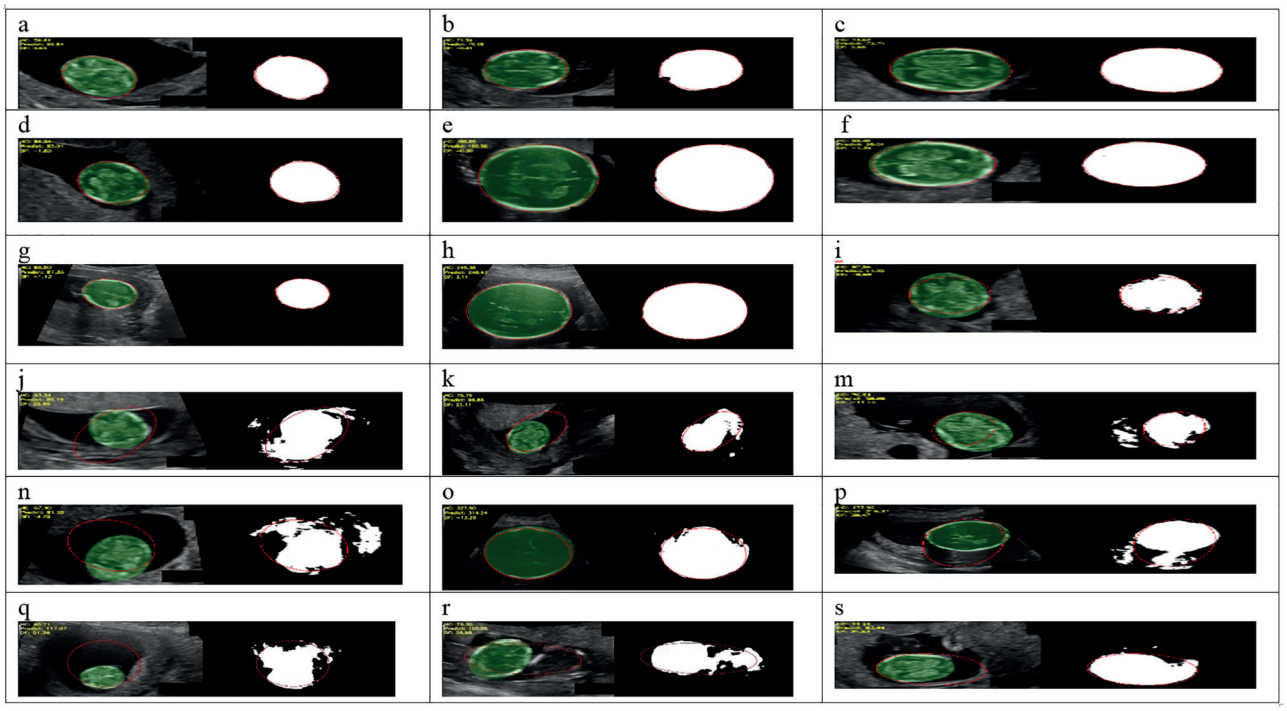

Figure 9: The results obtained from testing the basic method on those images that the results of the proposed method have been reported on them

In each of two above Figures, 8 samples of the results obtained from the proposed and basic methods are shown parallel to the relevant reference image, which shows how well the result of the proposed method matches the original contour (path of the red color). Also, the values of HC and DF parameters are included next to each image in order to clarify the quality of the results.

$$DSC = \frac{2 \times Area(GT) \cap Area(P)}{Area(GT) + Area(P)} \quad (12)$$

$$ADF = |HC(P) - HC(GT)| \quad (13)$$

$$Jaccard\ (X, Y) = \frac{X \cap Y}{X \cup Y} \quad (14)$$

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN} \quad (15)$$

$$Precision = \frac{TP}{TP + FP} \quad (16)$$

In general, these eighteen images, which actually represent the diversity in the results of the tests, can be analyzed in three main categories. The first group of images includes samples (a) to (h), the cases where the detection resulted from the basic method and the proposed method of this article were both acceptable.

In Table 1, the structure of the proposed method is illustrated. This architecture and training strategy aims to effectively segment the fetal head circumference in the ultrasound image dataset.

Table 1: Structure of deep learning method

Parameter	Description
Structure	4 convolutions, 4 max pooling, 4 encoders and decoders
Config	CNN (32,64,128,256)->MP(2,2)->Sig->Relu
Encoders, Decoders	4 encoder, 4 decoder
Number of trainable params	30,235,922
Optimizer	Adam
Batch size	32
Activation functions	ReLU
Loss function	Binary Cross entropy
Number of folds	5
Epochs per fold	20
Learning rate	1e-4

For example, in the sample shown in 8-c and 9-c, it can be observed that the measurement errors of the proposed and basic methods are 0.68 and 1.11, respectively, which both may be considered as negligible deviations and are not significantly different from each other.

The contour obtained in both these results shows acceptable match with the ground truth

contour (the contour drawn around the green area). In other samples of this category, we see a more or less similar situation. Although it should be noted that in this type of results, sometimes the results of the proposed method are slightly superior to the basic method (such as the cases of f, g and h), and sometimes the results of the basic method are somewhat better (such as the cases of a-e). However, as both types of results are acceptable, these small differences do not seem meaningful. The second category of samples are cases in which the quality of the results obtained from the proposed method is significantly better than those related to the basic method. In this type of results that obviously include images (i-q), the basic method has practically led to unacceptable boundaries around the tissue, while the boundary and the amount of error obtained in the estimation of the proposed method were acceptable. For instance, it is possible to check the images (8-i) and (9-i), in which the method of this article has led to a deviation of 0.18 which is acceptable and the basic method has led to a deviation of 6.59 (that is, about 37 times the error of the proposed method) which seems completely unacceptable. The comparison of the obtained texture boundaries in these two samples and the extent of their agreement with the ground truth (the path around the green reference area) also confirms the same fact.

As we will see in the continuation of the analytical results of the article, the accuracy of none of the methods is perfect; therefore, there are probably a few images in which the results of both the basic and proposed methods are unacceptable. We see examples of these images in samples (r-s). Therefore, in both of these examples, the measurement error of the environment surrounding the tissue in both methods was a two-digit number, and visually, the drawn contour is completely inconsistent with the ground truth boundary.

In this way, the visual results and the difference parameter between the estimation of the circumference of the fetal head and the benchmark value clearly indicate the superiority of the proposed method. Therefore, the obtained results briefly indicate that the performance of the proposed method in extracting the border around the head circumference of the fetus was either better than the proposed method, or at least in a similar quality. Thus, in the discussion section, the same topic is shown with more diverse parameters and based on quantitative analysis on the entire images.

Discussion

In the previous section, the results obtained from testing the proposed and alternative methods on the fetal ultrasound image dataset were compared. However, this comparison was reported visually and only on a limited number of images. In this section, the comparisons are reported numerically and based on the total results of the test process, which gives a more comprehensive view of the effectiveness of the proposed method. However, in order to make such a comparison, it is necessary to use the standard parameters that are used in the field of fetal detection in ultrasound images, as described below. These parameters include Dice Coefficient, Difference, Absolute Difference, Jaccard index, precision and accuracy.

The Dice Similarity Coefficient (DSC) is a comparison parameter that measures the spatial overlap between the ground truth segmentation (GT) and the predicted segmentation(P). It is calculated using the formula shown in Equation 12. The DSC value ranges from 0 to 1, with 1 indicating perfect overlap between the ground truth and prediction. It provides a quantitative assessment of how well the predicted segmentation matches the actual segmentation. A higher DSC value indicates better performance of the segmentation method.

To quantify the comparison between the results obtained by each examined method and the ground truth, the Absolute Difference Factor (ADF) was calculated. The ADF represents the absolute difference between the predicted fetal head circumference (HC) and the real/ground truth HC, expressed as a positive value in millimeters. The ADF is calculated using the formula shown in equation 13, where HC(GT) is the ground truth fetal head circumference and HC(P) is the predicted fetal head circumference. The ADF provides a measure of the deviation between the predicted and actual values, with lower ADF indicating better performance of the examined methods.

Since in several studies in this field, DF and ADF values were usually reported separately, in this research, despite the semantic connection of these two parameters, they were calculated

and reported separately. The Jaccard index is a statistic used to measure the similarity and diversity between two sample sets. It quantifies the similarity between finite sample sets, such as sets X and Y, as demonstrated in equation 14.

The Jaccard index ranges from 0 to 1, where 0 indicates that the two sets have no overlap (completely dissimilar), and 1 indicates that the two sets are identical (completely similar). The Jaccard index provides a way to numerically evaluate the degree of overlap or similarity between two finite sample sets.

Accuracy is a metric that calculates the percentage of predicted values that match the actual values for binary labels. Since the labels in the images of this article are binary, accuracy is expressed as the probability of the predictions being equal to 1, as shown in equation 15.

In this article, TP (True Positive) represents the count of pixels in a labeled image that belongs to an actual HC segment, and the baseline or proposed method correctly predicts them as an HC segment. TN (True Negative) represents the count of pixels in a labeled image that belongs to an actual non-HC segment, and the examined methods correctly predict them as a non-HC segment. FP (False Positive) refers to the number of pixels in a labeled image that belongs to a non-HC segment, but the examined methods determine them as an HC segment. FN (False Negative) indicates the pixels of HC segments that both methods failed to detect. The accuracy metric provides an overall measure of how well the prediction methods match the ground truth labels for the binary classification task.

In equation 16, precision is a metric that measures the proportion of true positive predictions out of all the positive predictions made by the model. It indicates how accurate the model is at identifying the positive class.

A high precision value means that the model is making very few false positive predictions, i.e., it is correctly identifying the positive instances most of the time. Precision is calculated as the ratio of true positives to the sum of true positives and false positives, and is a useful evaluation metric when the cost of false positives is high.

The tests of this section were also performed in two categories. In the first type of tests, the performance of the proposed method based on data augmentation was compared with the performance of the basic method in which data augmentation concept has not been utilized.

In this comparison, all the elements for two methods were the same, except that the innovation considered in this article occurred in one of them (the proposed method) and did not happen in another (i.e., basic method). In this way, the difference between the results of these two algorithms may be clearly considered as an indicator of the effectiveness of the proposed method of this research. The results of this scenario are shown in Table 2. The Dice value for the basic case is 94.37%, while it has been obtained equal to 97.61% for the proposed scheme; therefore, from the point of view of Dice parameter, 3.24% improvement can be considered for the method of this article.

A similar improvement is also observed in the parameters of ADF and DF, by extents of 4.17 and 4.3 millimeters, respectively. Another noteworthy point is the significant reduction of the tolerance of these two parameters in the proposed method compared to the basic method, which is considered an important achievement for the innovation of this article.

It may be observed that for the three parameters of Dice, DF and ADF, the variance of the results has decreased by 7.34%, 10.89mm and 11.2mm, which means that the proposed method has gained more reliability and reproducibility, in addition to being better than the basic method. Finally, the table shows that the proposed method led to improvements of orders 5%, 1%, and 3.4% in the Jaccard, accuracy, and precision parameters. Due to the shuffling, each training

Table 2: Comparison of DSC, DF and ADF parameters obtained for entire dataset belonging to the proposed and basic schemes

Method	The Basic Method	The Proposed Method
DSC (%)	94.37±9.29	97.61±1.95
DF (mm)	5.12±13.55	0.82±2.66
ADF (mm)	6.23±13.07	2.06±1.87
Jaccard Index (%)	90.3	95.3
Precision (%)	94.2	97.6
Accuracy (%)	97.5	98.7

Table 3: Comparison of DSC and ADF parameters obtained for entire dataset by applying the proposed method and some state of art alternatives

Method	DSC (%)	ADF (mm)
Proposed Method	97.61±1.95	2.06±1.87
Heuvel et. al. (7)	97.00±2.8	2.8±3.3
Sobhaninia et. al. (16)	96.84±2.89	2.12±1.87
Sobhaninia et. al. (17)	93.75	2.27

sample with specific augmentation happens only once with a high chance. Therefore, the variety of the training samples increases and the model can be better generalized. In the second type of tests, the performance of the proposed method is compared with three well-known methods in the field of intelligent fetal head extraction in ultrasound images. The results of this scenario shown in Table 3 indicate that the proposed method has a slight advantage even over its nearest alternative [i.e., (7)] and more considerable gain against other state-of-art schemes.

By comparing the results of the proposed method with the results obtained in (7), it may be observed that although the improvement in Dice parameter has not been so high (about 0.6%), the ADF parameter has been promoted significantly (i.e., approximately 0.74 mm) by using proposed method.

However, the reduction of tolerance results from 2.8% to 1.95% in measuring the dice parameter and from 3.3 mm to 1.87 mm in the ADF parameter is quite significant and indicates the improvement of the performance of the proposed method. In the case of the other two alternatives [i.e., (16, 17)], the superiority of the proposed method is much more noticeable, so that the advantage in the dice parameter has reached up to approximately 4% and in the ADF parameter up to 0.74 mm.

Conclusion

In this study, a new method was proposed to improve the automatic measurement of the fetal head circumference in ultrasound images. In this method, first, to address the challenge of the sensitivity of deep neural networks to the volume of training data, unsupervised data augmentation scheme was used, and then the VNET neural network was trained with these data. Usually, the region identified as the fetal head by the neural network includes two categories of missing and extra subregions, both of which cause errors in diameter or circumference measurements. In this research, by using the method of estimating the optimal ellipse contour, there was an attempt to minimize the amount of both of these error areas and thus estimate a more accurate circumference for the fetal head.

The results of testing the proposed method on real data and comparing it with existing alternatives clearly indicated the effectiveness of both ideas. In first scenario, the Dice parameter belonging to the head circumference estimated by the proposed scheme was about 3.2% higher than that obtained from basic method. In the same way, the proposed augmentation algorithm could improve the Jaccard, precision and accuracy parameters in a range between 1% to 5% compared to the method based on only the original data. In the second scenario, it was observed that compared to the methods published in the articles of this field, the proposed method was able to improve the dice parameter in the range of approximately [0.6 3.9] percent and the DF parameter in the range of [0.06 0.74] millimeters. Finally in both scenarios, the variances of the results of the proposed method were significantly lower than alternatives, which indicates that this method provides more reliability in addition to better performance.

Although the proposed method has been able to perform better than the basic and alternative methods in obtaining performance parameters, there are still limitations that may be solved in future researches. One of these cases is the increase in neural network training time due to the increase in data. Another limitation is that augmentation by the mentioned method does not necessarily lead to the best amount of diversity in the data. It seems that if other methods such as Generative adversarial network are used to generate fake data, it may be possible to obtain more diversity in the training data and thus improve the quality of the results.

Furthermore, utilizing more advanced neural network architectures, such as multi-scale networks or transformer-based networks, may improve the results because these methods will have a higher potential in modeling non-linear

data in the problem of fetal head circumference estimation.

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All authors declare that the present article has not been published in whole or in part elsewhere and is not currently being considered for publication in another journal. Furthermore, authors have been personally and actively involved in substantive work leading to the manuscript, and will hold themselves jointly and individually responsible for its content.

Authors' Contribution
Seyed Vahab Shojaedini: conceptualization, data curation, supervision. Amir Saniyan: data curation, simulations and tests. Mohammad Reza Riahi: drafting the manuscript and primary writing. Mahsa Monajemi: review, and final editing.

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Original Article

Fear and Anxiety of COVID-19 and Its Relationship with Nurse Caring Behaviors of Nursing Students: A Cross-sectional Study

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Abstract

Introduction: The emergence of COVID-19 and its pandemic nature has caused great fear worldwide. The pandemic led to economic, social, and mental health problems. Fear and anxiety are some of the main factors affecting the life and mental health of students, which can affect the caring behaviors of nurses. The aim of the present study was to determine the correlation between the fear and anxiety of COVID-19 and the nurse caring behaviors of nursing students at College of Nursing and Midwifery in Shiraz.

Methods: This descriptive-analytical study was conducted on 236 nursing students in 2021 at College of Nursing and Midwifery in Shiraz. The census sampling method was used. Data collection was done using Internet links through Whats app given to the participants. The data collection tool included the fear of COVID-19 designed by Ahorsu et al. which has 7 items., the COVID-19 Disease Anxiety Scale designed by Alipour et al. which consists of 18 questions, and the Caring Behavior Inventory (CBI) designed by Wolf et al. which has 42 questions. Data collection was carried out within 2 months. Data analysis was also done in SPSS v. 21, using descriptive analysis including frequency, percentage, mean and standard deviation, and inferential statistics including Spearman's correlation coefficient.

Results: The highest percentage of students had moderate (30.9%) and high (20.7%) anxiety levels represented by scores 17-29, and 30-54, respectively. 85.2% of the students were not afraid of COVID-19. There was no significant correlation between fear of COVID-19 disease and care behavior (r=0.3, P=0.644) and anxiety with care behaviors (r=-0.17, P=0.801).

Conclusion: Nursing students experienced moderate and high levels of COVID-19 anxiety, while few of them were afraid of COVID-19. However, their average caring behavior was desirable. Managers and officials of the nursing profession should take measures to manage the nursing students' anxiety during the epidemic.

Keywords: Fear, Anxiety, COVID-19, Nurse caring behaviors, Nursing students

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Introduction

The widespread outbreak of the SARS-COV-2 virus caused the World Health Organization (WHO) to declare a public health emergency worldwide (1). With the increasing death rate, the COVID-19 pandemic has become one of the biggest threats to human health in the recent century and has created a historical emergency even worse than World War II (2). Pandemics such as COVID-19 cause economic and social problems and lead to an increase in mental health problems (3). Some of these problems include the fear of getting infected, stress, insomnia, hopelessness, and depression (4).

Fear is a natural and adaptive response to threat and danger, which can become chronic and exhausting under continuous and ambiguous conditions such as the COVID-19 pandemic, which ultimately makes it more difficult to control the disease (5). The emergence of COVID-19 and its pandemic nature has caused great fear worldwide (6). Nursing students face the fear of contracting the disease due to clinical education (7). In addition, another psychosocial problem that is seen during the outbreak of

diseases is anxiety (3). Anxiety is known as a very common disorder among all students, but nursing education has been associated with higher anxiety due to clinical challenges, which can reduce the quality of care, and patient safety and lead to medical errors (7, 8). Anxiety has negative effects on students' quality of life, their academic status, and clinical education, and can even lead to dropout (9).

On the other hand, during the COVID-19 pandemic, students were prone to mental problems due to travel restrictions, social distancing, quarantine, as well as the closing of dormitories and borders all over the world (10, 11). The results of a study on more than 7000 students during the COVID-19 outbreak in China showed that 24.9% of students had anxiety (12); there are concerns about the caring behaviors of nurses under the pandemic conditions and subsequent negative impacts on their activities (13).

Therefore, despite the lack of manpower, limited resources, and high risk of infection, nurses work under highly stressful conditions and are thus exposed to the risk of physical, emotional, and psychological problems that hurt the quality of care (14). In this regard, the study of Rabia and Koca showed that there was a positive and inverse correlation between anxiety and fear of the COVID-19 disease (15). The study of Alagamy et al. also indicated that the nurses studied had mild levels of fear and stress of COVID-19, which had negatively affected their healthcare behaviors. On the other hand (16), Asadi et al.'s study also revealed that nurses working in the COVID-19 wards suffered from moderate anxiety, but the level of caring behavior provided by nurses was desirable (17).

Caring behaviors are a combination of purposeful nursing actions and attitudes that meet the physical, emotional, spiritual, social, and psychological needs of the patient. These behaviors ultimately increase the feeling of security in patients and shorten the course of the disease (18, 19). Developing care competencies is one of the most important goals of nursing education and the main pillar of this profession (20). People who enter the nursing profession should improve their caring skills at the same time as they progress in different levels of education, which ensures proper caring behavior (21, 22). If nurses do not pay attention to the correct caring behavior, the desired educational outcomes will not be achieved (23).

Previous studies have emphasized the need to investigate the mental health status of students during the pandemic (12, 24, 25). However, few studies have evaluated the psycho-social impacts of COVID-19 disease on nursing students (12). Most of the studies conducted during the COVID-19 era have investigated the psychological effects of caring for the COVID-19 disease in nurses(26-28), and fewer have targeted nursing students, since anxiety and fear may affect nursing students' caring behavior and patient safety. Therefore, this research aimed to investigate the hypothesis that there is a correlation between fear and anxiety of COVID-19 and the nursing care behaviors of nursing students.

Materials and Methods

Study Design and Participants

This descriptive-analytical study was conducted on 236 nursing students of the College of Nursing and Midwifery in Shiraz (largest city in southern Iran), from December 2021 to July 2022. The census sampling method was used in the present research which included all undergraduate nursing students. Inclusion criterion was passing at least one nursing internship. Exclusion criteria also included transferring from other universities, failure to complete the entire questionnaire, and the presence of self-reported mental illness. Before we conducted this research, permissions were obtained from the Ethics Committee of the university.

The researcher obtained the names and phone numbers of the students from the nursing faculty. The researcher called the students, explained the purpose of the research, and emphasized the anonymity of the questionnaires and the confidentiality of the information. The researcher provided the informed consent and questionnaires via Internet link through WhatsApp and then called the students and encouraged them to complete the questionnaires faster. It should be noted that the participants were assured that they could withdraw from the study at any time they wished. Finally, among 260 nursing students, 245 participated in the study, and after collecting the questionnaires, 9 questionnaires were excluded from the study due to incomplete information. Therefore, finally, the data of 236 nursing students were analyzed.

Data Collection Tools

Four questionnaires including a demographic information questionnaire (age, gender, marital status, place of residence, GPA (Grade Point Average), academic semester), Fear of COVID-19 questionnaire (29), COVID-19 Disease Anxiety Scale (CDAS) (30) and Caring Behaviors Inventory (CBI) (31) were used.

Fear of COVID-19 Questionnaire

This scale was designed by Ahorsu and colleagues in Iran in 2020 and has 7 items. Answers were rated using a five-point Likert scale (Strongly disagree, Disagree, neither agree nor disagree, agree and completely agree). The minimum and maximum scores for each question are 1 to 5, respectively, and the total score range from 7 to 35. A higher score indicates a greater fear of COVID-19. The correlation between each item and the total score ranged from 0.47 to 0.56 and the factor analysis ranged from 0.66 to 0.74. Internal consistency of 0.82 and test-retest reliability of 0.72 were obtained for this scale. Validity was estimated simultaneously with the Hospital Anxiety and Depression Scale (HADS) and Perceived Vulnerability to Disease Scale (PVDS) questionnaires and showed a significant correlation (both P<0.001) (32).

COVID-19 Disease Anxiety Scale (CDAS)

This scale was designed by Alipour and colleagues in Iran in 2020 and consists of 18 questions and 2 dimensions. Questions 1 to 9 measure psychological symptoms and questions 10 to 18 measure physical symptoms. All the questions of this questionnaire are scored based on a 4-point Likert scale, ranging from Never (score 0) to Always (score 3). The possible scores range from 0 to 54. No anxiety or mild anxiety, moderate anxiety, and severe anxiety are represented by scores 0-16, 17-29, and 30-54, respectively. Face and content validity were evaluated based on the opinions of professors and experts. To check the criterion validity of this questionnaire, we used the GHQ-28 questionnaire, and all the coefficients were significant (P<0.01). The reliability of the whole questionnaire was reported as 0.91 using Cronbach's alpha method (30).

Questionnaire Caring Behavior Inventory (CBI)

The 75-item caring behavior inventory (CBI) was designed by Wolf et al. (1998) and finally reduced to 42 questions after revision. Wolf et al. reported the Cronbach's alpha of this questionnaire as 0.93 (31). In Iran, this questionnaire has been used by Hajinezhad and Azodi (2014). The questions are scored based on a six-point Likert scale, ranging from Always: 1 to Never: 6. This questionnaire consists of 5 subscales, which include respect for others (questions 1 to 12), assurance of human presence (questions 13 to 24), positive communication and attitude (questions 25 to 33), professional knowledge and skills (questions 34 to 38), and attention to the experiences of others (questions 39 to 42). The possible score range is from 42 to 252. A higher score indicates a high caring behavior. To examine the narrative of the content, the text Questionnaire simply and fluently way in Persian language was translated and then available for polling ten members of the nursing faculty and the research council and verification the final inventory was prepared and last reviewed by Faculty Council. Then, internal consistency was used to determine the reliability of the instrument of caring behaviors with alpha coefficient(r=0.93) (33).

Data Analysis

Data analysis was carried out using descriptive analysis including frequency, percentage, mean, and standard deviation, and analytical statistics were used for qualitative and quantitative normal data. Spearman's correlation coefficient was used to determine the correlation between fear and anxiety of COVID-19 and students' caring behaviors. Spearman's correlation coefficient was used to determine the correlation between demographic variables and nurses' caring behavior, fear, and anxiety about COVID-19. Also, to investigate the correlation between the mentioned variables with demographic characteristics, we used analysis of variance and an independent t-test. The collected data were analyzed using SPSS v.21. P-value < 0.05 was considered as the statistically significant level.

In this study, only the sample that had values for all variables was used in calculations and analyses; if there was missing data for a variable, that sample was completely excluded.

Results

The mean (SD) age of 236 participants in the present study was 22.40±2.27 years. Most of the participants were male (n=121, 51.3%) and

single (n=220, 93.2%). There was a positive and significant correlation between the nursing care behavior of nursing students and the level of interest in the nursing field (P=<0.001, r=0.287).

Table 1 shows the frequency distribution of demographic characteristics and their correlation with the 3 variables studied (nurse caring behavior, fear, and anxiety of COVID-19). The results showed an inverse and significant correlation between COVID-19 fear in the state of residence (P=0.003, r=-0.191) and anxiety about COVID-19 and the state of residence (r=-0.146, P=0.02).

The results of the study showed that there was a significant correlation between gender and caring behaviors (P=0.03, r=0.141). The mean score of fear of COVID-19 was 15.5±5.5 in female students and 14±6.9 in males; As to anxiety about COVID-19, the mean score was 12.6±19 in females and 16.95±16 in males. As for caring behaviors, the mean score of was 200±24 in female students and 192±31 in male students. The details of the mean and standard deviation for nursing students' caring behavior, COVID-19 fear, and anxiety are presented in Table 2.

The mean mental anxiety was 11.52±7.6 and the mean physical anxiety was 6.7±7.9, which indicates that students had higher mental anxiety. In the present study, 48.3% of students reported low anxiety levels, 30.9% reported moderate anxiety levels, and 20.7% reported high anxiety levels. 85.2% of students' fear of COVID-19 was lower than the mean. In the present study, using Spearman's correlation coefficient, it was determined that there was no correlation between fear of COVID-19 disease and caring behavior (r=0.3, P=0.644) and anxiety of COVID-19 with caring behaviors (r=- 0.17, P=0.801).

Also, there was no significant correlation between the mental and physical dimensions of anxiety of COVID-19 with subgroups of caring behavior including "respect for others, assurance of human presence, communication and positive attitude, professional knowledge and skills, and attention to others' experiences" (P>0.05).

Discussion

The present study aimed to determine the correlation between the fear and anxiety of COVID-19 and the caring behavior of nursing students. The results generally showed that more than half of the nursing students experienced

Table 1: Frequency distribution of demographic characteristics and their correlation with 3 variables in 236 participants

Variable	Category	Frequency (%)	mean±SD	Caring behavior of the nurse	Fear of COVID-19	Anxiety of covid 19 disease
Age(year)	≤20	32 (13.5%)	22.4±2.27	r=0.033 P=0.613	r=0.03 P=0.642	r=-0.008 P=0.901
	21-25	188(79.9%)				
	<26	16 (6.8%)				
Gender	Female	115 (48.7%)	----	r=0. 141* P=0.031	r=0.115 P=0.078	r=0.073 P=0.267
	Male	121 (51.3%)				
Marital status	Single	220 (93.2%)	----	r=0.054 P=0.406	r=0.495 P=0.865	r=0.045 P=0.495
	Married	16 (6.8%)				
Interest in the field	Low	20(8.5%)	----	r=0.287** P<0.001	r=0.38 P=0.556	r=0.041 P=0.530
	Mediate	125 (53%)				
	High	91 (38.6%)				
Dwelling	Home	81 (34.3%)	----	r=0.024 P=0.715	r=0.191** P=0.003	r=0.146* P=0.025
	Dormitory	155 (65.7%)				
Academic year	First year	21 (8.9%)	-----	r=-0.64 P=0.331	r=0.002 P=0.979	r=-0.016 P=0.811
	Second year	61 (25.9%)				
	Third year	71 (30.1%)				
	Fourth year	83 (35.2%)				

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Table 2: Mean and standard deviation of caring behavior of nursing students, fear, and anxiety of Covid 19 disease

Variables	Min	Max	Mean	SD
Caring behavior of the nurse	44	228	196.29	28.07
Fear of COVID-19	7	35	15.24	6.29
Anxiety of COVID-19	17	85	18.2	14.4

moderate and high levels of COVID-19 anxiety, while many maintained lower fear of COVID-19 and manifested desirable caring behaviors. In addition, the fear and anxiety of COVID-19 did not significantly correlate with the caring behaviors of nursing students.

According to the results of the present study, more than half of the nursing students suffered from moderate and high levels of anxiety. In this regard, Babadi et al. (2021) in Ahvaz showed that 29% of students revealed anxiety, stress, and depression symptoms due to the COVID-19 disease (34). Furthermore, Cao et al. (2020) found that 24.9% of students experienced anxiety due to the outbreak of COVID-19 (12). A descriptive study in Turkey showed that nursing students obtained high scores on the COVID-19 fear and anxiety test, and 51.5% suffered from severe anxiety (35). The findings of the mentioned study are in the same line with our results concerning the high anxiety experienced by nursing students. In this respect, a study reported that the severe anxiety of nursing students negatively influenced their anxiety levels during the pandemic, leading to social isolation, economic instability, future uncertainty, remote learning challenges, and fear of infection (7). In addition, other reasons, such as the lack of masks and disinfectants and the report of exciting and incorrect news and headlines, raise anxiety (36). High anxiety in nursing students can also result from quarantine conditions and physical distances, where reduced interpersonal correlations can significantly contribute to anxiety incidence and intensification (37).

The present study also found that many nursing students manifested a low fear of COVID-19. In this regard, with similar results to our findings, Tekir (2022) in Turkey reported that students' fear of the COVID-19 disease was below the average (38). Likewise, Rana et al. (2022) discovered that fear of COVID-19 was moderate, mild, and severe in 61%, 28.1%, and 10.8% of the participants, respectively (39). On the other hand, the results of the study carried out by Albikawi (2023) during the COVID-19 pandemic in Saudi Arabia contradicted our findings, indicating that 79.3% of nursing students were afraid of this disease (40). Since our study coincided with the second year of the pandemic, the lower fear of nursing students might result from their adaptation to the current situation, injection of two doses of the COVID-19 vaccine at the minimum, and competence to cope with the conditions.

Among the other findings of this study, we can refer to the nursing students' high mean score of caring behaviors. These findings are in line with the results of the study by Asadi et al. (2020), who found that nurses working in COVID-19 wards manifested extensively desirable caring behaviors. These results imply that nurses do their best to provide nursing care to patients despite any critical conditions (17). The nursing students in the present study acted according to their ethical and professional commitments and cared for the patients properly. Furthermore, the circumstances were more stable during the sampling time regarding the prevalence of COVID-19 disease, and a large portion of the population was fully vaccinated. Hence, the students were engaged in providing nursing care to patients with peace of mind.

The results of the present study showed that the fear and anxiety of COVID-19 did not correlate with the caring behaviors of nursing students. In this concern, the findings of a cross-sectional study in Kerman revealed that nurses experienced moderate degrees of anxiety, and there was no significant correlation between COVID-19 anxiety and the caring behaviors of nurses working in COVID-19 wards. To justify the absence of such a correlation, the researchers argue that although nurses experience moderate levels of anxiety, this issue does not interfere with their nursing care and caring behavior as fundamental nursing responsibilities since nurses are committed to their accomplishment (17). However, a cross-sectional and descriptive study in Egypt has yielded different results, i.e., a positive and significant correlation between fear of COVID-19 disease and stress among nurses. This study also reported a negative and significant correlation between stress and fear of COVID-19 and the caring behaviors of nurses (16). A similar study in Australia reached the same results. The researchers claim that nurses' inadequate fear and stress management during this global crisis negatively influence their performance and caring quality, as well as patients' security (41).

Besides, the researchers found significant correlations between demographic variables such as the place of residence (dormitory or home with family), degree of interest in nursing, and gender and anxiety, fear, and caring behaviors. The results showed a negative and significant

correlation between the place of residence of nursing students and their COVID-19 fear and anxiety. In this regard, our results are consistent with those of a descriptive study carried out in Turkey, where the researchers enumerated the strict quarantine conditions in cities on weekends and long home-stay times as the reasons for their results (12). The findings of a similar study also revealed that during the COVID-19 pandemic, nursing students living in cities experienced higher levels of anxiety than their peers in villages (42, 43). In this respect, the outcomes of another quest reported that the living of students in rural regions was an influential protective factor in experiencing the anxiety of COVID-19 (7). Thus, the results of the present study also correspond with the findings of the mentioned research.

Our study also found that the degree of interest in the nursing field and gender were positively and significantly correlated with the students' caring behaviors. These results indicate that more interest in and enthusiasm for the field make nursing students outperform in caring behaviors. In this regard, the findings of a cross-sectional study entitled "Effective Factors in Medicine and Nursing Students' Eagerness to Care for COVID-19 Patients in South Korea" showed that high knowledge of the COVID-19 pandemic, positive attitudes, and preventive behaviors contributed to students' willingness to take care of COVID-19 patients (44). Perhaps the factor that caused a non-significant relationship between the fear and anxiety of nursing students and caring behaviors established in this study was the time of performing the study, considering that the COVID-19 disease was introduced as a new disease in the world in 2018, but this study was done three years after the incidence of disease. The other reason is all nursing students were vaccinated against COVID-19, and also the faculty officials had provided sufficient personal protection facilities to the students, so the students' fear and anxiety were affected and they cared for patients more confidently.

Furthermore, based on the outcomes of the current study, female students manifested more desirable caring behaviors than their male peers. However, in their research, Asadi et al. (2020) found no significant differences between male and female nurses in their caring behaviors with COVID-19 patients (17). Another research compared the quality of safe nursing care in COVID-19 and non-COVID-19 hospital wards in Tehran and found significant differences between gender and the dimensions of safe care quality; the mean scores of safe care quality in all its dimensions were higher in males than in females in both wards. These differences in the measurement dimensions of nursing skills, evaluation of physical needs, assessment of teamwork, and total safe care quality score were significant (45). The difference between the results of the present work and the mentioned studies can be due to the groups examined and instruments employed.

The most important strength of the present study is that, to the best of the researchers' knowledge, it is the first study determining the correlation between fear and anxiety of COVID-19 and the caring behaviors of nursing students.

Limitation of Study

This research suffered from some limitations. The most crucial one was the presence of individual differences among the students mentally and psychologically. By applying the census sampling method and reaching the maximum sample size, the researchers endeavored to keep the impact of these differences at a minimum. In addition, since the samples comprised students of a nursing faculty in Iran, the results are not generalizable to all Iranian nursing students. Moreover, the sampling did not coincide with the COVID-19 peak days; thus the results do not reflect the examined variables in the critical conditions of this disease. Therefore, the researchers suggest investigating the correlation between the fear and anxiety of COVID-19 and the caring behaviors of nursing students in larger samples and several nursing faculties throughout the country in the future.

Conclusion

The results of the present study showed that nursing students experienced moderate and high levels of COVID-19 anxiety while mildly fearing this disease. However, their average caring behavior was desirable. Furthermore, according to the findings, the fear and anxiety of COVID-19 disease were not significantly correlated with the caring behaviors of the nurses. All in all, the results imply that despite experiencing fear and anxiety, nursing students attempted to provide

nursing care properly. Desired caring behavior led to the safety and satisfaction of patients. Hence, nursing managers and authorities are suggested to consider some approaches to managing nursing students' anxiety and stress during the pandemic. Officials can provide a protective environment for students by providing them with necessary facilities in crises; also, by holding educational workshops, they can increase students' skills in cognitive, motor, and emotional dimensions: The researchers suggest that qualitative studies should be conducted on the mentioned variables in crisis conditions.

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Authors' Contribution
L.H. and A.Z. conceptualized the study AND conducted the research. L.H and A.Z. and A.F. wrote the manuscript and approved the final version of the manuscript.

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Ethics Approval and Consent to Participate
This study was approved by the Ethics Committee of Shiraz University of Medical Sciences with the ethics code of IR.SUMS.NUMIMG.REC.1400.067. The access link to the ethics permission is https://b2n.ir/k40471. In the present study, the participants were not asked to write their names, and they were assured about the confidentiality of their information.

Consent for publication
Not applicable.

Conflict of Interest
There are no conflicts of interest

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Original Article

Resilience Status of Hospital Service Quality According to the World Health Organization Evaluation

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Abstract

Introduction: Ensuring and maintaining the health of the population is one of the most important programs in any country. Those involved in this field strive to provide quality services to society under all conditions, including times of crisis and epidemic. This study examined the resilience status of the hospital services quality based on six building blocks evaluation by World Health Organization.

Methods: This study used a quantitative method from the beginning of 2020 to the end of 2021. The sample of the study was purposefully composed of 50 senior and middle managers of Shiraz Medical Hospitals who were continuously providing services during the COVID-19 pandemic. A researcher-developed questionnaire in the field of Six building blocks was used to collect the data, and SPSS software version 21 was used for data analysis.

Results: Hospital service quality resilience generally showed that, with a mean and standard deviation of 68.51±8.53%, the extent of access to medicines and medical equipment (79.50±16.12) and the extent of financing (60.42±16.01) were the highest and lowest.

Conclusion: The quality of hospital services is considered an indicator of governance during the COVID-19 pandemic. Despite many efforts in this area, the assessments reveal that most hospitals in the country face many problems and unfavorable conditions. To ensure resilience and better healthcare outcomes in future crises, managers should also prioritize communication and collaboration with other healthcare facilities and provide medications and medical equipment for better response during pandemics. Also, comprehensive hospital preparedness must be a top priority for policymakers and healthcare managers.

Keywords: Quality resilience, Hospital services, Six building blocks, Covid-19 virus

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Introduction

Providing and maintaining the health of people is one of the most important programs of the health and treatment system of any country and is one of the development priorities. Stakeholders strive to use the resources available to provide quality healthcare and treatment in all situations, even during crises and epidemics (1). In the health system, hospitals, as the main centers of health- care, play an important role in achieving the goals of the health sector, whose main mission is to provide quality care in each country (2).

Quality health services must have the characteristics of accessibility when needed, safety, efficiency, accuracy in the use of diagnostic and therapeutic services, and effectiveness of treatment in all conditions (3). Using quality services by eliminating re-work and wasting resources will save the costs, increase patient satisfaction and loyalty, improve staff morale, and enhance patients' and staff's safety (4-6).

The World Health Organization defines quality in terms of effectiveness, price, social acceptability and accountability, and emphasizes the importance of the quality and continuity of healthcare (7). Continuity of quality services refers to the quality of services resilience; that is, hospitals can have the best response and performance in providing quality health services

in stressful and unfortunate situations as normal conditions (8).

One of the unfortunate situations is the COVID-19 epidemic, which appeared with a high transmission rate and spread rapidly, confronting all countries of the world with huge health and medical challenges (9), even increasing the number of cases and saturating the capacity of health systems. Ultimately, this has led to high mortality rates worldwide (10, 11). Disinfection of the hospital environment and inadequate control of the cut and chain have disrupted the provision of quality services (12).

Hospitals must be resilient in providing optimal care to deal with the challenges and adverse conditions of COVID-19 pandemic (13) and respond to crises in a timely and prepared manner by providing preparedness, planning, and flexibility (14). Prompt and timely referral plays a critical role in reducing mortality and saving patients (15). Evaluation of their performance is important. One of the methods of performance evaluation based on the Six building framework of health systems is the World Health Organization, which evaluates the health systems in terms of service delivery, manpower, information systems, and access to essential drugs, medical care, financial resources, leadership, and governance (16).

At the beginning of the epidemic, most hospitals in the country were disrupted due to the lack of preparedness, followed by an increase in the number of patients and prolongation of the pandemic, with capacity saturation, which disrupted the care process and increased mortality in these conditions to improve the patients' performance. There are many resilience assessments that can identify vulnerabilities, strengths, weaknesses and plans to improve hospital performance in the face of epidemic crises (15, 17).

The effective factors on the resilience of hospitals in the study showed that training management, resource capability, equipment, and organizational structure have been identified (18). Another study in Iran identified factors such as communication and information technology system, training and equipment and its elements, equipment, response, coordination and transport system as dimensions affecting hospital resilience. (19).

It is necessary to study the resilience of the quality of services in the hospitals in the country because Shiraz University of Medical Sciences is one of the type one universities in the country and even in the world and has various teaching and specialized hospitals equipped with modern diagnostic and treatment equipment and experienced professors and doctors (20). Also, it has an organ transplant treatment centre, which is the first and largest centre in Iran and the third transplant centre in the world after the United States and Spain; it provides services to a large number of patients in need of transplantation in the country and even the Middle East, so measuring and analyzing their resilience is important.

The present study aimed to investigate, for the first time in Iran, the resilience of the quality of hospital services under epidemic conditions in teaching hospitals in Shiraz; the policymakers and health system managers in similar conditions can use the results of this study in hospital planning and preparation.

Methods

Study Design

This is a quantitative study at Shiraz Medical Sciences Hospital in 2020-2021.

Study Population

A purposive sampling method was used to select the participants. From the 70 senior and middle managers in ten hospitals affiliated to Shiraz University of Medical Sciences, the sample size was estimated 59 subjects by using Morgan's table (21), but due to the lack of permission from the hospital manager for the researcher to enter the hospital, and also the unwillingness of some sample members to participate in the research due to COVID-19 virus, only 50 people were selected for the study. Under the conditions and restrictions of COVID-19, administrators allowed limited sampling to ensure staff safety and reduce traffic problems at hospitals. First, the hospital management was contacted and, if they agreed, information was collected.

Inclusion Criteria

- Infection control supervisors, quality improvement managers, training supervisors, patient safety coordinators, human resource managers, hospital managers, and nursing managers were selected.

- Individuals who had direct experience of providing ongoing services in the context of the COVID-19 crisis.
- Individuals who were willing to participate in the research

Exclusion criteria
- Lack of permission from the hospital management
- to participate in the study

Setting and Data Collection

A researcher-designed questionnaire was used to assess the resilience status of hospital service quality. The questionnaire was designed into three parts. The first part included information on the characteristics of hospitals with four questions (type of hospital specialty, identification of non-clinical and clinical participants, number of active beds, and number of nurses). By consulting experts and studying articles (22), the research team came to the conclusion that these characteristics can be effective on the resilience of hospital service quality.

The second part of the questions on the continuity of hospital services quality, based on the Six building framework for health system evaluation, has 47 questions in six dimension, including service delivery (questions 1 to 17), workforce dimension (questions 18 to 21), access to medicines and medical care (questions 22 to 25), financing dimension (questions 26 to 32), governance and leadership dimension (questions 33 to 43) and health information system dimension (questions 44 to 47), with the option of answering no, to some extent, and yes.

The third part, including the status of indicators of hospital service quality, was designed with 25 indicators. The list of indicators was prepared by the research team. In a focused group meeting, 4 members of the Faculty of Health Care Management with research experience in the field of quality and resilience were appointed. The experts' suggestions and corrections were applied to the list of indicators, and finally 25 final indicators were selected.

The content validity of the questionnaire was assessed by 12 experts in healthcare management, disaster health, health policy, hospital managers, nursing managers, and quality improvement managers. To determine the content validity ratio (CVR), we gave the questionnaire to the experts and they were asked to rate each question on a three-point scale: "not necessary, useful but not necessary, or necessary". Acceptance of questions was based on Laoche (23), and questions with a content validity ratio greater than 56% were accepted.

The reliability of the questionnaire was tested using Cronbach's alpha coefficient, which ranged from 0.82 to 0.92. This indicated the reliability of the questionnaire (Table 1).

Table 1: Reliability of the questionnaire according to the resilience dimensions of hospital service quality

Dimensions	Cronbach's alpha coefficient
Service delivery	0.92
Human resource	0.85
Access to medicine and medical care	0.91
Financial security	0.82
Management and leadership	0.89
Information system	0.87

In order to collect the information, we first coordinated the time schedule with the participants; then, the questionnaire was completed in a face-to-face meeting with questions from them. Simultaneously, the ambiguities were explained to the participants to better understand the questions, and by referring to the quality improvement or statistical unit of the hospital, the information on the performance indicators of the hospitals before and after COVID-19 was received, and the performance of the hospitals was compared over two years.

Data Analysis

The data collected were entered into SPSS software version 21 and analyzed. The normality of the data was first checked using the Kolmogorov-Smirnov test with a significance level of P=17.17. The independent T-test was used to determine the hospital services quality resilience, and the Mann-Whitney test was used to compare the indicators.

Results

The results showed that 72% of the participants were female and 28% were male. Their mean age was 41.48±6 6.18 and work experience was 18.72±23 8.23 years. 20% of the research participants were hospital managers, 20% were quality improvement officers or secretary of hospital executive management committee, 20%

were nursing managers, and 40% were hospital ward managers and supervisors.

Table 2 shows that the resilience status of service quality in Shiraz medical hospitals using t-test was 68.51%, and the highest mean resilience of hospital service quality was related to the dimension of access to medicine and medical care (79.50±16.12); also, the lowest value was related to the financing dimension (60.42±16.01).

Table 2: Service Quality Compatibility Status in Shiraz Medical Hospitals

Dimensions	Standard Deviation± Mean to Percent
Service delivery	69.59±14.21
Human resource	77.80±12.66
Access to medicine and medical care	79.50±16.12
Financial security	60.42±16.01
Management and leadership	62.23±11.82
Information system	73.40±11.17
The average of the total quality of hospital services	68.51±8.53

Table 3 shows that there was no significant difference (P>0.05) in the resilience dimensions of hospital service quality between clinical and non-clinical participants. The mean and standard deviation of hospital service quality were 66.81±8.69% for clinical participants and 71.07±7.80% for non-clinical participants.

Table 4 shows that there was no statistically significant difference between the performance indicators of hospitals based on COVID-19 and non-COVID -19 patient care centers and the performance indicators of hospitals before and after COVID-19; moreover, the percentage of nosocomial infection rates was 3.76±1.17, satisfaction of staff 57.98±4.41, the patients' satisfaction 77.54±5.15, patients' homework within 12 hours was 85.80±7.35, and the shortage of nursing staff was 12.63±9.62

Discussion

The present study examined the resilience status of service quality in Shiraz teaching hospitals during the COVID-19 epidemic based on the Six building blocks framework of the WHO Health Systems Assessment in the dimensions of service delivery, human resources, information systems, access to essential drugs and medical care, financial resources, leadership, and governance.

The results of the present study showed that the quality-of-service status of Shiraz medical hospitals with a mean and standard deviation of 68.51±8.53% and the quality of service between non-clinical participants' point of view (71.07±7.80) with clinical participants' point of view (66.81±8.69). The difference was not statistically significant (P=0.08). Consistent with the results of this study, Narwal et al. in India showed reduced access to essential medical services, lack of facilities and infrastructure for triage, lack of isolated wards and hospital beds, delayed care and patient safety, and quality of hospital care. The length of the epidemic (24) also showed that delayed action to control COVID-19 virus disease led to unpleasant accidents and a decline in the quality of hospital care (25).

In the present study, the quality-of-service delivery, with a mean and standard deviation of 69.59±14.21%, and the challenges of slow patient allocation, long waiting times and increased numbers of patients were observed. Nosocomial infections were also observed. In addition, Douglas et al. in Nigeria found that the unpreparedness of hospitals or lack of facilities to deal with the epidemic reduced the quality of services (26). The findings of a study by Gonijal et al. (27) are consistent with the results of the present study.

The present study showed that the equipment required for neurological surgeries in Shiraz had only one hospital, which was designated as a hospital for COVID-19 virus patients and caused a lack of access to services for patients with brain

Table 3: Status of the quality of hospital services from the perspective of the participants

Dimensions	Non-Clinical participants	Clinical participants	sig
	Standard Deviation±Mean to Percent	Standard Deviation±Mean to Percent	
Service delivery	72.04±12.64	67.95±15.15	0.32
Human resource	79.50±11.90	76.66±13.21	0.44
Access to medicine and medical care	83.75±13.51	76.66±17.28	0.12
Financial security	64.64±13.80	57.61±16.97	0.13
Management and leadership	64.23±11.97	60.89±11.73	0.33
Information system	75±10.51	72.33±11.65	0.41
The average of the total quality of hospital services	71.07±7.80	66.81±8.69	0.08

Table 4: Comparison of performance indicators of hospitals by service center for COVID-19 and non-COVID -19 patients and before and after COVID-19

Variable	Hospitalization center for covid-19 patients	Hospitalization center for Non covid-19 patients	P value	Standard Deviation±Mean to Percent		P value
	Standard Deviation±Mean	Standard Deviation±Mean		2018 (before of covid-19)	2020 (after of covid-19)	
Percentage of bed occupancy	58±57	72.80±7.80	0.13	76.39±14.34	67.57±16.45	0.23
Average patient length of stay by day	3.35±0.22	6.71±1.69	0.11	5.77±3.22	5.45±3.35	0.84
Duration of level 1 triage	2.72±0.92	2.20±0.37	0.64	2.63±1.23	2.39±0.38	0.86
Duration of level 2 triage	6.33±2.90	8.44±4.01	0.68	8.50±2.93	7.65±2.61	0.83
Duration of level 3 triage	8±2.26	14.05±7.21	0.46	10.53±3.15	11.87±4.53	0.82
Duration of level 4 triage	8.74±1.51	23.20±15.14	0.39	12.50±3.39	17.78±9.441	0.61
Duration of level 5 triage	7.67±3.18	23.60±15.59	0.36	12.25±3.63	17.63±9.82	0.62
Net mortality rate	7.45±4.40	6.10±2.90	0.81	6.63±1.83	6.60±2.27	0.99
Gross mortality rate	4.69±0.21	7.60±3.46	0.44	7.60±2.05	6.77±2.45	0.79
Percentage of maternal mortality	7.32±7.29	0.01±0.01	0.42	0	2.75±2.73	0.34
Percentage of personnel death due to corona	0	0.05	0.37	0	0.03±0.03	0.35
Percentage of hospital infection	2.12±1.26	4.75±1.64	0.25	3.29±1.05	3.76±1.17	0.76
Percentage of assignment of patients under 6 hours	92.75±1.51	91.73±5.56	0.86	94.56±3.61	92.11±3.37	0.62
Percentage of assignment of patients under 12 hours	81.48±13.41	88.40±9.64	0.69	98.49±1.35	85.80±7.35	0.13
Percentage of staff satisfaction	57.95±9.95	58±7	.99	63.41±3.19	57.98±4.41	0.34
Percentage of patient satisfaction	67.13±11.87	82.75±3.98	.39	78.81±3.36	77.54±5.15	0.84
Number of dead morgues	3.67±2.66	2.80±1.39	.79	3.13±1.21	3.13±1.21	1
Percentage of patients falling	.03±0.02	2.04±1.02	0.12	0.53±0.36	1.28±0.71	0.37
Percentage of bed sores	0.28±0.01	0.21±0.12	.65	0.20±0.06	0.23±0.08	0.81
Percentage of medication error	0.02±0.01	4.33±2.04	0.10	3.26±2.20	2.72±1.45	0.84
Percentage of medical error	2.53±2.39	6.41±2.55	0.31	3.06±1.33	4.95±1.86	0.42
Percent of failed CPR	48.69±25.27	38.28±21.33	0.68	52.39±12.58	39.68±15.42	0.53
Percentage of surgery cancellation	10.86±7.08	5.45±3.03	0.53	6.81±2.51	7.48±3.10	0.86
Percentage of voluntary discharge from hospital	8.90±2.15	8.82±2.59	0.98	6.90±1.86	8.85±10.70	0.45
Percentage of voluntary discharge from the emergency room	5.79±3.19	4.95±0.31	0.81	3.88±0.84	5.26±10.07	0.32
Percentage of nursing staff shortage	19.33±3.48	8.60±4.23	0.09			

tumors in this regard. A study by Akinyemi et al. states that patients in need of surgical care were severely deprived of access to care due to the allocation of hospitals to care for patients with COVID-19 virus disease (28). It appears that the lack of beds and equipment in Shiraz hospitals is hampering the provision of quality care. It has compromised the safety of patients during treatment.

In the present study, it was also shown that in the field of leadership and governance of Shiraz hospitals in medical sciences the mean and standard deviation were 62.23±11.82. The medical services were also identified. Poor crisis management is the result of surprise and unpreparedness for an epidemic and delayed decision-making. A study in China showed that crisis management in hospitals was unpredictable (29). It seems that in hospitals with more donor support, the decision-making power of hospital managers to provide quality care was greater, while in other hospitals the decision-making power of managers was more limited (30).

The present study has focused on the resilience of the hospital services quality in the dimension of human resources in Shiraz Medical Sciences Hospitals, with a mean and standard deviation of 77.80±12.66%, which is known as the main challenge faced by the study participants. Also, in Crincho's study, respondents reported that the shortage of health workers in the country worsened with the spread of the epidemic and challenged the functioning of health systems (31, 32). These findings are consistent with our study.

It is well known that one of the challenges hospitals are faced with is the shortage of nursing staff. This shortage of staff affects the provision of services to COVID-19 patients. Based on the results of the present study, Narwal et al. in India and a study by Haldane et al. on 28 countries, the challenge of labor shortage has been identified as one of the factors reducing the resilience of hospitals. This has led to delays in patient care, staff burnout, medical malpractice, and unsafe patient care (24, 33).

There seems to be a severe shortage of nursing staff in the hospitals affiliated with Shiraz Medical Sciences. Even in one of the study hospitals for obstetrics and gynecology, this is the place of hospitalization for COVID-19 patients for pregnant mothers. The head nurse of the COVID-19 ward has a degree in midwifery, but due to the sensitivity of pregnant mothers, midwifery and nursing services should be provided during an epidemic. They do not receive respiratory care to provide services to patients.

In the present study, staff training went well in all hospitals. In this regard, the results of the study were satisfactory, and the colleagues showed that the training of the personnel in the processes of rapid identification and isolation of suspected cases of COVID-19 was successful (34). Shiraz hospitals were successful in this area, and the strength of this epidemic enhanced their knowledge and readiness in critical epidemic conditions.

The present study showed that the dimension of access to medicine and medical care in Shiraz medical hospitals, with an average and standard deviation of 79.50±16.12, had the highest level of quality resilience. However, hospitals continue to face challenges in providing medicines and medical equipment during the COVID-19 pandemic. In some hospitals in Shiraz, there was a shortage of oxygen suppliers and ventilators during the treatment process for COVID-19 patients, which affected the provision of safe care for patients requiring oxygen. The provision of oxygen to patients was questioned (35). A study by Garge in India also showed that the lack of an oxygen machine made it difficult to provide safe care (36), which is consistent with the results of the present study.

In this study, one of the hospitals specializes in oncology and hematology. The drugs and consumables needed by cancer patients were insufficient and of low quality. In the same line with our study, Al-Shahrani et al. stated that COVID-19 was faced with medication shortages and insufficient nursing care (37). In a study by Edge et al. in Australia, 42% of cancer patients experienced a superficial level of care disruption (38), which is almost consistent with the present study.

In these circumstances, the sanctions appear to have had a significant impact on the supply of medicines and equipment, and the inadequacy of medical resources was exacerbated by the COVID-19 virus pandemic. Some consumables, such as serum guides or some drugs with an IV color set to avoid being affected by the light reaction, had to be injected into the patient, which was not done due to the lack of supply, and sometimes even cancer patient relatives were inevitably sent out of the hospital to buy medicine. These factors have a significant impact on patient safety.

In the present study, the resilience of the hospital services quality in the field of financing of Shiraz medical hospitals had a mean and standard deviation of 60.42±16.01%. According to the interviewees in the COVID-19 pandemic, with the increase in the use of personal protective equipment and antiseptics, a global shortage was created, which was imposed on hospitals by manufacturing companies due to the increase in prices. In a study by Aknemi et al., respondents acknowledged that the Nigerian health sector was underfunded before the outbreak and that the situation was worsened (28). This finding is consistent with the results of the present study. In Iran, the Ministry of Health, Treatment, and Medical Education is responsible for the health system. It seems that under the conditions of the epidemic disease, despite the severe sanctions in the field of funding and equipment needed by hospitals, it did its best to eliminate the disruption in the process of providing quality services.

In this study, staff satisfaction during the COVID-19 virus disease was 57.98±4.41% with a mean and standard deviation. It seems that this index was affected by double work pressure, untimely payment of staff demands, and lack of organizational vitality. The index is influenced by the patients' waiting status for care.

The present study showed that in the health information system of Shiraz University of Medical Sciences with 73.40±11.17%, the

participants faced challenges in compiling inappropriate guidelines, not registering patient records electronically, and slowing down the information system. A study in Pulla, India, found that hospitals performed poorly in terms of health information system infrastructure and electronic health records (39). Jabin's study suggested that electronic health records were being used in Iran and Nigeria (40), which contradicts the findings of this study. Among the hospitals studied, only one registered patient file was used as an electronic pilot study.

In general, the results of the present study show that most of the hospitals in the country have many problems and unfavorable conditions such as lack of manpower, lack of oxygen, poor quality of consumables, inappropriate beds, lack of motivation, the staff's dissatisfaction , patients' dissatisfaction, and long waiting lines.

Limitation

Limitations of this study could be the COVID-19 pandemic conditions and the reluctance of hospital staff to share their experiences due to the sensitive nature of the epidemic. Another limitation was that managers allowed limited sampling of the researcher to maintain social distance and reduce traffic in the hospital.

Conclusion

The quality of hospital services is an indicator of the governance of the Ministry of Health during the pandemic. Significant health inequalities were observed. The assessment shows that despite the many efforts made in this area, most of the hospitals in the country face many problems and unfavorable conditions. Policymakers and managers need to prioritize comprehensive hospital preparedness during critical epidemics. To enhance hospital resilience, managers must provide medications and medical equipment, as well as personal protective gear and strategies for recruiting, retaining and training staff. Managers should also prioritize communication and collaboration with other healthcare facilities and governmental agencies to ensure a coordinated response during the pandemics. The researchers suggest that systematic review studies should be conducted on the quality of hospital services resilience in the pandemic conditions.

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Authors' Contributions

All the authors conceived and designed the study. NM collected the data. All authors analyzed the data. NM wrote the first draft of the manuscript. All the authors approved the final manuscript.

Ethics Approval

This study was approved by Iran University Medical Science, IR.IUMS.REC.1400.110.

Conflict of Interest

There are no conflicts of interest

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Original Article

Design and Implementation of a Fuzzy Intelligent System to Estimate the Photoplethysmogram Systolic Features by Persian Medicine Pulsology

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Abstract

Introduction: In Persian medicine (PM), pulsology is one of the most important ways of knowing the internal states of the body and diagnosing diseases. On the other hand, the photoplethysmogram (PPG) signal provides significant information about the heart function for specialists. In this design, fuzzy systems have been used to correlate features from both PPG signal and PM pulsology. Such a system may help pave the path towards a worldwide accepted paradigm of integrative medicine.

Methods: Using the information of 64 individuals, a fuzzy system was designed by MATLAB software. First, the information related to age and pulse parameters including frequency, strength, speed, length, and width were acquired by a PM specialist via traditional pulse examination and considered as input variables. Subsequently, their PPG curve was also recorded by a PO80 beurer pulse oximeter. Afterwards, variables of slope, height, and time of systolic upstroke curve at points of 25%, 50%, 75%, and 100% amplitude of PPG curve were calculated and considered as output variables.

Results: A system with 236 rules was designed and the error of this system was less than 0.05, which is considered an acceptable estimate.

Conclusion: This designed pilot system estimated the PPG systolic features using PM pulsology with an error of less than 0.05, which can be used to help improve the clinical skills of PM students and practitioners and can establish the relationship between PM and common medicine.

Keywords: Pulse, Persian medicine, Fuzzy system, Photoplethysmogram, Pulsology

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Introduction

The latest global medical approach and also reputable medical centers are towards integrative medicine, which is the combination and integration of approved diagnostic and treatment methods of traditional and complementary medicine with conventional medicine (1). One of the most rooted schools of traditional medicine is Persian medicine (PM) which is currently faced with academic criticism and revival in many countries, including its motherland,Iran. Pulse diagnosis is one of the most important methods of clinical diagnosis in PM, which has been used for many centuries by traditional medicine specialists to assess the health status and disease of clients (2, 3). As pulsology includes more than a quarter of the pages written about semiology in major PM

textbooks, the use of its capacities seems fruitful and usable for identifying and diagnosing diseases aside from conventional methods of diagnosis (4, 5). On the other hand, there are concerns and considerations regarding the experience and analysis of pulse results by practitioners and the training of students in this field because pulse examination in PM is done with the fingers of a specialist, which can be associated with errors, and inferring from the rules of the pulse is complicated due to the high number of these rules. In recent years, broader and newer dimensions of artificial intelligence applications, such as fuzzy systems, have been shown to help develop a standard PM Pulse diagnosis and its integration with conventional methods of diagnosis because fuzzy logic is a soft computing method that studies reasoning systems in which graded true and false concepts are considered (3, 5, 6). Fuzzy logic is very suitable for the development of knowledge-based systems in medicine, as well as disease diagnosis and real-time monitoring of patient's data (6-8).

This research aimed to evaluate the usability of Persian medicine pulsology to estimate the slope, height, and time of the systolic curve of PPG signal with the help of a fuzzy system design. Thus, a fuzzy system was designed to estimate the different characteristics of the systolic upstroke of photoplethysmogram (PPG) signal using selected pulse parameters of PM. The significant and innovative aspect of such a study is to validate and evaluate the talents of PM practitioners and their diagnostic claims in analyzing the pulse, by using the capabilities of Artificial Intelligence, especially fuzzy systems. This will help integrate the approved statements of centuries of traditional knowledge and clinical experience of PM physicians into conventional medicine benefiting human health. Below, the concepts related to the pulse of PM and the PPG signal, as well as fuzzy inference systems, are reviewed and then the method of design and analysis of the results of the fuzzy system is stated.

Pulse

In PM literature, – li ke modern physiology,the regular periodic expansion of an artery due to the ejection of blood into the arteries by heart contractions is known as pulse. Each pulse is considered to include two movement periods of expansion and contraction, and two pauses, lying in between every two movements. The pulse of each individual is analyzed by different parameters to determine the health and disease status. These parameters include pulse expansion in three spatial dimensions, strength, speed, frequency, vessel fullness and consistency, quality of the overlying skin and tissue, pulse uniformity or diversity, and pulse weight or music. However, in this study, we have minimized the acquired pulse parameters to the parameters of frequency, strength, speed, length, and width as they theoretically seemed to be most related to the systolic phase curve of the PPG signal (1, 9-11).

Fuzzy systems

Fuzzy logic is currently used in various branches of science. In artificial intelligence, which is designed based on non-deterministic data, fuzzy logic and rules of this logic are widely used. The fuzzy set A in the global space U is defined by a function $\mu_A(x)$ that takes values in the interval [0,1] and is defined as Equation (1):

$$A = \{(x, \mu_A(x)) | \ x \in U\} \quad , \mu_A(x) \in [0,1] \qquad (1)$$

Therefore, a fuzzy set is a generalization of a classical set; in other words, a classical set could only have two values 0 and 1, while the membership function of a fuzzy set is a continuous function in the range [0,1]. The structure of a fuzzy expert system consists of four parts: fuzzification of inputs, rules, inference engine, and defuzzification of outputs. Suppose in the if-then fuzzy rules with the given centers is a normal set, and the rules base with the product inference engine are given by Equation (2) and singleton fuzzifier and center average defuzzifier are given by Equations (3) and (4):

$$\mu_B(y) = max_{l=1}^{M} \left[sup_{x \in U} \left(\mu_A(x) \prod_{i=1}^{n} \mu_{A_i^l}(x) \mu_{B^l}(y) \right) \right] \qquad (2)$$

$$\mu_A(x) = \begin{cases} 1 & if \quad X = X^* \\ 0 & if \quad X \neq X^* \end{cases} \qquad (3)$$

$$y^* = \frac{\sum_{l=1}^{M} \bar{y}^l w^l}{\sum_{l=1}^{M} w^l} \qquad (4)$$

Then, the fuzzy system will be in the form of Equation (5):

$$f(x) = \frac{\sum_{l=1}^{M} \bar{y}^l \left(\prod_{i=1}^{n} \mu_i^l(x) \right)}{\sum_{l=1}^{M} \left(\prod_{i=1}^{n} \mu_i^l(x) \right)} \qquad (5)$$

where y and x are the input and output variables of the system and A and B are the fuzzy sets related to the input and output of the system, n is the number of input variables, and M is the number of rules of the fuzzy system; also, $x^* \in U$ has a membership value 1 at x^* and 0 at all other points in U, $\bar{y}^l$ is the center of the lth fuzzy set, and w^l is its height. It is noted that the fuzzy system in the form of Equation (5) can approximate all continuous functions with the desired accuracy (12). Therefore, with these fuzzy systems, all continuous functions can be estimated with the desired accuracy.

Photoplethysmogram

Photoplethysmogram (PPG) is a non-invasive optical technique used to measure blood volume changes per pulse (13). PPG has a wide application in healthcare where it is used to predict vital health-related parameters. Also, PPG has been used for determining the heart rate, atrial stiffness, blood oxygen saturation, and blood glucose levels (14). The PPG sensor consists of two components: a Light-Emitting Diode to illuminate the skin surface and a photo-detector for measuring the changes in light absorption over a period of time. The high-frequency part of the PPG signal contains information regarding heart pulsation. This part is superimposed onto a large non-pulsating lower frequency part affected by various factors which are respiration, absorption from non-vascular tissue, and sympathetic nervous system activity (13, 14).

The pulse wave analysis refers to signal processing and extraction of certain characteristic features from the PPG waveform. This method requires only one measurement sensor, PPG. Developments in computing and data analysis tools have simplified the pre- and post-processing of physiological signals such as PPG (13).

Systolic time intervals (STI) provide a temporal description of successive phases of the cardiac cycle and are physiologically influenced by the same variables that influence the left ventricular function (15). STI is one of the first non-invasive heart function tests that is simple and reliable to perform. It has shown significant diagnostic and prognostic value in evaluating the overall functions of the heart. By using systolic time intervals, successive stages of the cardiac cycle can be detected. STI is a promising tool used to follow up on the long-term condition of patients with chronic cardiovascular diseases (14, 16, 17). Figure 1 shows a PPG signal diagram indicating the points of 25% (a), 50% (b), 75% (c), and 100% (d) amplitude of the systolic peak on the systolic upstroke curve.

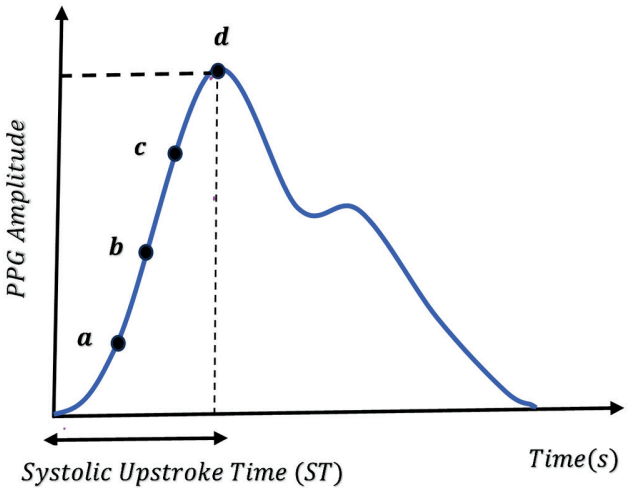

Figure 1: A PPG signal curve indicating the points of 25% (a), 50% (b), 75% (c), and 100% (d) amplitude of the systolic peak

In recent years, the use of fuzzy systems to diagnose, predict, and control diseases is increasing. Even in the detection of the Covid-19 virus, much research has been done with the help of fuzzy systems, including the works done by Painuli et al. (18), Abeer Fatima et al. (19), as well as Dehghander et al. (20, 21). Among the few cases where fuzzy systems have been used in PM, some of them are discussed. In 2015, Dehghander and his colleagues used fuzzy theory to rank the temperature of feverish diseases in Persian medicine, also known as Iranian traditional medicine. In this research, considering eleven input variables, and five output variables, and compiling 32 rules, they presented their proposed model (3). Also, in another study, Dehghander and his colleagues in 2016 used fuzzy theory to determine the retentive causes of the pulse by the pulse parameters of PM. They presented their proposed model assuming ten input variables, three output variables, and 25 rules (6). Also, Dehghandar et al., in another study in 2022 estimated the gradient of brachial blood pressure in men with 11 input variables and one output variable, and 36 rules, and explained how to estimate the gradient of brachial blood pressure in men using pulse parameters of PM (8).

Considering that PPG is a technique for measuring blood volume changes per pulse

and PM pulse parameters show the quality and changes of blood in each pulse, which are very closely related, in this research with the help of a fuzzy intelligent system the PPG systolic features are estimated by PM pulse parameters.

Materials and Methods

In this study, the slope, height, and time of several selective points of the systolic upstroke curve of the PPG signal were estimated by selective pulse parameters of Persian Medicine with the help of fuzzy system design. Given the absence of similar studies, this is a pilot study with a sample population of 64 individuals. These individuals were examined at the Ahmadieh PM Clinic of Tehran University of Medical Sciences. In this research, the individuals were between 7 and 69 years old and all were healthy; heart patients were excluded from this data. First, the pulse was examined according to traditional PM pulse examination by a PM specialist physician, and the information related to the pulse parameters, including pulse frequency, strength, speed, length, and width were evaluated and recorded with very low, low, medium, high and very high values with numbers 1 to 5. Subsequently, their PPG diagrams were also recorded in 5 seconds by a PO80 beurer pulse oximeter.

The system design process is shown in Figure 2.

According to the definition of relations (2) and (4) related to the structure of the fuzzy system and their compatibility with the fuzzy systems of this research and the high accuracy of the defuzzifier of relation (3), the design of the fuzzy system based on the singletone fuzzifier, product inference engine and center average defuzzifier was performed similarly to previous studies (8, 20). To calculate the slope, height, and time of selected points of the systolic upstroke curve of the recorded PPG diagrams, first, the coordinates of the graphs were obtained for each person in a 5-second period, and the average of the systolic PPG signal was plotted using the polynomial interpolation method. Then, the slope, height, and time values at points of 25% (a), 50% (b), 75% (c), and 100% (d) amplitude of systolic peak on the systolic upstroke curve were obtained.

Next, the data were normalized, by Equation (6), to simplify and decrease the error of data comparison and after normalization; all the data were between 0 and 1.

$$x_{new} = \frac{x_{old} - x_{min}}{x_{max} - x_{min}} \qquad (6)$$

where x_{new} is the new normalized data, x_{old} is the current data, x_{min} is the smallest data, and x_{max} is the largest data.

The input data and the output data of the slope, height, and time of the systolic upstroke curve at 25% of PPG curve peak amplitude are shown in Table 1.

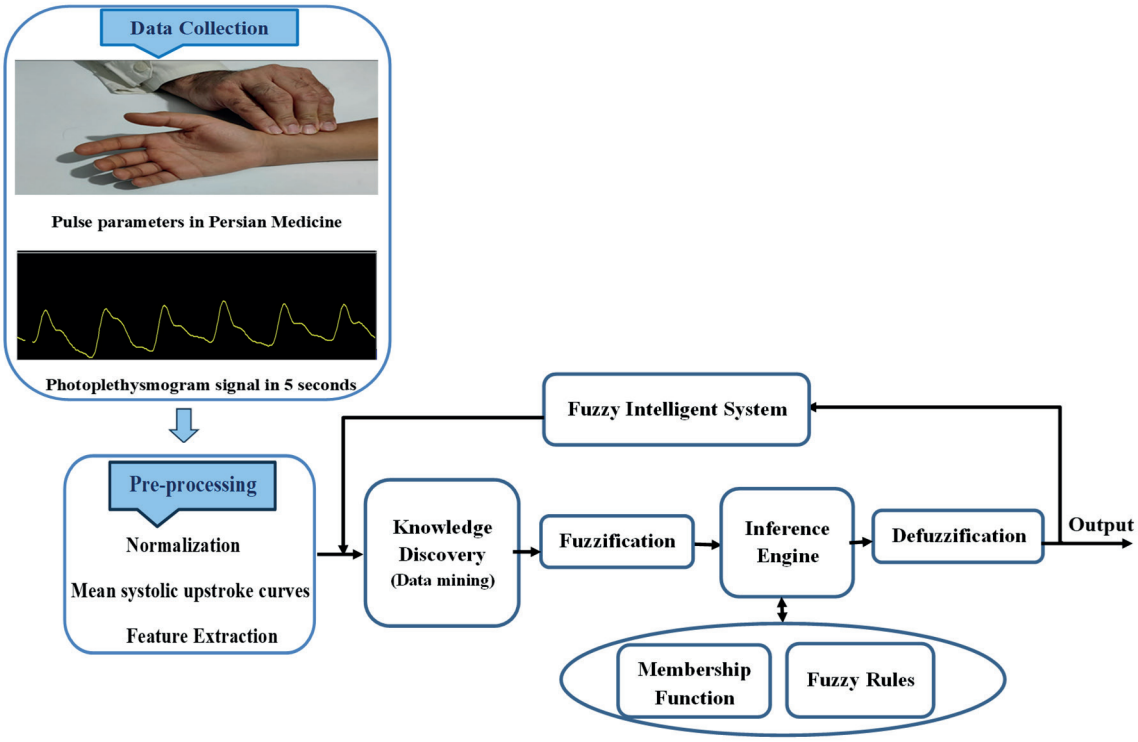

Figure 2: The flowchart of Designing a fuzzy intelligent system to estimate the PPG systolic features PM pulsology

Table 1: Values of input and output data at 25% of PPG curve peak amplitude

I/O	Variables	Max	Min	Mean
I_1	Age	69	7	35
I_2	Pulse Frequency	5	1	2.53
I_3	Pulse Strength	5	1	3.79
I_4	Pulse Speed	3	1	2
I_5	Pulse Length	3	1	2
I_6	Pulse Width	5	1	3
O_1	PPG Slope	14.5	3.2	8.85
O_2	PPG Height	51.62	16.82	34.22
O_3	PPG Time	0.0742	0.0339	0.0541

Then, all the data except speed, length, and width were normalized; therefore, taking into account the intervals obtained after data normalization, we determined the input variables of age, frequency, and strength with Gaussian Membership functions, as shown in Figure 3.

For the input variables of pulse speed, length, and width, the triangular membership function was used. In addition, the division of the output variables of slope, height, and time has been done with the Gaussian membership function, as shown in Figure 4.

The definition of fuzzy sets in the membership functions was done in such a way that the input and output spaces were covered and, therefore, complete fuzzy sets were used. Also, as can be seen, the fuzzy sets are designed in such a way that the condition of Equation (7) is satisfied in them and they are normal.

$$\forall A_i^l : \exists x_i \mid \mu_{A_i^l}(x_i) = 1 \quad (7)$$

In other words, in every fuzzy set A_i^l, there is a member x_i whose height is equal to 1. Then, 5 variables of pulse frequency, strength, speed, length, and width plus the variable of age were considered as 6 input variables, and 3 variables of slope, height, and time of the systolic upstroke curve at each point of 25%, 50%, 75%, and 100% amplitude of systolic peak of PPG curve were considered as the output variables.

Finally, as to the accuracy of the system, it is necessary to mention that the membership functions are designed to have an error of less than 0.05. In other words, if an input can activate or fire any of the designed rules, each of the fuzzy

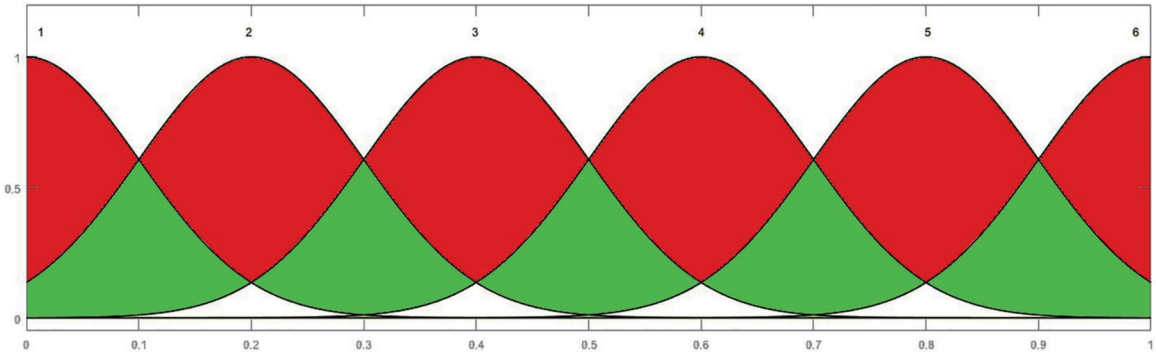

Figure 3: Membership function of input variables of age, frequency, and strength

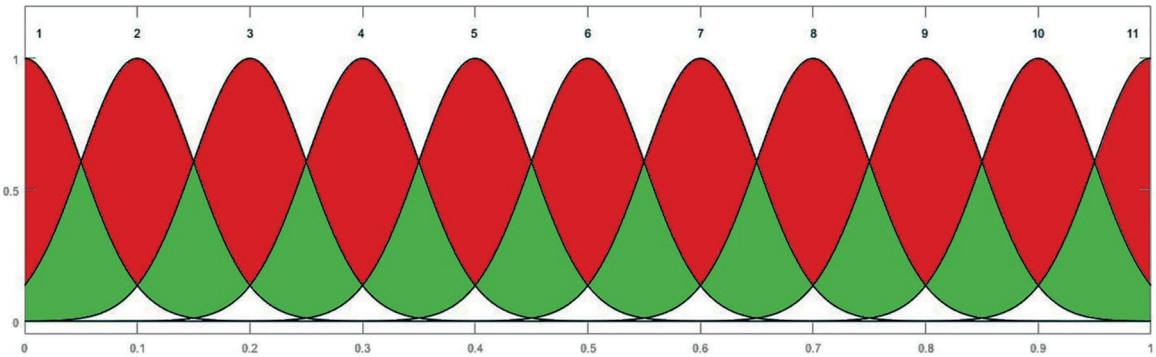

Figure 4: Membership function of the output variables of slope, height, and time

sets A_1 … A_{11} shown in Figure 4, will have an error of less than 0.05, according to Equation (8):

$$\forall\, y \in A_i : |y - Y_i| \leq 0.05 \quad (8)$$

Where Y_i is center of A_i.

For example, as shown in Figure 5, if the output of fuzzy set A_6 with 0.5 as its center is used, then its estimated output will be between 0.45 and 0.55.

Results

After removing similar and conflicting rules, which were 16 in number, this system was designed with 236 rules, each of which with 59 rules at 25%, 50%, 75%, and 100% of the PPG signal, and based on the defined membership functions, the maximum error created was 0.05. In the following section, the process is shown by an example for person number 1 at point 25% of the PPG signal as follows:

For person number 1, first, in a time interval of 5 seconds, the image of PPG systolic curve was taken, which included 7 pulses; then, using the image processing tool in MATLAB software and determining their coordinates, we calculated the average PPG systolic curve using the interpolation method. A polynomial was drawn which can be seen in Figure 6.

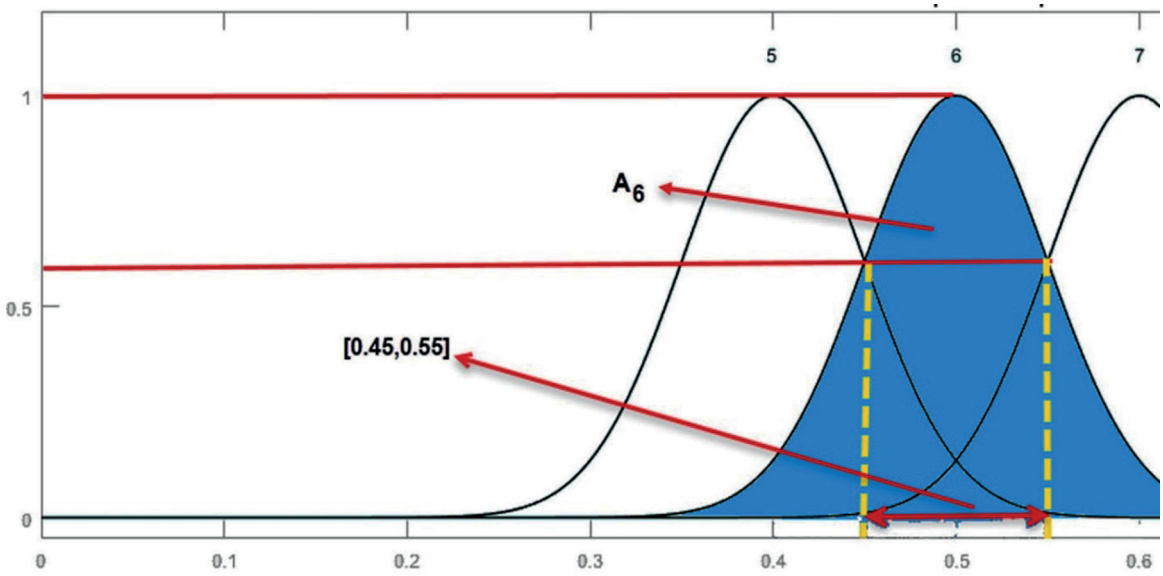

Figure 5: Interval [0.45,0.55] for each output estimate converging with the fuzzy set A_6 output membership functions

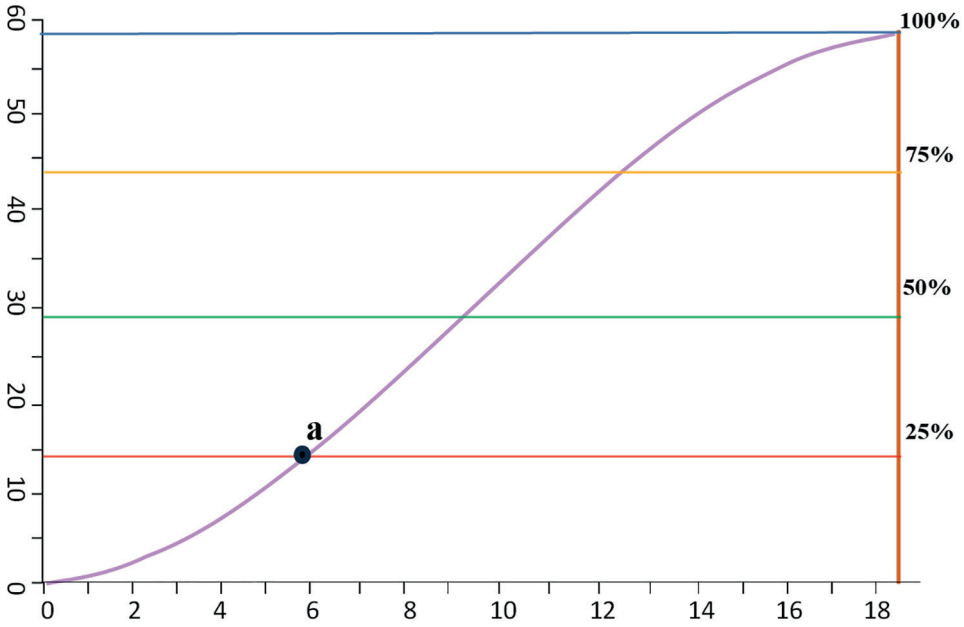

Figure 6: Systolic PPG signal plotted by interpolation, point "a" is the point of 25% of systolic peak amplitude

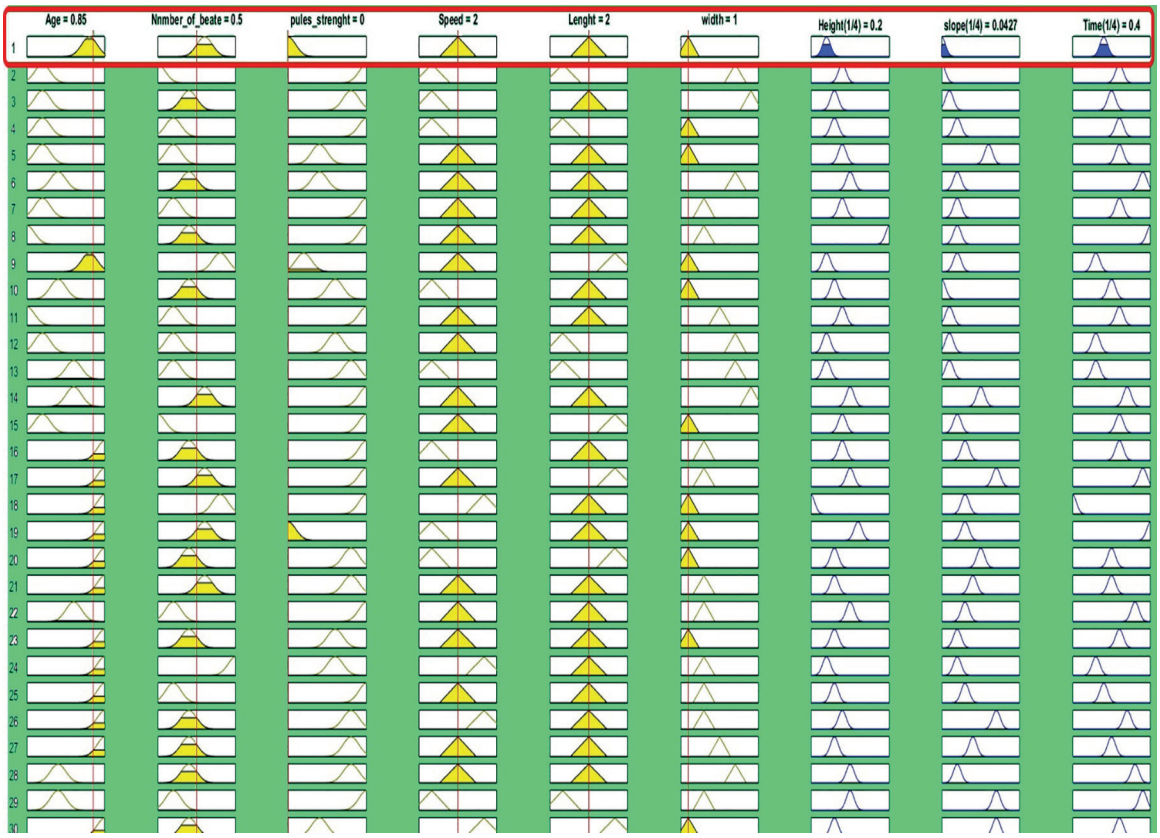

Figure 7: The 3 result outputs (right columns) of the fuzzy system by applying the 6 (left columns) input variable (0.85, 0.5, 0, 2, 2, 1)

The value of the slope, height, and time at point 25% of the PPG curve of Figure 6 was recorded as 3.63, 24.32, 0.048 for this person, which became 0.216, 0.038, 0.356 after normalization of all data. The input data comprising age and pulse parameters, including frequency, strength, speed, length, and width were also applied to the system after normalization (0.85, 0.5, 0, 2, 2, 1), as shown in Figure 7.

In Figure 7, it can be seen that by applying the input (0.85, 0.5, 0, 2, 2, 1), rule 1 is activated and the output of the system for slope, height, and time at point "a" has been estimated 0.2, 0.0427, and 0.4. Considering that the actual values of this output are 0.216, 0.038, 0.356, it can be seen that the error is 0.016 in the slope, 0.0047 in the height, and 0.044 in the time value, which means a maximum error of 0.044 in this example. It is noteworthy that all the error values were less than the specified error limit of 0.05.

Discussion and Conclusion

As mentioned, the aim of this research was to evaluate the usability of Persian medicine pulsology to estimate the slope, height, and time of the systolic curve of the PPG signal with the help of a fuzzy system design. A fuzzy system was designed based on product inference engine and center average defuzzifier. In this system, by compiling 236 rules, acceptable estimates of the slope, height, and time of the systolic upstroke curve at the points of 25%, 50%, 75%, and 100% amplitude of the PPG curve were obtained by PM pulse parameters including frequency, strength, speed, length, and width. According to the definition of membership functions, the maximum error produced was 0.05.

Eventually, according to the set acceptable error value of 0.05 which was based upon the design method of the membership functions for the input and output values of the system and also the results showing errors less than 0.05, the estimation is considered to be acceptable.

With only 64 individuals, reaching an acceptable precision of less than 0.05 error may be considered innovative. On the other hand, due to the lack of similar previous studies to be used as a reference for comparison or verification, it seems that at the pilot study level, the designed system is useful and applicable as it estimates PPG systolic features by using PM pulsology with an error of less than 0.05. However, with more data and

variables, its efficiency may be improved.

In previous studies such as (3, 6-8) that were conducted using artificial intelligence and fuzzy systems in PM, the connection and bridge between conventional medicine and PM were not seriously discussed, but in this research, such a connection was made with the correlation of the PPG signal with PM pulsology.

Also, there are concerns and considerations regarding the analysis of pulse results by specialist physician and the training of students in PM because the pulse examination in PM is performed with the fingers of an expert, which can be associated with errors and inferences. The pulse rules are complicated due to the large number of these rules, but by using the PPG signal, this error will be greatly reduced and the analysis results will be much more reliable. Given that PM pulse parameters show the quality and changes of blood in each pulse and PPG is a technique for measuring blood volume changes per pulse, which are very closely related, with the help of a fuzzy intelligent system the PPG systolic features are estimated by PM pulse parameters which can have significant applications and ease the work for similar studies and research in this field.

Subsequently, considering the significant diagnostic and prognostic value of systolic PPG intervals as one of the first-line non-invasive indicators of heart function and also considering the importance of pulse diagnosis in PM, the use of artificial intelligence may not only help increase both clinical skills of PM students/practitioners and accuracy of disease diagnosis and prediction, but also may be promising to bridge the gap between PM and mainstream medicine and help advance the global movement toward integrative medicine.

Ethical Approval

In this study, after obtaining informed consent for admission at Ahmadieh PM Clinic of Tehran University of Medical Sciences as a research and training clinic, we considered only routine pulse examination and plethysmography data obtained for health benefits in the analysis; in addition, no confidential personal information or interventions were involved and thus no additional ethical approval was necessary for this work.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflict of Interest

There are no conflicts of interest

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Original Article

Historical Developments, Hotspots, and Trends in Infodemic Scientific Publications: A Bibliometric Analysis

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Abstract

Introduction: With the prevalence of global crises, an overwhelming influx of reliable and unreliable information occurs, referred to as an infodemic. Given the significance of the infodemic phenomenon, this study examines trends in the dissemination of scientific publications on infodemics.

Methods: This study is a descriptive and analytical study conducted with a bibliometric approach. The study population included all scientific publications on infodemic in the Web of Science database until July 15, 2023. The data analysis was performed using the bibliometrix package in the R software.

Results: 1157 scientific publications on infodemics have been extracted since 2019, with the highest number of publications occurring in 2021. The majority of these publications were articles. The most important keywords in infodemic scientific publications were "health," "information," "news," "social media," and "communications." The keywords during the 2019-2020 outbreak period were "outbreak," "information," and "COVID-19." In the year 2021, the keywords were "health," "determinants," and "news." During 2022, the keywords were "information," "impact," and "health literacy." In the year 2023, the keywords were "attitudes," "health," and "African-American."

Conclusion: Infodemic research aims to utilize new and updated data in the field of health and medicine, as well as develop methods to combat infodemics. This study offers a more accurate understanding of this field and provides valuable information for future interdisciplinary and medical research.

Keywords: Infodemic, Information, Scientific, Research, Bibliometrics

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Introduction

Today, maintaining health relies on receiving reliable information, and the Internet has become the primary source of health information for many people. In the United States, 80% of adults search for their health information online (1). An overabundance of information (accurate or inaccurate) that occurs during an epidemic is known as an infodemic. During the outbreak of COVID-19 and with the spread of this disease, the volume of information related to this disease increased rapidly, which caused the emergence of the infodemic and has been recognized as a great threat by the World Health Organization (2, 3). Infodemics encompass both rumors and conspiracy theories, as well as an overload of information—both false and accurate—that can lead to increased confusion, sensitivity to misinformation, and mistrust (4). On the contrary, the lack of high-quality information can also lead to information gaps that are quickly filled with false information (5). Infodemics can be published online through social media and messaging apps or offline in conversations and through traditional media (such as newspapers, television, and radio). Infodemia is a situation in which there is a large amount of information offline and online, which makes it difficult to identify reliable information, and it creates ambiguity (6).

During the COVID-19 pandemic, the exchange of information has been increasing at an astonishing rate, driven by advances in information and communication technologies, especially social media platforms. Such platforms have not only facilitated access to information on various issues related to the epidemic, but have also been particularly important for maintaining people's communication at home (7).

Small et al. reveal that infodemics are as serious as epidemics and can spread at a faster rate than epidemics. Therefore, proper and timely handling of an infodemic is very important and necessary to promote health and well-being and help to prevent, vaccinate, and manage the disease (8). Also, Kwood Hari et al. state that the emergence of the Internet and social media has intensified the creation and dissemination of false information in all health fields (9).

Since current thinking and future directions in any scientific field are built upon insights gained from its historical context, it is of educational, epistemological, and scientific value for researchers and scientists to have a perspective on the developments and historical trends in the published literature regarding infodemics.

One of the methods for evaluating scientific activities is bibliometrics. Bibliometrics is a field that quantitatively analyzes scientific production and publications, providing a comprehensive and multidimensional analysis of the scientific knowledge in a specific field. The analysis of bibliometrics logically and precisely evaluates the contribution of research and publications to the advancement of knowledge in a subject, offering an objective, empirical, and unbiased insight into that particular subject (10, 11).

Moreover, to better understand quantitative data and their relationships in a scientific field, visualization and mapping of scientific landscapes are mentioned as suitable solutions. A scientific map represents the spatial relationships between disciplines, domains, specialties, and individual or group-authored articles, displayed through physical proximity or relative positions. Drawing the scientific and social structure of researchers in a scientific field provides valuable information about the position of each researcher within the body of that field's knowledge and serves as an indicator of their influence (12)

Based on the previous investigations, no studies were found that specifically examined the scientific literature analysis of infodemics using bibliometric and scientometric indicators. However, this approach can be valuable as it offers a more comprehensive and extensive analysis of scientific advancements in the field of infodemics over time. Furthermore, considering the increase and proliferation of unintentional and intentional misinformation during health crises such as pandemics and the emphasis of the World Health Organization on the importance of addressing infodemics, the present study aimed to analyze scientific publications and map the scientific structure of the field of infodemics. Nonetheless, greater emphasis should be placed on the reasons for choosing this approach and its importance in filling the existing research gaps.

Methods

Study Design

This study is a descriptive and analytical research conducted using bibliometric techniques. The study included all scientific publications in the field of infodemics that were indexed in the core database of the Web of Science (WOSCC). In bibliometrics studies, given the varying structure of scientific data across different databases, data is typically extracted from a single scientific database and then analyzed. This approach ensures consistency and comparability of the results (13-15). Furthermore, given that this study is specifically centered on the bibliometric analysis of historical developments, research hotspots, and trends in infodemic research, the search was meticulously conducted using the core keywords of the concept. This search was applied on the titles, abstracts, and keywords of the publications, following the established search strategy (TS=(infodemics) OR TS=(infodemic)). The choice of the Web of Science Core Collection (WOSCC) as the primary database was due to its comprehensive coverage of high-impact journals and its reliability for bibliometric analysis in this field (16).

Data Extraction

The bibliographic details of the retrieved publications, including author names, titles, abstracts, keywords, publication years, journals, and affiliated institutions, were systematically extracted and compiled into a structured dataset. The data were then meticulously cleaned and standardized to maintain consistency across the dataset. This process involved unifying author names and keywords to avoid duplication and enhance the accuracy of the subsequent analysis.

Bibliometric Analysis Techniques

Data analysis was conducted using the Biblioshiny tool, which is based on the Bibliometrix package in R software. Bibliometrics is a tool that visualizes information in Bibliometrics analyses based on scientific productions and publications,

such as country/region indices, journals, authors, articles, author keywords, and research institutions. This tool provides all the necessary features for comprehensive bibliometric analysis and various scientific mapping (17-19). The following analyses were performed in this study:

Annual Trend Analysis: To examine the growth of infodemic-related research over time, we conducted an analysis of the annual publication trends.

Publication Type Analysis: The distribution of different types of scientific publications (e.g., original articles, reviews, editorial materials) was analyzed to understand the nature of the contributions in this field.

Geographic and Institutional Contributions: The contributions of different countries and institutions were analyzed to identify key players and research hubs in the field of infodemics.

Collaboration Network Analysis: A collaboration network was constructed to visualize and analyze the level of international cooperation among researchers and institutions in infodemic-related studies.

Keyword Co-occurrence Analysis: The relationships between keywords in the retrieved publications were analyzed to identify the key themes and research focuses within the field.

Thematic Mapping: A strategic thematic map was generated to categorize and visualize research themes based on their centrality and density, providing insights into the development and importance of various topics within the infodemic research domain.

Thematic Evolution Analysis: The evolution of research themes over different periods was examined to understand how the focus of infodemic research has shifted over time.

Visualization: The results of these analyses were visualized using various charts and maps generated by the Excel Software and Biblioshiny tool, including trend charts, bar charts, network maps, word clouds, and thematic maps. These visualizations provided a clear and comprehensive overview of the scientific landscape, key contributors, and evolving trends in the field of infodemics.

Results

The search results in the WOSCC database have extracted 1157 scientific publications related to infodemics. Given the precisely designed search

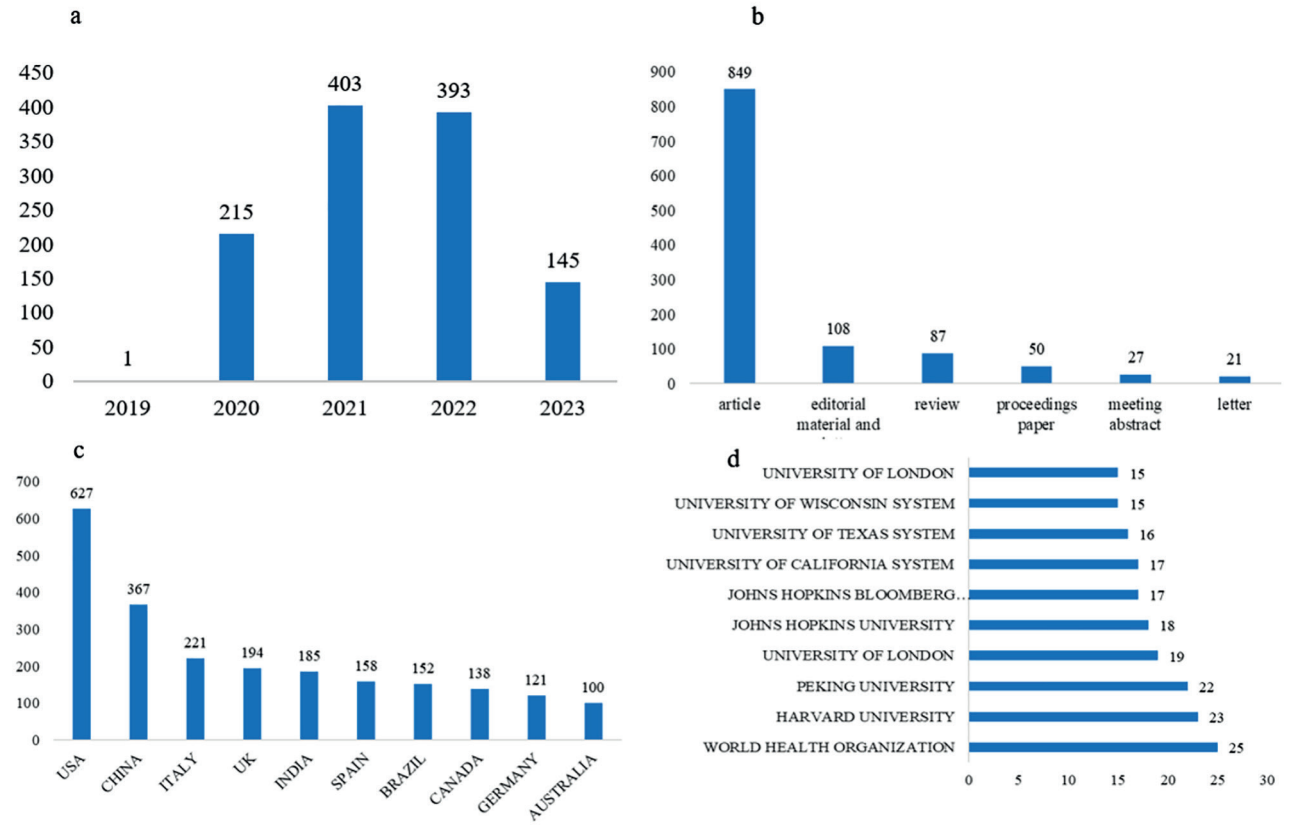

Figure 1: a) Annual Trend Chart of Scientific Publications in Infodemics. b) Chart of Types of Scientific Publications in Infodemics. c) Top Countries in the Number of Scientific Publications in Infodemics. d) Top Organizations in the Number of Scientific Publications in Infodemics. *The data has been extracted for the period from 2023 to July 15

strategy, all relevant scientific publications that are in the same line with the study objectives were extracted. Therefore, no specific inclusion or exclusion criteria were applied. Figure 1 illustrates the temporal distribution of scientific publications, categorizes the types of these publications, and highlights the top countries and institutions contributing to the production of infodemic-related research.

Figure 1 shows that scientific publications on infodemics have been released since 2019, with the highest number of publications (403) occurring in 2021. Furthermore, the majority of scientific publications consisted of 849 original articles, 108 editorial materials, and 87 reviews. The top countries in terms of publication volume were the United States with 627 cases, China with 367 cases, and Italy with 221 cases of scientific publications. The leading institutions in terms of the highest number of scientific publications were the World Health Organization with 25 cases, Harvard University with 23 cases, and Peking University with 22 cases of scientific publications.

Figure 2 illustrates the level of collaboration among countries in scientific publications on infodemics.

The data illustrated in Figure 2 shows that the highest level of collaboration in scientific publications on infodemics has been observed among the countries of the United States, the United Kingdom, China, and Italy.

Figure 3 presents a word cloud of the top 50 keywords in infodemic scientific publications, highlighting 'health,' 'information,' 'news,' 'social media,' and 'communications' as the most prominent keywords

Figure 4 illustrates a thematic map that depicts the relationship between density

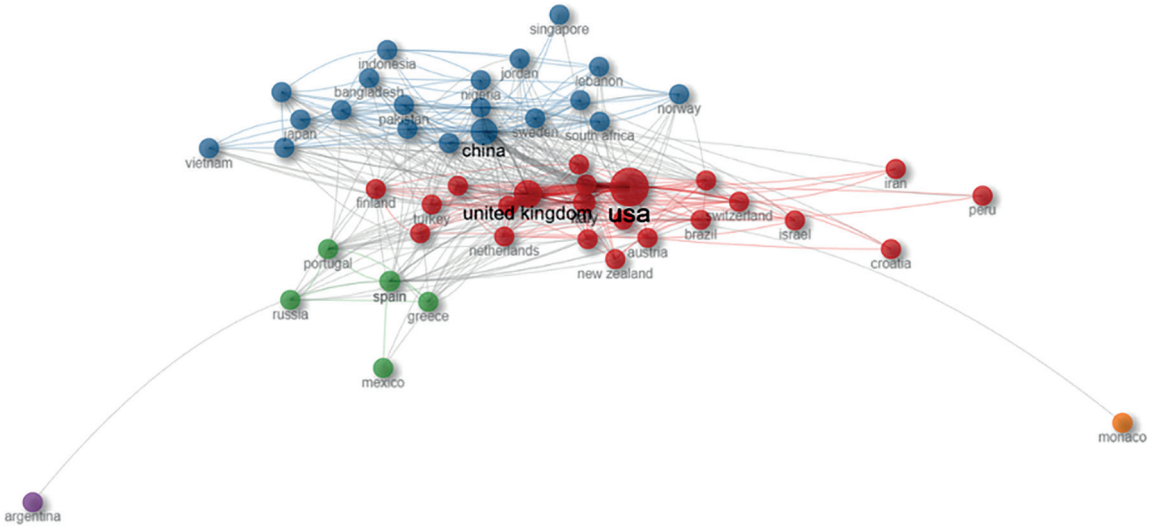

Figure 2: Level of International Collaboration in Scientific Publications on Infodemics

Figure 3: Key Thematic Keywords of Infodemic Scientific Publications

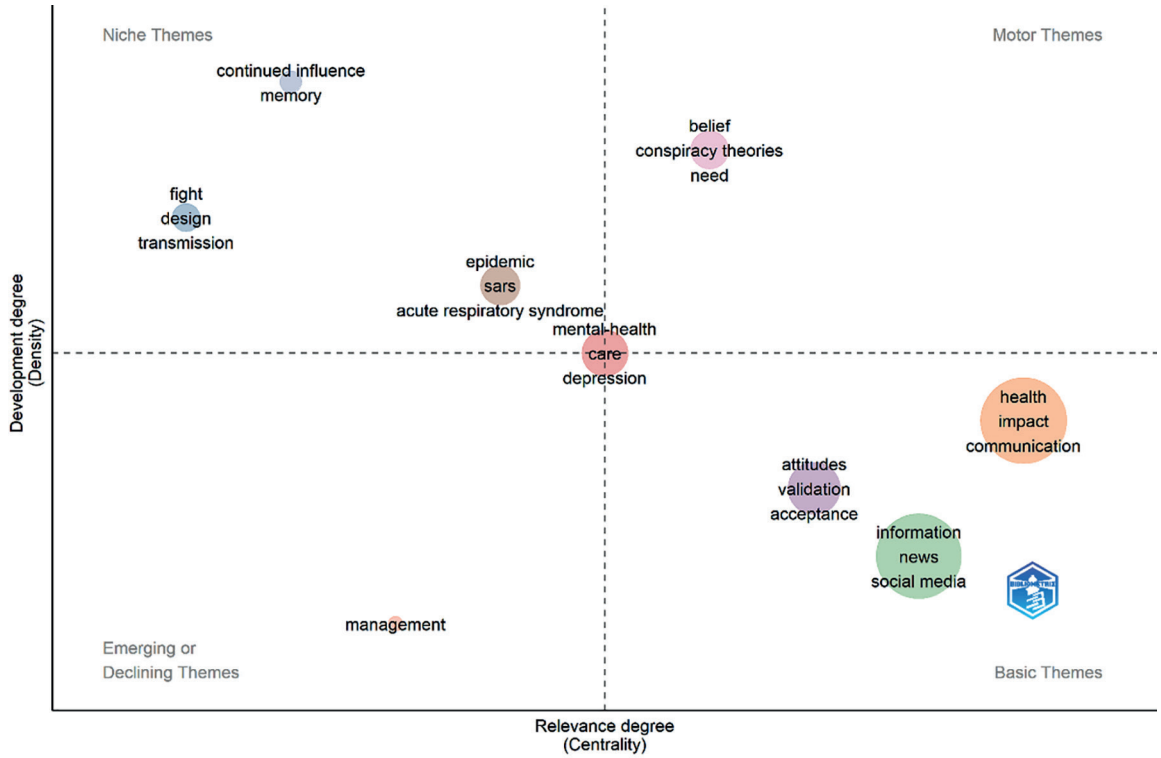

Figure 4: Strategic Thematic Map of Infodemic Scientific Publications

(y-axis) and centrality (x-axis). Centrality is the significance or importance of the selected theme, while density represents the level of development or progress associated with the chosen theme.

In Figure 4, the upper-right quadrant represents motor themes characterized by high centrality and density. These themes, namely belief, conspiracy, and need, are described as more developed and essential in an infodemic. In the upper left quadrant, there are niche themes that represent peripheral and specific topics within the research field. Some of the related topics in this quadrant include "continued influence," "fight design and transmission," and "epidemic, SARS, acute respiratory syndrome."

The fundamental themes are depicted in the lower right quadrant. These themes are foundational, broad, and cross-cutting within the research domain. Topics related to "health, impact, communication," "information, news, social media," and "attitude, validation, acceptance" serve as fundamental themes in the context of the infodemic. In the lower left quadrant, emerging or declining themes can be observed. One of the themes present in this quadrant is management. Figure 5 illustrates the temporal evolution of thematic trends in scientific publications on infodemics in four time intervals: 2019-2020, 2021, 2022, and 2023.

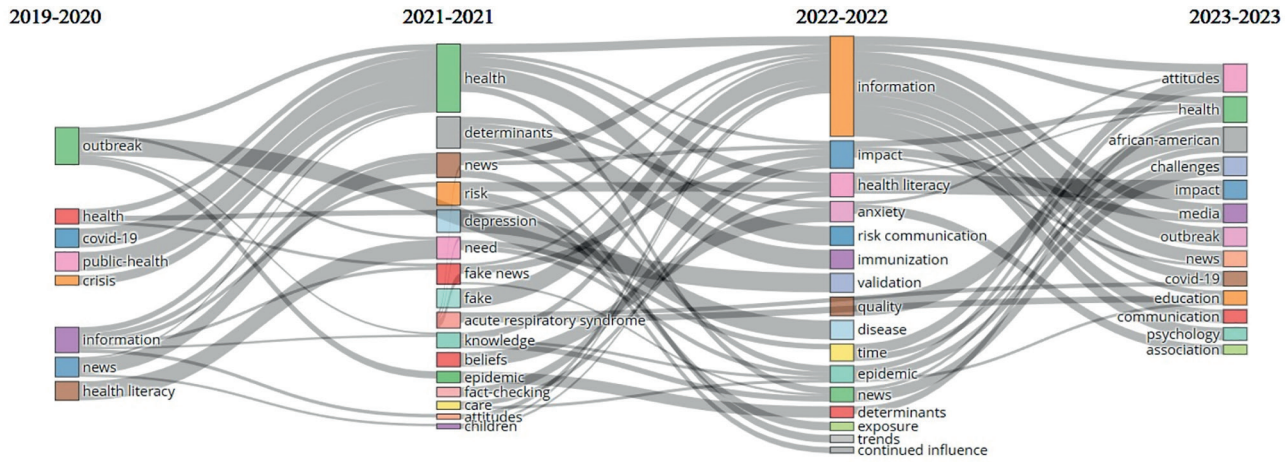

Figure 5: Thematic Evolution of Infodemic Scientific Publications

The data in Figure 5 indicate that the keywords in scientific publishing infodemic have evolved. During the 2019-2020 outbreak period, the main keywords were "Outbreak", "Health," and "COVID-19". In the timeframe of 2021, the keywords shifted to "health", "determinants," and "news". In 2022, the keywords were "information", "impact," and "health literacy". Finally, in the year 2023, the keywords were "attitudes", health," and "African-American".

Discussion

Nowadays, health crises such as pandemics have increased the growth and sharing of crisis-related information. This information can be either accurate or inaccurate. Consequently, the topic of infodemics arises alongside these crises. The current study results have shown that scientific publications related to the pandemic started in 2019 and have been rapidly growing. Following the global outbreak of COVID-19 in late 2019, which was considered a global crisis, information related to this disease quickly proliferated on online platforms and social media networks. The World Health Organization has referred to it as a global epidemic and identified it as a serious public health concern (2). Accordingly, researchers have also initiated various studies to combat the phenomenon of infodemic, leading to an increase in scientific publications in the field of infodemic since 2019.

The current study results have shown that the terms "health," "information," "news," "social media," and "communications" are the most important keywords in infodemic scientific publications, and infodemic scientific publications revolve around these keywords. In this regard, it can be said that the keyword "health" is the primary term in infodemic scientific publications. Additionally, the keyword "information" is also identified as another key term in infodemic, highlighting the role and importance of information flow in promoting health and conveying accurate and reliable information about diseases in society. The keywords "news," "social media," and "communications" are also commonly used in infodemic scientific publications, referring to the transmission of information and news through social media platforms and virtual communications.

According to the literature, even social media platforms, which play a crucial role in disseminating accurate news about COVID-19, are associated with the disease. While they serve as platforms that help spread public health messages to the population; they also promote opinion-based reports (20). The overload of information, along with the production and dissemination of fake news on communication platforms like social media, is steadily increasing. This fake news acts as narratives that either add to or omit information from the facts (Naem et al., 2020), directly impacting the infodemic (21).

Past studies indicate that social media networks such as YouTube and Twitter provide direct access to an unprecedented volume of information. This shift from traditional news paradigms has deeply influenced social perceptions and narrative framing. It has also impacted communications and public discourse, particularly when controversial topics are involved (22, 23). Consequently, social media platforms amplify the sharing of news and rumors. Moreover, false and suspicious news and information spread at a faster pace on these platforms (24). Specifically, during the COVID-19 pandemic, social media played a vital role in the dissemination of information within an unmediated news cycle, with the published information and news significantly affecting public health (25).

The results obtained from the thematic map have demonstrated the themes present in the domain of infodemics in scientific publications. The thematic map illustrates the subject areas covered by scientific publications. Accordingly, four categories of themes have been well-developed: Motor themes, which are ed and well-developed topics; Niche themes, which are highly specialized and peripheral topics; Emerging or declining themes, which represent newly emerging or declining subjects; and Basic themes, which represent fundamental research areas (26).

The current study results indicate that the themes mentioned in this article are important and dynamic within infodemics. These themes include belief, conspiracy, and need identified as significant and developed themes in infodemics. This demonstrates that beliefs, conspiracy theories, and societal needs are crucial within the realm of infodemics and should receive special attention in the examination and study of this

medical field.

Conspiracy theories are incorrect beliefs that secret organizations organize major events. These beliefs have emerged during health crises such as COVID-19 (27), the H1N1 pandemic (28) and the measles outbreak (29). Conspiracy theories are often associated with misinformation about medical facts and weaker health outcomes; they quickly spread, influencing public beliefs and preventive behaviors regarding the crisis (30). Furthermore, the terms "health, impact, communication," "information, news, social media," and "attitude, validation, acceptance" have been identified as the key themes in the field of infodemic. These themes indicate that health, impacts, communications, information, news, social media, attitudes, validation, and acceptance of information are important factors in studying and researching infodemics. News media is among the key influential factors in a public health emergency, with a crucial responsibility for effective media communications during such situations (31). Social media also provides an important platform for information dissemination and news sharing, playing a special role and position due to the widespread access of the general public to it, facilitating communication among individuals in society (32, 33). Communications are an integral part of any response to a crisis (34). Trust and communications are interconnected in health crises as communications can either build or erode community trust (35, 36). Communication, due to its vital role in relationships, contributes to trust-building (37).

The present study also showed that the themes 'continued influence', 'fight, design, transmission' and 'epidemic, SARS, acute respiratory syndrome' have been identified as specific and related subjects in the field of infodemic. Furthermore, the keyword 'management' has been mentioned as an emerging or declining topic in scientific publications on infodemic."

These themes indicate that specific factors such as the methods of disease transmission and specific diseases like SARS and acute respiratory syndrome are important in infodemic publications. These themes suggest that pandemics and crisis factors are the driving forces behind infodemics. Additionally, the management of infodemics requires more attention and effort, and researchers should pay closer attention to this field.

Lack of proper management of infodemics can spread rumors and misinformation, resulting in the suppression of science. Accordingly, Eizenberg proposes four solutions for effective infodemic management, which include (1) monitoring information, (2) building capacities for electronic health literacy and scientific literacy, (3) promoting knowledge refinement and quality improvement processes, and (4) translating accurate and timely knowledge (38).

The results of the current study regarding the trend of developing themes and keywords in scientific publications on infodemics have shown that infodemic research in the period of 2019-2020 focused on topics such as outbreak, information, and COVID-19. With the increasing prevalence of COVID-19 in society, in 2021, the infodemic concentration shifted towards subjects such as health, determinants, and news. Furthermore, in 2022, the infodemic focus was on topics such as information, impact, and health literacy, and in 2023, keywords like attitudes, health, and African-American emerged as the main areas of investigation in infodemic studies within the field of healthcare. In this context, reports have indicated the simultaneous spread of the infodemic alongside the outbreak of COVID-19 (39, 40).

This trend indicates that infodemic research aims to utilize new and updated data in health and medicine to improve and expand related studies. Therefore, paying attention to health literacy and attitudes during 2022 and 2023 is crucial in combating this issue, and researchers have given special attention to promoting awareness and knowledge related to it during this time. Attitudes refer to individual perspectives, beliefs, and expectations towards various issues that infodemic can influence.

Conclusion

This study provides a comprehensive understanding of the evolving landscape of infodemic research, emphasizing the critical role that health, information flow, and communication channels play in addressing the challenges posed by the spread of misinformation during health crises. The identification of key themes and their progression over time highlights the dynamic nature of this research area, underscoring the necessity for continuous monitoring and adaptation to effectively combat the detrimental

effects of infodemics on public health.

The findings suggest that while significant progress has been made in understanding and addressing infodemics, there remains a need for more targeted and strategic efforts to manage the spread of misinformation. This includes enhancing public health communication strategies, fostering greater collaboration among researchers, policymakers, and media platforms, and improving health literacy among the general population. As infodemics continue to evolve alongside global health challenges, future research must focus on developing robust frameworks and tools that can mitigate the impact of misinformation and support the dissemination of accurate and reliable information.

Ultimately, this study highlights the necessity of a multifaceted approach to addressing infodemics, emphasizing the importance of collaboration across disciplines such as health sciences, communication studies, and information technology. Conducting interdisciplinary research in this area can lead to the development of more effective strategies for combating misinformation and strengthening resilience against information crises.

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Conflict of Interest

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Letter to Editor

Repeating the Terrorist Attack in Shahcheragh, Iran, 2023: Endless Repetitions ...!!!

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Dear Editor

Terrorism is the illegal use of power and violence against individuals or society to intimidate or force governments (1). The occurrence of such incidents is not far from expected as these incidents have been increasing in recent decades in Iran (2). On Sunday, August 13, 2023, at 19:30, a terrorist attack was carried out by two terrorists in Shahcheragh shrine (one of the holy and religious places in Shiraz city) in Iran. The terrorist entered the courtyard from one of the main doors and started shooting with a gun. During this incident, 2 persons were killed and 7 individuals were injured. A few minutes later, the armed person was arrested by the police and the second person ran away. The terrorist group of the Islamic State of Iraq and the Levant (ISIS) took responsibility for this terrorist attack by declaring a statement. This review was written with the aim of investigating why lessons were not learned from previous incidents, especially the Shahcheragh terrorist incident that happened in 2022, and this incident was repeated again.

Possible Causes of Recent Terrorist Attack and Suggested Strategies

The causes of these terrorist incidents can be examined from two perspectives: first, the goals of terrorist groups, including the support of organizations and beneficiaries with sinister goals, the pressure of certain groups on the government to act in a specific field, political and religious conflicts, and, secondly, the program and readiness of the responsive systems, which include downplaying the events which happened previously, lack of planning and lessons learned from previous incidents, non-scientific policies based on emotional decisions, weakness and inconsistency of the responsive systems, and inadequate risk perception of the authorities. Although terrorist incidents are often unpredictable, the risks and consequences of them can be reduced by planning and improving preparedness. Regarding the first perspective which is related to the sinister goals of terrorist groups, the role of security-political systems that have complex tactical dimensions is highlighted. From the second perspective, which is related to the readiness of responsive systems, strategies such as scenario-based planning, sensitization of authorities, continuous training and exercises, analysis of real incidents and compilation of action plans, strengthening of security systems and all-dimensional modernization of response systems

are suggested, which can play a significant role in the prevention and management of terrorist incidents.

Conclusion

Although most terrorist incidents cannot be predicted, they can be prevented to some extent by strengthening security systems, improving the level of preparedness, and minimizing the risks caused by these incidents. Strategies such as planning, continuous training and exercises, integration and coordination of the involved organizations, and the use of experiences and lessons learned in exercises and real incidents are effective measures in response to terrorist incidents.

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