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The Effect of Underlying Diseases on Kidney Transplant Survival Rate

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Abstract

Background and Aim: Identifying factors affecting kidney transplant survival in patients with end-stage renal disease is essential to improve transplant survival and improve the kidney transplant process. This study aimed to determine the effect of underlying diseases on kidney transplant survival rates in transplant recipients from living donors at Farhangian Hospital.

Materials and Methods: This cross-sectional and retrospective study was conducted on 700 patients who underwent kidney transplantation in Farihectan Hospital between April 2020 and September 2023. Sampling was based on a census, and researcher-made demographic information questionnaires and inpatient files of transplant patients were used to collect data. Kaplan-Meier, Cox regression, and log-rank tests were utilized to estimate survival rates and identify the impact of underlying diseases on transplant survival using SPSS version 23. The significance level of the tests was considered smaller than 0.05.

Results: The Kaplan-Meier method estimated the 1-year, 2-year, 3-year, and 4-year transplant survival rates at 94.71%, 86.4%, 81.1%, and 77.0%, respectively. The Cox regression model demonstrated that recipient age (P <0.05), donor age (P <0.05), and the presence of diabetes and hypertension as underlying diseases (P <0.001) significantly affected kidney transplant survival rates.

Conclusion: The transplant survival rate in Farhikhtegan Hospital was higher than in the past years and in some of the country's major transplant centers. Therefore, it seems necessary to pay attention to other factors affecting graft survival rates in addition to the present ones.

Keywords: Transplant Survival, Kidney Transplant, Graft Rejection, Underlying Disease.

Introduction

Kidney transplantation is the most cost-effective and preferred strategy for managing patients with end-stage renal disease (ESRD), which is considered one of this century's most successful transplant procedures and a significant advancement in treating renal failure (1). Over recent years, substantial progress has been made in dialysis and kidney transplantation, and current knowledge strongly supports the finding that kidney transplantation markedly improves quality of life and significantly reduces complications and mortality associated with ESRD (2). In the past decade, survival rates for kidney transplant recipients have improved due to advancements in immunosuppressive therapies, surgical techniques, and follow-up protocols. Additionally, the number of transplants from living donors has also increased. According to the European dataset, the global 5-year survival rate is approximately 92% for deceased-donor transplants and 95% for living-donor transplants. Regarding graft survival, these rates are estimated at around 81% and 87%, respectively (3). Identifying factors affecting transplant survival is essential to further extending kidney graft longevity.

A kidney transplant recipient's prognosis can be affected by several variables, including but not limited to donor and recipient age, donor type (living or deceased), recipient comorbidities (e.g., hypertension, diabetes,

hepatitis B infection, cardiovascular diseases), race, HLA mismatch, dialysis duration, postoperative complications, polyomavirus infection, immunologic rejection, socioeconomic status, and several others. Some of these details, such as gender and age, is possible to be determined before the kidney transplant procedure. According to studies, previous kidney transplants may affect the graft's survival rate. However, Meier-Kriesche et al. reported that whether the transplant was the first or a repeat did not have an independent or significant impact on kidney transplant survival (4). Results regarding transplant survival and transplant patients have varied across studies. In a 2022 study, Mohammad Rahimi and colleagues indicated that survival rates differed between male and female patients (5). In contrast, a 2021 study by Sevim et al. reported that recipient gender did not correlate with transplant survival (6). In a 2019 study, Behnani et al. identified diabetes as a significant predictor of survival rates in kidney transplant recipients, emphasizing that this factor should be considered to improve transplant longevity (7). Ying et al. highlighted in a 2020 study that reductions in early and late post-transplant mortality over the past 40 years represent a significant achievement (8). Similarly, Alenazi et al. (2019) reported that graft survival was unaffected by the gender of the donor or recipient, as well as the presence of diabetes or hypertension in recipients (9). This body of research highlights the complex interplay of factors influencing kidney transplant outcomes, underscoring the need for individualized assessments and tailored management strategies to optimize patient and graft survival.

Based on the resources, the most common comorbidities among the patient population include diabetes, high blood pressure, cardiovascular diseases, infections, tumors, and autoimmune diseases (10). Pre-transplant diabetes mellitus (DM) in kidney recipients has been associated with a higher risk of cardiovascular diseases, increased mortality rates, and shorter allograft survival. Some studies have indicated that the death rate and

graft rejection in transplant recipients with diabetes are almost two to three times higher than in healthy recipients (11). In kidney transplant recipients, cardiovascular syndrome, characterized by diastolic dysfunction due to venous congestion along with chronic pulmonary hypertension, left ventricular hypertrophy, and heart failure, contributes to reduced kidney transplant survival (10). More explanation about the complications of cardiovascular diseases in kidney transplant recipients compared to the general population with a high prevalence of coronary artery disease and left ventricular hypertrophy has been provided (12). Given the significance of these factors, the present study was conducted at Farhangian Hospital to determine the impact of comorbidities on kidney transplant survival rates among transplant patients with living and deceased donors.

Materials and Methods
This cross-sectional study utilized retrospective data and included all adult kidney transplant patients (aged over 18) who received transplants from living or deceased donors between 2020 and 2023 at Farhangian Hospital. The related data were gathered from the registered data in the patient's clinical records at the hospital. Sampling was conducted through a census approach, resulting in 700 samples being included in the study. Inclusion criteria comprised the completeness of medical records, patients over 18, and willingness to respond to phone calls and cooperate with the researcher's questions. Exclusion criteria included records with erroneous data that could not be corrected or cases where the patient passed away in the operating room.

Data Collection
After the proposal approval and obtaining the ethical code written permission and an introduction letter were acquired from the Vice-Chancellor for Research and Technology at the Islamic Azad University, Sari Branch. The principal investigator then visited Farhangian Educational and Research Hospital. To adhere to ethical principles, the

researcher presented the introduction letter to the hospital authorities and explained the study's purpose, subsequently obtaining sampling authorization. Following the sampling protocol, the researcher listed the names, surnames, and contact numbers of individuals who had undergone kidney transplants within the specified period (2020-2023) and had complete medical records. Eligible participants were identified through phone contact, considering the inclusion criteria. After selecting the study participants, data were collected from the patient's medical records and the hospital's Health Information System (HIS) using a custom-designed data collection form. This form recorded details including age, gender of both donor and recipient, history of diabetes, hypertension, hepatitis, autoimmune diseases, transplant survival, and the final health status of the patient. Additional information regarding patients' conditions was obtained via follow-up phone calls by the researcher. The data collection tools included the patient's medical records and a researcher-designed data registration form consisting of two sections. The first section documented demographic information about the kidney transplant recipient and donor, including age, gender, and underlying diseases. The second section was dedicated to specialized factors related to transplant survival.

Data Analysis

After data collection, descriptive statistics were used to describe the data, with central tendency and dispersion indices calculated for quantitative variables and frequency and percentage used for qualitative variables. Data analysis was conducted using SPSS version 27, employing statistical methods including Kaplan-Meier, log-rank test, and Cox regression model. A significance level of 0.05 was set for data analysis.

Results

A total of 700 donors, including 463 men (66.1%) and 236 women (33.7%), were examined with an average age of 33.22 ± 9.74 years. The most common blood groups among kidney donors were O and A,

accounting for 40.9% and 28.9%, respectively. Of the 700 kidney transplants performed, 529 (75.6%) were from living donors, while 171 (24.4%) were from deceased donors. The kidney transplant recipients included 700 individuals, with 440 men (62.9%) and 260 women (37.1%). The average age of the recipients was 43.75 ± 13.04 years. The most common blood group among recipients was O, comprising 36.9%, while group A accounted for 30%. Among the recipients, 162 (23.1%) had diabetes, 270 (38.6%) had hypertension, 75 (10.7%) had hepatitis, and 57 (8.1%) had autoimmune diseases. Out of the 700 transplants, 178 (21.9%) were conducted in 2019, 194 (23.9%) in 2020, 201 (26.1%) in 2021, and 116 (14.3%) in 2022. Of the transplants reviewed, 583 (71.9%) were successful, with 10 cases (1.2%) experiencing hyperacute rejection, 37 cases (4.6%) acute rejection, and 70 cases (8.6%) chronic rejection. Among the transplant patients, 679 (83.7%) were alive, and 21 (2.6%) had passed away. Of the 700 individuals who underwent kidney transplants, approximately 125 (15.4%) required dialysis post-transplant, while 575 (83.7%) did not require further dialysis. The one-year, two-year, three-year, and four-year kidney graft survival rates are illustrated in Figure 1. The present study's Kaplan-Meier analysis for kidney transplant recipients demonstrated that the one-year, two-year, three-year, and four-year graft survival rates were 94.71%, 86.4%, 81.1%, and 77.0%, respectively.
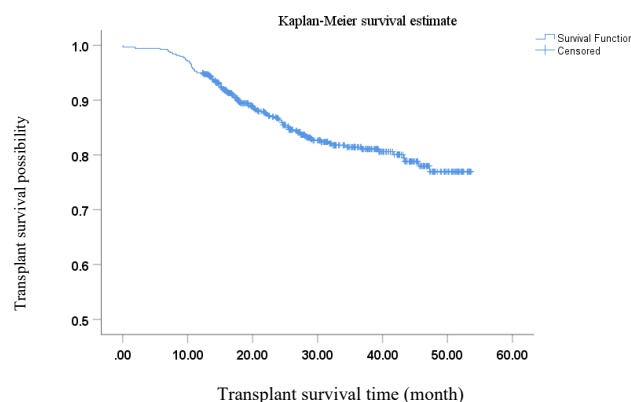

Figure 1. Kidney transplant survival rate curve among transplanted patients examined in a 4-year time frame

As shown in Table 1, there was a statistically significant difference at the level of 1% between the graft survival rates in different groups of transplant recipients and donors (P<0.01). There was no statistically significant difference in the transplant survival rate between male and female transplant recipients and kidney donor gender subgroups (P>0.01).

Table 1. Frequency distribution of kidney transplant recipient and donor patients in a 4-year time frame according to age and gender variables and log-rank test results

arameter	ge (Year)/ Gender	ransplan t survival	tandard error	ower bound	pper bound	p.value
Ransplan t Recipient	24-8	47.1	1.6	44.4	50.8	0.07
	44-5	48.8	0.73	46.7	49.0	
	60-5	44.9	1.5	42.2	46.6	
	75-1	43.5	1.5	39.1	46.9	
Ransplan t Donor	24-8	48.3	1.3	45.2	51.4	0.001
	44-5	46.6	0.35	44.2	47.0	
	60-5	44.7	1.7	41.9	47.5	
	75-1	18.2	0.11	17.2	19.2	
Ecipient Gender	ale	46.5	0.61	44.6	47.4	0.79
	emale	46.5	0.74	44.4	48.6	
Onor Gender	ale	47.4	0.14	45.4	48.4	0.03
	emale	45.5	1.9	42.1	47.9	

The results of the univariate Log-Rank test analysis indicated a statistically significant difference at the 1% level (P<0.001) in kidney transplant survival rates between patients with underlying conditions (43.51%) and those without underlying conditions (51.00%). The kidney transplant survival rate was significantly higher in non-diabetic recipients compared to diabetic recipients (Table 2). Similarly, the transplant survival rate was significantly higher in recipients without hypertension than in those with hypertension. On the other hand, there was no statistically significant difference in kidney transplant survival rates between recipients with hepatitis and those without hepatitis (P=0.881). According to Table 2, the univariate Log-Rank test analysis results also showed no statistically significant difference in kidney transplant survival rates between

recipients with autoimmune diseases and those without autoimmune diseases (P=0.305).

Table 2. Frequency distribution of kidney transplant recipients from April 2020 to September 2023 based on underlying conditions and Log-Rank test results.

Variable	Subgroup	Transplant Survival (%)	Standard Error	Lower Limit	Upper Limit	P.Value
Diabetes	No	49.17	0.573	48.05	50.29	0.0001
	Yes	38.52	1.51	41.48	51.51	
Hypertension	No	49.20	0.637	47.96	50.45	0.0001
	Yes	42.45	1.12	40.25	44.64	
Hepatitis	No	46.58	0.639	45.32	45.32	0.881
	Yes	45.84	1.81	42.28	48.28	
Autoimmune Diseases	No	46.76	0.626	45.53	47.99	0.305
	Yes	44.67	2.07	40.60	48.75	

Discussion

The results of the present study indicated that the one-year, two-year, three-year, and four-year kidney transplant survival rates among recipients at the Farhikhtegan Educational Research Hospital were 94.71%, 86.4%, 81.1%, and 77.0%, respectively. In a study by Abedi et al. conducted at Hasheminejad Hospital in Tehran, the estimated one-year, five-year, and eight-year kidney transplant survival rates were approximately 90%, 83%, and 74%, respectively (13). Another study by Ghanai et al. 2012 conducted on transplant patients at Shahid Tajrish Hospital in Tehran calculated the one-year and five-year survival rates at 89% and 82.5%, respectively (14). Comparing the findings of the present study with those of Abedi et al. and Ghanai et al. highlights the improvement in kidney transplant survival rates in Iran. Possible explanations for the improvements in survival rates in these studies and the current study include enhanced experiences in transplant centers and among surgeons, improved surgical techniques, and advancements in prescribed medications throughout different stages of the surgery (15).

The age of both the donor and the recipient is among the crucial factors that may influence kidney transplant survival (16). The present study revealed that kidney transplant survival was significantly higher among recipients aged 18–24 and 25–44 compared to those aged 45–60 and 61–75 years. In line with these findings, Xin et al. demonstrated that kidney transplant survival rates were associated with the recipient's age in patients who underwent transplants at Sichuan

University Hospital (17). Gerbase-DeLima et al. (2020) also reported that lower transplant survival rates in older individuals may be attributed to higher comorbidities and increased susceptibility to infections (18). Explaining the present study's findings, it seems that younger kidney transplant recipients may benefit from stronger immune systems, which contribute to faster recovery and higher survival rates. In contrast to the present study's findings, a study by Hashemian et al. reported no significant association between recipient age and kidney transplant survival (19). Discrepancies between these findings and those of the current study may be due to differences in other demographic variables or the inclusion and exclusion criteria of the studies.

The present study also found that donor age was significantly associated with transplant survival, with a higher survival rate observed in recipients of kidneys from donors younger than 45 years compared to those from donors older than 45 years. This study's increased survival rate for transplants from younger donors may be attributed to structural, functional, and developmental factors that significantly impact kidney transplant survival (20). Consistent with these findings, Gerbase-DeLima et al. (2020) demonstrated that transplants from younger donors tend to have better survival rates, likely due to the higher number of functional nephrons (18). A literature review reveals a lack of consensus among researchers regarding the association between recipient gender and transplant survival. While some studies indicate that men have better kidney transplant outcomes compared to women, others report similar results across genders, and yet others suggest that male gender is an independent prognostic factor for poorer transplant outcomes (21). However, the present study's findings indicated no significant association between recipient gender, transplant survival, or the risk of graft rejection. Contrary to the results of this study, research by Chesnay et al., García et al., and Chen et al. suggested that transplant survival rates are higher in female recipients than in males (22). A possible explanation for these observations and the

inconsistencies with the present study's findings may lie in sociocultural differences between men and women across various countries, which influence health awareness and the likelihood of following healthcare providers' recommendations. In some countries, women may be more attuned to their health status and more inclined to adhere to medical advice, which could positively affect transplant outcomes (23).

An underlying disease significantly impacts transplant and patient survival rates (24). The present study's findings indicated that underlying diseases had a considerable effect on transplant survival. Diabetes is one of the most critical underlying conditions leading to kidney failure, substantially influencing transplant survival. The results demonstrated that transplant survival in diabetic individuals was significantly lower than in non-diabetic patients. These findings align with those of Hashemian et al. (19), who similarly observed that transplant recipients with diabetes had poorer outcomes and lower graft survival rates compared to non-diabetic recipients. Despite extensive research on the pathophysiology and risk factors of diabetes, the exact mechanisms by which this condition affects transplant outcomes remain unclear. Some studies, however, report contrasting results, showing no significant impact of diabetes on kidney transplant survival (25). The discrepancy could be due to the smaller sample sizes in these studies, which may lack the statistical power needed to detect such associations. In explaining the current study's findings, it can be suggested that diabetes, due to complications such as infections and prolonged hospitalization, contributes to reduced transplant survival in diabetic patients compared to non-diabetic individuals.

The results indicated that transplant survival in patients with hypertension was significantly lower than in non-hypertensive individuals. Furthermore, hypertension was identified as a risk factor for transplant rejection. These findings were consistent with previous studies, where Agarwal et all demonstrated that hypertension in patients significantly decreases kidney transplant

survival compared to non-hypertensive patients (26). Post-transplant hypertension risk factors included those associated with chronic kidney disease, such as renin-angiotensin-aldosterone system activation, sympathetic nervous system activity, and increased extracellular fluid volume, and specific factors related to kidney transplantation, such as calcineurin inhibitors, corticosteroids, transplant renal artery stenosis, and angiotensin II receptor-activating antibodies (27). Additionally, hypertension is a well-established risk factor for post-transplant cardiovascular diseases, including congestive heart failure, ischemic heart disease, and stroke among kidney transplant recipients. Hypertension also an independent risk factor for decreased kidney function and poor graft survival (28). In experimental studies, hypertension in transplant patients accelerates kidney failure progression through increased glomerular capillary hydrostatic pressure and glomerular hyperperfusion (27). Alexandrou et all also demonstrated the adverse effects of hypertension on transplant outcomes (29). All these factors implicitly confirmed the present study's results, highlighting hypertension's negative impact on transplant survival among kidney transplant recipients. Given that hypertension was shown to be a risk factor for transplant rejection in the current study, managing hypertension before transplantation appears to be essential One of the limitations of the study is that the study population in the present study includes all adult kidney transplant patients (aged over 18 years) from living/cadaveric donors who underwent transplantation at Farhikhtegan Hospital between 2010 and 2013. Therefore, the results may not be generalizable to transplant recipients in other centers or other countries around the world.also The use of self-report instruments in part of the study may have been associated with bias.

Conclusion

Based on the results, The present study was conducted to determine the factors affecting the survival rate of kidney transplants in patients transplanted from kidney donors using the Cox model. The results showed the effect of the factors of donor and recipient age, family relationship between the recipient and donor, duration of dialysis before transplantation, underlying diseases of diabetes and blood pressure, serum creatinine level, postoperative complications, body mass index, receiving a transplant from a living or cadaveric donor, and duration of hospitalization on the survival rate of the transplant. Therefore, it is suggested that special attention be paid to these factors as factors affecting the risk of kidney transplant rejection.Therefore, it is recommended that hospitals pay special attention to these factors as significant risk factors for kidney transplant rejectionEthical considerations: Before conducting the study, the study objectives were explained to the participants, informed consent was obtained from them, and they were assured that their information would remain confidential. This study was approved by the Ethics Committee of Islamic Azad University, Sari Branch, under the ethics code number (IR.IAU.SARI.REC.1403.084).

Conflict of interest

The authors declare that there is no conflict of interest in this study.

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Investigation of Blood Indices (Red Blood Cells, White Blood Cells, Platelets) in Radiology Workers in Shahrud County in 2024-2025

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Abstract

Background and Aim: Ionizing radiation is extensively used in medical, industrial, and military applications, playing a pivotal role in technological advancements. However, prolonged exposure to radiation, even at low doses, can adversely impact the hematological system and health of radiation workers. This study aimed to assess the effects of ionizing radiation on the hematological indices of radiology staff in Shahroud hospitals.

Materials and Methods: This cross-sectional study was conducted on 57 radiation workers. Demographic, dosimetry (including HP(10), beta dose, 6-month and 30-month cumulative doses), and hematological index (RBC, WBC, PLT) data were collected and analyzed using descriptive and analytical statistical tests (including t-test, ANOVA, and correlation) with SPSS 26.

Results: The mean Red Blood Cell (RBC) count significantly decreased at doses exceeding 0.2 mSv (P<0.001). A significant correlation was observed between cumulative radiation doses and alterations in hematological indices, with the most substantial changes seen in RBC. No significant correlation was found between hematological indices and demographic variables such as age, work experience, or number of shifts.

Conclusion: Ionizing radiation, even at low doses, can adversely affect the hematological system, with pronounced effects on RBC. Comprehensive

monitoring of radiation workers and advanced assessment methods, such as cytogenetic assays, are crucial for evaluating radiation-induced biological damage. Developing effective protective protocols is recommended to mitigate radiation-associated risks.

Keywords: Ionizing Radiation, Radiation Workers, Hematological Indices, Cumulative Dose, Radiation.

Introduction

There is global concern about ionizing radiation in the medical field as X-rays, gamma rays and beta particles, the use of ionizing radiation as one of the most important methods of diagnosing and treating diseases is widely increasing. The necessity, importance and benefits of radiology are obvious, but if appropriate protective measures are not taken, it can have adverse effects on people who are directly or indirectly exposed to radiation. X-rays cause dangerous biological effects, as they can have an ionizing effect when penetrating living tissue, destroy living cells, cause chromosomal aberrations and cause carcinogenic effects (1-4). The harmful effects of ionizing radiation are categorized into acute and chronic. Acute effects occur shortly after exposure and typically result from high-intensity radiation, while chronic effects arise from prolonged exposure to relatively low radiation doses over time (5). Typically, acute effects are rare in diagnostic radiation exposure due to controlled duration, dose levels, and proper use of protective equipment. Long-term effects associated with chronic low-dose exposure remain the primary risk factor for diagnostic radiation workers. Radiologists and radiology technicians in diagnostic imaging centers are

consistently at risk of potential harm from such exposure (6-7).

Abnormal annual trends in red blood cell (RBC) or hemoglobin levels have been observed in some radiation workers. Thus, RBC monitoring should be prioritized for workers exposed to radiation (8).

Given the lack of similar studies in the country on blood cell changes among medical imaging professionals exposed to radiation, this study investigates blood indices (RBC, WBC, platelets) in radiology workers in Shahroud County in 2024-2025.

Methodology
Design and Method
This study was designed and implemented using a cross-sectional and descriptive-analytical method to investigate the effects of ionizing radiation on blood parameters and its relationship with various variables. The study was conducted in three hospitals in Shahroud, including Khatam, Bahar, and Imam Hossein hospitals, and the statistical population included 57 radiation workers working in these centers. Ethical approval for the study was obtained from the relevant institutional review board, with the ethics identification number IR.IAU.SARI.REC.1403.363.

Study Design and Population: This descriptive-cross-sectional study was conducted in 2024 on all radiation workers (n=57) from the three main radiology centers in Shahroud County (Khatam Al-Anbiya, Bahar, and Imam Hossein hospitals).

Demographic Data
Basic demographic data (age, gender, work shifts, and average work experience) were collected via standardized questionnaires. Questionnaires were distributed in person to radiation workers and collected after completion. Data accuracy was verified by hospital safety officers.

Radiation Dosimetry Data
Data on HP(10), beta dose, 6-month cumulative dose, and 30-month cumulative dose were extracted from personal dosimetry monitoring systems and hospital dosimetry reports. Reported doses were measured using film dosimeters and electronic systems. This

information was periodically recorded at the treatment centers and used for analysis in the study.

Blood Sample Collection
Blood samples were collected from participants under standard conditions at three hospital laboratories. Analyzed parameters included RBC, WBC, platelets, and related indices. Tests were conducted using advanced equipment under laboratory supervision, with two sampling periods (6 months apart).

Data Collection
Demographic and occupational data were collected via a questionnaire.

Dosimetry data (HP(10), beta dose, 6-month and 30-month cumulative doses) were extracted from personal dosimetry records. Blood samples for CBC analysis were taken twice, six months apart.

Statistical Analysis: Data were analyzed using SPSS software (version 26) with descriptive statistics, independent t-test, ANOVA, and correlation tests. A significance level of $P < 0.05$ was considered.

Data Recording and Monitoring
All demographic, diametric, and hematological data were entered into a centralized database for precise analysis and integrity. Access was restricted to researchers and authorized personnel.

Research Tools
1) A researcher-designed checklist was used to collect demographic data (age, gender, shifts, work experience). Checklist were simplified for clarity and reviewed to ensure accuracy.
2) Dosimetry Systems
   Film dosimeters measured cumulative radiation doses, including HP (10), beta doses, and 6-month/30-month cumulative doses.
3) Laboratory Equipment
   Blood samples were analyzed using automated hematology analyzers for RBC, WBC, and platelet counts.
4) Statistical Software
   SPSS and generalized linear models were used for correlation analysis, mean

comparisons, and examining relationships between radiation variables and blood parameters.

Result

In this study, the demographic and occupational characteristics of radiation workers, including the number of work shifts, work experience, age, and gender, were examined. The total number of subjects studied was 52, whose information was fully collected and analyzed. The results showed that the average number of work shifts among radiation workers was 21/21 shifts per month, with a minimum of 4 shifts and a maximum of 35 shifts. The work experience of the radiation workers was also examined in detail. The demographic characteristics of participants of study and hematological characteristics is listed in Table 1 and Table 2, respectively.

Table1: Demographic characteristics of participants (n=57)

Variable	Number	Minimum	Maximum	Mean
Shift/month	57	4	35	21.3
Work experience (years)	57	1.5	35	16.97
Age (years)	57	25	70	48.7

Table 2: Hematologic characteristics of participants (n=57)

Parameter	Number	Unit	Minimum	Maximum	Mean	SD
WBC	57	cells/mm³	2951	8902	5647	633.89
RBC	57	million / mm³	1.89	4.95	4.48	0.50
PLT	57	cells/mm³	88514	296185	204136.77	53332.72

Of the 57 radiation workers surveyed, 26.5 percent (55 people) were within the normal dose range (11 millisieverts). Only 3.5 percent of people received doses of 1.15 and 1.2 millisieverts.

These data indicate that most radiation workers were adequately protected and their HP (10) radiation levels were within safe limits.

All 57 radiation workers were 100% within the normal beta dose range (below 0.05 mSv). These results confirm that beta radiation in workplaces is well controlled and the risks associated with this type of radiation are minimized.

The results showed that 93% of the subjects (53 subjects) had a 6-month cumulative dose below 0.05 mSv. Only 7% of the subjects (4 subjects) had received doses above 0.05, with values ranging from 0.05 mSv to 0.2 mSv. These data suggest that although most radiation workers were exposed to safe doses, there is a need for more careful monitoring for a small number of subjects. For the 30-month cumulative dose, 63.2% of subjects (36 people) were below 0.05 mSv. 36.8% of subjects (21 people) had higher doses, with cumulative dose values ranging from 0.05 to 13.65 mSv. Higher-than-normal values included doses of 3.55, 11.34, and 13.65 mSv, which require further protective consideration.

Blood indices including red blood cells (PLT) and platelets (RBC), white blood cells (WBC) were examined in two groups of men and women. The results showed differences in the mean and standard deviation of these indices between the two groups (Table 3).

Table 3: Descriptive analysis of blood indices in males and females.

Blood Index	Gender	Number	Mean	Std. Deviation	Std. Error
WBC	Male	32	5,303.8	642.71	113.61
	Female	25	5,905.9	631.99	126.39
RBC	Male	32	4.5234	0.31903	0.05640
	Female	25	4.4208	0.67223	0.13445
PLT	Male	32	194,352.34	54,809.14	9,688.97
	Female	25	216,660.84	49,655.08	9,931.02

The mean RBC count significantly decreased at doses exceeding 0.2 mSv (P<0.001), demonstrating more substantial changes compared to WBC and PLT. A significant correlation was observed between cumulative radiation doses and alterations in hematological indices.

The current study demonstrates that ionizing radiation, even at low doses, can cause significant changes in the blood system. These changes include reductions in red blood cells (RBC), white blood cells (WBC), and platelets, highlighting the high sensitivity of blood cells to radiation exposure. White blood cells, due to their key role in immune response and greater susceptibility to radiation damage, showed a significant decrease among radiation workers. These findings align with previous research indicating radiation-induced immune dysfunction and emphasize the need for

rigorous monitoring of radiation workers' immune status (Table 4).

Table 4: Mean and Standard Deviation of Blood Indices in Two Levels of 30-Month Cumulative Dose

Blood index	Cumulative level (D30M)	Mean	SD
WBC	Normal	6203.7	599.87
	Above Normal	1068.00	141.42
	Dangerous	1590.00	1036.62
RBC	Normal	4.52	0.37
	Above Normal	4.68	0.03
	Dangerous	3.12	1.74
PLT	Normal	207096.09	53260.55
	Above Normal	130015.00	15535.13
	Dangerous	1999036.50	6849.73

One of the key findings of this study is the impact of cumulative radiation doses on blood indices. Specifically, doses exceeding 20 millisieverts over six-month and 30-month periods were associated with significant reductions in red and white blood cell counts. These results suggest that cumulative radiation can have harmful effects, even at low doses, which become evident over the long term. Additionally, no significant correlation was found between blood indices and variables such as work history or shift frequency, indicating that cumulative radiation dose may play a more dominant role than other factors.

Analytical Findings

➢ The decrease in the mean RBC count at doses higher than 0.2 mSv (in HP(10)) was statistically significant (P < 0.001).
➢ A significant correlation was observed between cumulative radiation doses (6 and 30 months) and a decrease in hematological indices (especially RBC) (P < 0.05).
➢ Based on ANOVA, a significant decrease in mean RBC was observed with increasing HP(10) dose level (P = 0.004). This decrease was not significant for WBC (P = 0.094) or PLT (P = 0.469).
➢ No significant correlation was found between hematological indices and demographic variables (age, gender, work experience, number of shifts) (P > 0.05 for all).

Discussion

These findings underscore the importance of developing and implementing effective protective protocols. The use of personal protective equipment and regular monitoring of radiation exposure can mitigate associated risks. Furthermore, advanced methods for assessing blood changes, such as cytogenetic testing, could replace conventional methods like CBC, providing greater accuracy in identifying radiation effects. Overall, this study strongly advocates for more precise monitoring of radiation workers' blood status and the design of more effective protective programs to prevent ionizing radiation damage.

In this context, our study focused on the effects of ionizing radiation on blood indices (CBC) and showed that radiation can lead to significant changes in red blood cells, white blood cells, and platelets. In contrast, another study examined skin wrinkles among healthcare workers (9). Their results indicated that ionizing radiation could increase wrinkles in various areas of the face and neck, demonstrating its structural and aesthetic impacts.

These two studies collectively demonstrate that the effects of ionizing radiation are not limited to internal systems like the hematopoietic system but also extend to external tissues such as the skin. This comparison highlights the importance of multidimensional perspectives in radiation-related studies, as only by considering all aspects of these effects can effective protective and monitoring measures be designed for Beyond the effects of ionizing radiation on the blood system and skin changes, broader and more comprehensive investigations into occupational radiation exposure's impact on workers' health are essential. The occupational health of radiation workers is not only affected by direct radiation but also significantly influenced by workplace conditions and ergonomic factors. Specifically, work-related musculoskeletal disorders (WMSDs) are a common issue among radiation workers, requiring special attention.

A study by Li Yan et al. (2024) examined the prevalence and risk factors of musculoskeletal disorders among 1,669 radiation workers in Guangdong Province, China [10]. The research found that 15.3% of radiation workers suffered from these

disorders, with factors such as gender, alcohol consumption, repetitive movements, overtime work, and prolonged static postures significantly increasing the risk. These results highlight the importance of ergonomic interventions, such as adjustable chairs and optimal environmental temperatures, in reducing these risks.

Compared to the current study and the research by Huriye Aybüke Koç, which focus on the blood system and skin changes due to radiation, Li Yan's study reveals another dimension of occupational health that indirectly affects workers' well-being and performance. This diversity in research outcomes demonstrates that radiation-related studies must consider not only the direct effects of radiation on tissues but also ergonomic and psychosocial workplace factors (9-10).

Moreover, the effects of ionizing radiation are not limited to specific tissues like blood or skin but can also impact other body systems. For example, a study by Galina et al. investigated the impact of long-term occupational exposure to ionizing radiation on non-cancerous respiratory diseases, such as chronic bronchitis and asthma, among workers at the "Mayak" nuclear facility (11). The study found that exposure to gamma and alpha radiation was associated with an increased risk of chronic bronchitis. Notably, the excess relative risk (ERR/Gy) from internal alpha radiation exposure was significantly higher than that from gamma radiation. In contrast, no association was observed between occupational radiation exposure and the incidence or mortality of bronchial asthma.

This study, using an advanced dosimetry system (MWDS-2013) to estimate radiation doses accurately, demonstrated that the biological effects of radiation depend on the type of radiation (gamma or alpha), dose level, and intervening factors such as behavioral habits (e.g., smoking). For instance, among workers with a history of smoking or high smoking indices, the risk of mortality from chronic bronchitis increased significantly. Compared to studies like ours on blood indices or Huriye Aybüke Koç's

research, this study emphasizes the effects of radiation on the respiratory system. This comparison underscores the need for comprehensive and extensive investigations into all body systems and potential effects at cellular and systemic levels to fully understand the consequences of ionizing radiation (9).

A study by Bahrami Asl et al, which examined the effects of long-term exposure to ionizing radiation on blood cells and interleukin-6 (IL-6) levels in radiation workers, shares significant similarities with the current research [12]. Both studies focus on hematological changes due to radiation and emphasize the importance of monitoring blood indices to understand its biological effects. In this study, in addition to traditional blood indices like CBC, IL-6 levels were evaluated as an inflammatory marker. The study found that even at radiation doses below the permissible limit (annual average of 1.18 millisieverts), IL-6 and eosinophil levels were significantly higher in the radiation worker group compared to the control group. These results suggest that occupational exposure to ionizing radiation, even at low doses, can cause biological changes that may lead to diseases like cancer in the long term.

Our advancements in this study represent an effective step in this direction, showing how new approaches can lead to a better understanding and improved protection of radiation workers' health.

Aknowledgement

Conflict of Interest
The authors declare no conflicts of interest.

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The Relationship between Anxiety and Nurses' Resilience During the Corona in Corona Reference in Mazandaran Provinc Hospitals

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Abstract

Background and Aim: The recent outbreak of the new coronavirus (Covid-19) has caused a great deal of stress and anxiety around the world/ The aim of this study was to investigate the relationship between anxiety and nurses' resilience during the corona in Sari and Ghaemshahr hospitals in 2021.

Materials and Methods: This research was a descriptive-applied correlation. The study population consisted of all nurses of public hospitals in the number of 1665 people and the samples of 384 people were selected by stratified sampling method using stratified sampling method and Krechsey Morgan. Data were collected from the standard Coronavirus Anxiety Inventory (CDAS) and Connor & Davidson (2003) Resilience Questionnaire with a Likert scale question Was finalized with 21spss software.

Results: The findings showed that anxiety (physical symptoms, fatigue, insomnia, psychological symptoms (positive acceptance of change and safe relationships), psychological symptoms (control and spiritual effects) are associated with nurses' resilience during coronation/ The present study also showed that anxiety is related to demographic characteristics including (age, sex and work experience, education, number of children, underlying disease, and marital status) which marital status is the highest and education is the lowest predictor of nurses' resilience Has had(p<0.005).

Conclusion: Anxiety with nurses' resilience in corona Therefore, to reduce the anxiety of medical staff, health policy makers should consider the necessary measures and measures.

Keywords: Anxiety - Resilience - Nurses – Corona.

Introduction

The lack of definitive treatment or prevention for COVID-19 has generated significant stress and concern within societies. COVID-19 is a highly contagious infectious disease that spreads through close person-to-person contact. The average number of people one infected individual can transmit the virus to is estimated between 2.8 and 3.8. Assuming an average transmission rate of 3.5, over 70% of the population is expected to become infected (1). The symptoms of this virus vary from mild to severe, commonly including fever, cough, and difficulty breathing (2).

Anxiety is a common symptom among patients with chronic respiratory disorders and can significantly reduce their quality of life. Stress and anxiety can weaken the immune system, making individuals more vulnerable to infections, including COVID-19 (3). Given that public health measures are the only effective method to control the disease, the pandemic led to the rapid implementation of strict quarantine protocols worldwide (4). Quarantine can be either voluntary or mandatory, and may apply at the individual or community level.

Resilience, as a personality trait, is described as the ability to successfully adapt to stressful and threatening conditions. According to the theory of Connor and Davidson, resilience is defined as the capacity and strength of an individual to cope with hardships and adversity (5). Resilience is the individual's ability to maintain biological and psychological balance under adverse conditions. In their view, resilience refers to

better adaptation under threatening circumstances (6).

Limited public knowledge about COVID-19, along with misinformation and rumors, has led to heightened levels of anxiety, fear, boredom, and hopelessness (4). Therefore, addressing only the physical health of patients is insufficient; psychological care is also crucial to reduce stress and mental pressure (7). For example, Liu's study demonstrated that social support can alleviate the psychological burden associated with the Ebola outbreak (8). Wang et al. reported moderate to severe psychological impacts—including depression, anxiety, and stress—during the COVID-19 outbreak in China (9). Similarly, studies conducted by Lin during the SARS pandemic indicated that despite individual differences, most people experienced feelings of isolation and struggled to cope with psychological stress (10).

Al-Rabia and colleagues found that frontline healthcare providers, particularly nurses, were not exempt from these psychological burdens and were significantly affected by mental stressors (11). This group may even be more vulnerable than the general population, experiencing higher levels of depression and anxiety (12). Since nurses' physical and mental health is directly linked to the quality of patient care, job satisfaction, and work performance (13), enhancing their resilience can reduce the costs associated with diagnosing and treating anxiety. Furthermore, resilience may play a critical role in mitigating anxiety among nurses.

Due to the limited research available on COVID-19 and the substantial physical, psychological, cultural, and social pressures it imposes (14), the importance of this study is underscored. Nurses constitute a central component of the healthcare team, representing over 10% of healthcare providers, and serve as the first line of defense in confronting the COVID-19 pandemic. The nursing profession involves prolonged and continuous stress, especially for those in helping roles who often feel overwhelmed by others' problems. According to the Iranian Ministry of Health,

approximately 45,000 nurses have been infected with COVID-19. In a study by Koh et al., more than half of the nurses (56%) reported experiencing stress (15).

Given the emerging nature of COVID-19, its psychological impact on nurses, and the lack of sufficient research in this area, conducting the present study is deemed essential.

Materials and Methods

This study employed a descriptive-analytical design. The statistical population included all nurses working in public hospitals of Sari (Imam, Bu-Ali Sina, Fatemeh Zahra, and Shahid Zareh) and Qaemshahr (Razi Hospital), totaling 1700 individuals. A sample of 384 nurses was selected based on Krejcie and Morgan's sample size table, using stratified random sampling.

Inclusion criteria were: employment in the nursing profession, willingness to participate in the study, and complete completion of the questionnaire. Exclusion criteria included lack of consent to participate, diagnosis of anxiety or depressive disorders, and incomplete questionnaire responses.For data collection, two standardized questionnaires were utilized: the Coronavirus Anxiety Scale (CDAS) and the Connor-Davidson Resilience Scale (CD-RISC, 2003), comprising 46 items rated on a Likert scale.Given the standardized nature of the instruments, content validity was considered established. Two questionnaires were validated in Iran by Alipour et al. and Vakili et al. Validity and reliability were 0.91 and 0.899, respectively, for the first questionnaire. And the validity and reliability of the resilience questionnaire were reported to be 0.87 and 0.92, respectively (16,17). the normality of the data distribution was first examined using the Kolmogorov–Smirnov test. In this study, written consent was first obtained from the participants. Then, the objectives and nature of the study were explained to the study subjects and the method of conducting the study. And ambiguities were resolved. Then, the questionnaire was made available to the nurses of both groups of coronavirus patients (101 people) and non-coronavirus patients

(283 people). The nurses completed the questionnaire. After completing the questionnaire, it was collected by the researcher. Then, the data was entered into the computer and was finally analyzed using SPSS version 21 software. The inclusion criteria for the study were being employed in the nursing field, having consent to participate in the study And the exclusion criteria were the nurses' dissatisfaction, having anxiety or depression, and questionnaires that were incompletely filled out were excluded from the study.Subsequently, the data were analyzed using Spearman correlation and Chi-square tests.

Findings

This study, aiming to investigate the relationship between anxiety and resilience among nurses during the COVID-19 pandemic, was conducted in 2021 on a sample of 384 nurses working in referral hospitals of Sari and Qaemshahr. Of the 384 total subjects, 153 (39.8%) were males and 231 (60.2%) were females. 51 subjects were in the 20-30 age group (13.3%), 256 subjects were in the 31-45 age group (66.7%), and 77 subjects were in the 45+ age group (20.1%). (Table 1)

Table 1: Demographic Characteristics of the Study Sample

	Group	Frequency (n)	Percentage (%)
Gender	Male	153	39.8
	Female	231	60.2
Age	20–30 years	51	13.3
	31–45 years	256	66.7
	Above 45 years	77	20.1
Work Experience	Less than 5 years	32	31.8
	5–10 years	122	44.8
	10–20 years	172	44.8
	More than 20 years	58	15.1
Work Unit	COVID-19 Ward	101	3.26
	Non-COVID Ward	283	7.73

According to the results presented in the table above, the distribution of scores for the study variables was found to be normal. This conclusion is based on the fact that the

significance values (p-values) for all variables were greater than the threshold level of 0.05. Therefore, the differences between the observed data distributions and the normal distribution were not statistically significant. As a result, the assumption of normality was met for both the main and sub-hypotheses of the study. Consequently, parametric tests were applied for hypothesis testing. (Table 2)

Table 2: Assessment of the Normality of Variable Score Distributions Using the Kolmogorov–Smirnov Test

Variables	K–S Statistic (Z)	Significance Level (p-value)	Criterion ($\alpha = 0.05$)	Distribution Status
Anxiety	0.216	0.208	> 0.05	Normal
Resilience	0.358	0.241	> 0.05	Normal

According to the results of the Pearson correlation test, there is a statistically significant relationship between anxiety and nurses' resilience (r = 0.642, p = 0.002). Given the correlation coefficient of 0.642, the strength of this relationship is moderate and the direction is positive. This indicates that during the COVID-19 pandemic, there was a positive correlation between anxiety and resilience among nurses working in COVID wards. (Table 3)

Table 3: Analysis of the Distribution of Research Variables

Significant Relationship	Degrees of Freedom (df)	Significance Level (p-value)	Correlation Coefficient (r)	Variable
Yes	384	*0.002	0.642	Anxiety and Resilience

According to the results of the Pearson correlation test, there is a statistically significant relationship between anxiety and nurses' resilience (r = 0.492, p = 0.002). Given the correlation coefficient of 0.492, the strength of this relationship is moderate and the direction is positive. This suggests that, among nurses working in non-COVID hospital wards, there is a positive correlation between anxiety and resilience. (Table4)

Table 5 presents the correlation coefficients

Table 4: Correlation Analysis Between Study Variables in COVID wards (Anxiety and Resilience)

Significant Relationship	Degrees of Freedom (df)	Significance Level (p-value)	Correlation Coefficient (r)	Variable
Yes	384	*0.002	-0.492	Anxiety and Resilience

between the predictor variables (age, gender,

work experience, education level, number of children, presence of underlying disease, and marital status) and the criterion variable (resilience) of nurses during the COVID-19 pandemic. This hypothesis was tested using multiple regression analysis. The correlation coefficient was calculated as r = 0.964, and the coefficient of determination R^2 = 0.930, with a p-value = 0.001.

Table 5: Correlation Analysis Between Study Variables in COVID wards (Anxiety and Resilience)

conclusion	R	R2	Std. Error	F	Significance Level
Significant	0.964	0.930	4.48	616.475	0.001

Since the obtained significance level (p < 0.001) is smaller than the standard threshold of 0.05, the null hypothesis is rejected, and the research hypothesis is confirmed. According to the regression output, the results indicate that there is a significant relationship between nurses' age, gender, work experience, education, number of children, underlying health conditions, and marital status and their resilience during the COVID-19 period. Table 6 shows that the variable age is significantly related to resilience, with a regression coefficient of 0.157 and a t-value of 3.246, and an R^2 value of 0.075. The gender variable is also significantly associated with resilience, with a coefficient of 0.156, t-value of 5.286, and R^2 of 0.063.The work experience variable has a significant relationship with resilience (β = 0.120, t = 3.779, R^2 = 0.049). The education level is also a significant predictor, with a coefficient of 0.104, t-value of 2.139, and R^2 = 0.009.The number of children variable is significantly associated with resilience, with a coefficient of 0.168, t-value of 4.917, and R^2 = 0.057. The presence of underlying health conditions also shows a significant relationship (β = 0.255, t = 6.476, R^2 = 0.048). Finally, marital status demonstrates a significant association with resilience, with a coefficient of 0.370, t-value of 8.957, and R^2 = 0.032.

Table 6: Estimated Coefficients of the Final Linear Regression Model for Study Variables

Predictor Variable	R2	Unstandardized Coefficients (B)		St.d. Error	t-value	Significance Level p
		B	Standard Deviation	BETA		
Constant		3.380	0/307		11.019	0.002
Age Resilience	0.075	0/159	0/049	0/157	3.246	0/001
Gender Resilience	0.075	0/355	0/067	0/156	5/289	0/013
Work Experience Resilience	0/049	0/131	0/168	0/120	3/779	0/002
Education Resilience	0/009	0/115	0/108	0/104	2/139	0/001
Number of Children Resilience	0/057	0/487	0/099	0/168	4/917	0/013
Underlying Illness Resilience	0/048	0/815	0/126	0/255	6/476	0/017
Marital Status Resilience	0/032	1/163	0/130	0/370	8/957	0/002

Discussion

The present study aimed to investigate the relationship between anxiety and resilience among nurses during the COVID-19 pandemic in hospitals of Sari and Qaemshahr in 2021. Given the widespread outbreak of COVID-19 and the high mortality rates associated with the disease globally, healthcare workers—being at the frontline—are more likely to experience psychological disturbances and anxiety than others.Findings from the current study indicated that there is a significant relationship between anxiety and resilience among nurses working in COVID-19 wards. Emerging mental health issues are influencing the decision-making capabilities of healthcare personnel and may have chronic negative effects. To improve mental health among healthcare workers, it is necessary to establish maximum working hours and shift arrangements, promote self-care, and reduce

excessive workload. Furthermore, enhancing knowledge related to infection control and self-protection among healthcare providers is essential.

This study demonstrated that nurses working in COVID-19 wards are at higher risk of exposure, experiencing greater emotional stress and workload. The findings are consistent with previous studies by Salari et al. (19), Chen et al. (20), Yan et al. (21), and Liu et al. (8). Salari et al. reported that increasing the sample size led to a statistically significant reduction in the prevalence of depression and anxiety, although stress prevalence increased with sample size but was not statistically significant. Their results also showed high levels of stress, anxiety, and depression among frontline healthcare workers managing COVID-19 patients (19). According to established protocols, the number of patients seen per shift and hour should be limited to reduce infection risk, with adequate distancing and appropriate protective equipment (e.g., masks, gloves, gowns, eye protection) for all staff. Liu et al. (8) found that healthcare staff in direct contact with COVID-19 patients exhibited higher anxiety levels compared to those with no direct contact.

The present study also showed a significant relationship between anxiety and resilience among nurses working in non-COVID wards. Anxiety, as a threat to mental health, has caused numerous concerns—such as fear of contracting COVID-19 among nurses. The resilience mechanism helps reduce anxiety through core components such as self-confidence, personal competence, trust in instincts, positive acceptance of change, control, and spiritual influence. These act as buffers against psychological stress.Nurses with high clinical resilience can endure even the most acute and stressful situations—such as the COVID-19 pandemic—without succumbing to psychological issues like anxiety and depression. These findings align with the studies by Yan et al. (21), Mir-Kazahi (22), and Variaei (23), but differ from the findings of Zarrabadi-Pour (24).Ashkani's findings revealed significant

differences in job stress and resilience (and their subcomponents) between nurses working in COVID and non-COVID wards in Shiraz hospitals. Job stress was higher, and resilience lower, among nurses in COVID wards (18). Variaei emphasized the need for an intermediate unit between COVID and non-COVID departments, and recommended strict protective protocols even in non-COVID units due to high anxiety about infection among nurses. Yan et al. (21) reported higher mild to moderate distress among second-line nurses compared to frontline nurses (31% vs. 25%). Living alone and perceived social support independently predicted lower anxiety. Their study concluded that all nurses experienced serious psychological issues during the COVID-19 pandemic, with second-line nurses reporting more severe concerns than frontline workers—a finding inconsistent with the present study. This discrepancy may be due to regional, cultural, educational, or religious differences.Zarrabadi-Pour (24) found no statistically significant difference in anxiety levels between the general public, COVID and non-COVID medical personnel. However, the present study reported higher anxiety among nurses in COVID wards, possibly due to differences in disease-related knowledge and awareness among healthcare professionals.Furthermore, this study revealed a significant relationship between psychological symptoms (e.g., worry) and resilience among nurses during the pandemic. Increased social capital and perceived social support led to enhanced spiritual well-being, which in turn improved resilience against COVID-related stress. Promoting these factors during periods of social distancing may enhance resilience.

These findings are consistent with those of Fariour (25) and Shahyad (26). Anxiety and worry, which are often irrational emotional responses, are symptoms of many psychological disorders. Anxiety is a universal human experience under pressure or tension, especially in the face of threatening or uncertain situations. The contagious nature of COVID-19 has triggered both physical health concerns and

psychological disorders. Moreover, the level of anxiety among medical staff in highly infected cities (such as Wuhan) was reported to be higher compared to medical personnel in less affected cities (20). The findings of the present study also indicated that age, work experience, education, number of children and underlying health conditions could serve as predictors of resilience among nurses. While the study by Sarsiam (27) found no significant relationship between gender and marital status with higher levels of anxiety, the current research demonstrated that both gender and marital status can predict levels of resilience in nurses. This inconsistency may be attributed to differences in research methodology or sample size Limitations of this study include the difficulty in accessing nurses due to the pandemic, variability in the accuracy of questionnaire responses due to individual differences and night shifts, which may have affected response quality.

Conclusion

Given the widespread outbreak of COVID-19 across the globe and the high mortality rate associated with the disease, healthcare workers—being on the front lines of the pandemic—are more vulnerable than others to developing psychological disorders and anxiety. The rapid transmission rate of COVID-19, which is one of its defining characteristics, led to a global public health emergency within just a few months of its emergence in various countries. This contagious disease not only raised serious concerns regarding physical health but also contributed to the onset of various psychological disorders. Therefore, possessing certain characteristics such as resilience can protect individuals against crises like the COVID-19 pandemic, which caused significant stress among the general population.

Conflict of Interest

The authors declare no conflicts of interest.

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The Prevalence of Helicobacter Pylori in Biopsy-Confirmed Dyspeptic Patients in Vali Asr Hospital in Qaemshahr in the Year 2018

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Abstract

Background and Aim: Helicobacter pylori is the most important cause of gastritis and indigestion in humans. Considering the importance of this bacterium and its varying prevalence in different regions of the country, This study aimed to investigate the prevalence of Helicobacter pylori in biopsy-confirmed dyspeptic patients at Vali Asr Hospital in Qaemshahr in 2018.

Materials and Methods: This retrospective study was conducted on 2007 patients referred to the hospital. To diagnose Helicobacter pylori in histological studies, Giemsa staining was used, and then the data were entered into SPSS-V22 statistical software.

Results: The average age of the patients was 51.23±16.42 years (%46.7 male and %53.3 female). The prevalence of Helicobacter pylori was %42.7. The most common finding observed was moderate gastritis in %61 of patients and intestinal metaplasia with a frequency of %85.3. The relationship between the incidence of Helicobacter pylori infection and gender (P=0.369) and age (P=0.524) was not significant, but its relationship with types of gastritis pathology was significant (P=0.000).

Conclusion: Considering the high prevalence of Helicobacter pylori infection and the complications arising from it in infected individuals, there is a need for continuous monitoring, health education, and precise control of reinfection in the studied population.

Keywords: Helicobacter Pylori, Gastrointestinal Disorders, Dyspepsia.

Introduction

Helicobacter pylori (HP) is a gram-negative and microaerophilic bacterium that is often seen in a spiral shape in the stomach mucosa and in a curved form in culture media (1). This bacterium is considered the main cause of chronic gastritis and peptic ulcer (stomach ulcer) and is the primary risk factor for peptic ulcers, adenocarcinoma, and gastric lymphoma (2). There are several methods for diagnosing Helicobacter pylori infection in patients. The diagnostic methods can be divided into two categories: invasive and non-invasive (3). Among the invasive methods are endoscopy, culturing biopsy samples, staining samples, and identifying urease enzyme activity. Non-invasive methods include the urea breath test and serological tests (4).

Helicobacter pylori infection is one of the most common chronic bacterial infections in the world, particularly in developing countries. The epidemiological pattern of this infection differs between industrialized and developing countries. In developing countries, the prevalence of infection in young individuals is more than %80, while in developed countries it is less than %10 (5). Aside from age, another major risk factor for acquiring infections is poverty. Studies have shown that there is a close relationship between individuals' socioeconomic status and the prevalence of this infection (5). According to studies conducted in Iran, the prevalence of pollution among individuals aged 35 to 55 is between %88.4 and %93 and in individuals aged 10 to 25 years, %44.9 has been reported (6-7). Considering the

importance of this bacterium and its varying prevalence in different regions of the country, This study aimed to investigate the prevalence of Helicobacter pylori in biopsy-confirmed dyspeptic patients at Vali Asr Hospital in Qaemshahr in 2018.

Materials and Methods

This research was conducted retrospectively on patients who presented with dyspeptic symptoms at Vali Asr Hospital in Qaemshahr in The year 2018. The study samples were selected through a census of all individuals who had visited the hospital with dyspeptic symptoms, and the medical records of patients from whom a biopsy sample of their tissue was taken after examination by a physician and the tissue biopsy was sent to pathology, and the stomach biopsy samples were stained using the Giemsa method, and Helicobacter species were identified in the histological samples. After reviewing the file, the demographic information and pathology results were also entered into the checklist. The collected data in this study was entered into the SPSS-V22 statistical software and analyzed.

Results

From 2007 patients under review, 938 patients (%46.7) were male and 1069 patients (%53.3) were female. the average age of patients was 51.23 ±16.42 years (with a range of 14-95 years). All patients in the pathological examination were affected by various types of gastritis according to Table 1. The most common gastritis based on pathology was moderate gastritis, observed in 1224 patients (%61 of the patients) studied.

Table 1: Frequency of types of gastritis in the studied patients

Types of gastritis	Abundance	Percentage of abundance
Mild	544	27.1
Moderate	1224	61
High	231	11.5
Erosio	8	0.4
Total	2007	100

In the examination of the prevalence of Helicobacter pylori, as shown in Chart 1, its prevalence was 856 (%42.7) cases (blue).

Pie chart 1: Abundance of Helicobacter pylori in patients studied
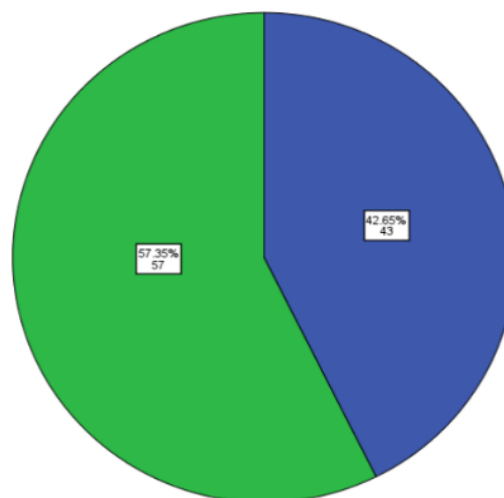
In the 1455 studied patients, no other noteworthy points were observed except for inflammation in the gastric pathology examination. The results of the examination of other individuals are shown in Table 2. The most common finding observed was intestinal metaplasia, with a frequency of %85.3.

Table 2: Frequency of findings other than inflammation in the studied patients

Finding other than inflammation	Abundance	Percentage of abundance
Intestinal Metaplasia	471	85.3
Intestinal Metaplasia + Dysplasia	10	1.8
Stomach Ulcer	1	0.2
Foveal Hyperplasia	23	4.2
Mild Glandular Hyperplasia	6	1.1
Hyperplastic Polyp	6	1.1
Reaction Change	29	5.3
Dysplasia	2	0.4
Mild Atypia	1	0.2
Epithelial Hyperplasia	1	0.2
Adenoma Velos	1	0.2
Intestinal Metaplasia + Adenoma Polyps	1	0.2
Total	522	100

In 219 patients (%46.5) with Helicobacter pylori infection, the simultaneous presence of

intestinal metaplasia in pathology was observed as the most common pathological finding alongside gastritis.

In the study of the relationship between Helicobacter pylori and gender, as seen in Table 3, no significant relationship was observed between these two parameters (P = 0.369).

Table 3. Relationship between Gender and Helicobacter pylori in the Studied Patients

ariable	Helicobacter Pylori		Helicobacter Pylori		mar Kay-Esquire	P-Value
	(Positive)		(Positive)			
	bundance	ercentage	bundance	ercentage		
ale	10	3.7	28	6.3	.808	.369
emale	46	1.7	23	8.3		

In examining the relationship between Helicobacter pylori and age, as shown in Table 4, no significant correlation between these two parameters was observed (P=0.524).

Table 4: The relationship between age and Helicobacter pylori in the studied patients

Variable	Helicobacter pylori	Abundance	Average age (standard deviation)	P-value
Age	Positive	856	50.96 (15.51)	0.524 T
	Negative	1151	51.43 (17.07)	Independent

In examining the relationship between Helicobacter pylori and types of gastritis pathology, as seen in Table 5, it was significant with a Pvalue of 0.000.

Table 5: The relationship between types of gastritis pathology and Helicobacter pylori

Types of gastritis pathology	Helicobacter pylori (Positive)		Amar Esquire		Amar Kay-Esquire	P-value
	Abundance	Percentage	Abundance	Percentage		
Mild	26	4.8	518	95.2		
Moderate	621	50.7	603	49.3	556.21	0.000
High	206	89.2	25	10.8		
Erosio	3	37.5	5	62.5		

Discussion

In developing countries, Helicobacter pylori is a challenging health problem. The %20 prevalence of this infection among white adults in the United States is striking compared to the rate of over %90 in parts of developing countries (8).

A study in northwestern Iran, an area with the highest rates of mortality and morbidity due to stomach cancer in the country, reported Helicobacter pylori infection in %89.2 of the residents (9). The results of the present study showed that the prevalence of Helicobacter pylori infection was about %43. In the study by Myint and colleagues, the overall prevalence of Helicobacter pylori infection was %48 (10). In the study by Khasag and colleagues, the Helicobacter pylori infection was high in all patients with gastrointestinal disorders throughout Mongolia, and the overall infection rate was reported to be 80%. In Khasag study (2018), Helicobacter pylori infection was high in all patients with gastrointestinal disorders throughout Mongolia, and the overall infection rate was reported to be %80 (11). In the Oling study (2015), the prevalence of Helicobacter pylori was reported to be %36 [12]. As can be seen, the results in various studies have been different, such that the prevalence of Helicobacter pylori has varied from less than %15 in some populations to about %100, depending on the socioeconomic status and development of the country. Various studies have shown that in developing countries, the prevalence of Helicobacter infections is high and is associated with low education levels, socioeconomic status, and inadequate health conditions (13-14). Another reason for the difference in the results of various studies can be attributed to the differences in the sensitivity of the different tests used in these studies to identify this bacterium. In the current study, the prevalence of Helicobacter pylori infection in men was slightly higher than in women, but this difference was not significant. Of course, the prevalence of dyspeptic disorders, regardless of concurrent infection with Helicobacter pylori, was briefly higher in women than in men. According to reports by Lopez from Mexico (2008), Saribasak from Turkey (2004),

Zheng from Singapore (2000), Ahmad from Pakistan (2009), the prevalence of male patients is higher than that of female patients; However, Khayat from Lebanon (2007) and Micivleviciene from Lithuania (2008) reported that the prevalence of female patients is higher than that of male patients (15-20). In the study Alavi from Ahvaz (2009), Kargar from Shahrekord (2008), Maleki from Mazandaran, Rasmi from Ardabil and Mansour from Rasht (2009) the number of female patients is higher than that of males and in the study Jafari from Tehran (2009), the number of males was reported to be higher than that of females (21-24). It seems that men are at a higher risk of contracting Helicobacter pylori infection due to more activities and less adherence to hygiene compared to women, as the prevalence of infection has an inverse relationship with hygiene practices (25).

The average age of the patients studied was approximately 52 years, and the results of the present study did not show a significant relationship between age and infection with Helicobacter pylori. In many studies, including the current study, no significant relationship was observed between age and age groups and the incidence of Helicobacter pylori infection (26-27). However, some studies have reported a higher prevalence of Helicobacter pylori infection in the age group of 20-40 years compared to older age groups (27-28).

The results of the present study showed a significant relationship between the pathological degrees of gastritis and Helicobacter pylori infection, such that in about %90 of severe gastritis cases, concurrent Helicobacter pylori infection was also observed. The results of Myint's study were also consistent with the present study, and individuals infected with Helicobacter pylori showed more severe gastritis (10). In the Qasimi Basir (2017) study, most patients with severe Helicobacter pylori colonization suffered from moderate to severe gastritis. Additionally, in this study, a significant correlation was observed between the intensity of colonization of this bacterium and histopathological findings, including

intestinal metaplasia (29). In the present study, the most common finding aside from gastritis was the pathological examination of intestinal metaplasia, which was observed in %47 of patients with concurrent Helicobacter pylori infection.

Conclusion

According to the findings of the present study, the prevalence of Helicobacter pylori in patients with dyspepsia was reported to be about 43%, and infection with this bacterium had a significant association with the observation of severe gastritis in pathological examination.

Conflict of Interest

The authors declare no conflicts of interest.

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Prevalence of Sudden Sensorineural Hearing Loss and Associated Factors in Audiology Clinics of Mazandaran Province (2022–2023)

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Abstract

Background and Aim: Background: Sudden sensorineural hearing loss (SSNHL) is a medical emergency characterized by a hearing loss greater than 30 dB in at least three consecutive frequencies occurring within 72 hours. This study aimed to investigate the prevalence and associated factors of SSNHL in audiology clinics across Mazandaran Province during 2022–2023.

Materials and Methods: This descriptive cross-sectional study included 300 patients aged 18 to 90 years who were diagnosed with SSNHL by an otolaryngologist based on audiometric findings. After obtaining ethical approval, demographic data (age, sex, place of residence), history of diabetes, and lipid profile (LDL and HDL levels) were collected and analyzed using appropriate statistical tests.

Results: A statistically significant association was found between SSNHL and age, diabetes, LDL, and HDL levels (p<0.05). However, no significant relationship was observed between SSNHL and sex or place of residence (p>0.05).

Conclusion: The findings indicate that advancing age, diabetes, and abnormal lipid profiles (LDL and HDL) are significantly associated with SSNHL. These results may contribute to planning preventive strategies and health promotion interventions for adult hearing health.

Keywords: Sudden Sensorineural Hearing Loss, Hearing Loss, Diabetes Mellitus, Dyslipidemias, Prevention and Control.

Introduction

Sudden sensorineural hearing loss (SSNHL) is considered a medical emergency and is typically defined as a rapid onset of hearing loss of more than 30 dB in at least three consecutive frequencies within a 72-hour period. In the majority of cases, the underlying cause remains unknown (1–3). Magnetic resonance imaging (MRI) with gadolinium contrast is now regarded as the diagnostic modality of choice for retrocochlear pathologies, offering superior sensitivity and specificity compared to methods such as brainstem auditory evoked potentials (BAEP) (4). MRI studies have demonstrated labyrinthine enhancement in some SSNHL patients, which may correlate with clinical findings (5–7).

Early diagnosis of SSNHL is crucial and should include otoscopic examination to rule out conductive causes, followed by pure tone audiometry to confirm the diagnosis and assess the degree and pattern of hearing loss (8–10). The condition typically presents unilaterally and may be accompanied by tinnitus, aural fullness, and vertigo (11–13). While approximately two-thirds of patients experience spontaneous recovery within the first two weeks (9), the incidence of SSNHL increases with age, ranging from 1.2 per 100,000 in children under 9 years to 77 per 100,000 in individuals over 65 years (14–16). Several etiologies have been proposed for SSNHL, including cochlear microcirculatory disturbances, viral infections, autoimmune diseases, trauma, cardiovascular disorders, and certain medications (17–23). Three viral mechanisms are suggested: direct infection of the cochlea or cochlear nerve, reactivation of

latent virus in the inner ear, and cross-reactivity of systemic antiviral antibodies with inner ear antigens (18). Hyperfibrinogenemia is also considered a potential risk factor for idiopathic SSNHL, possibly by increasing blood viscosity and promoting vascular thrombosis, leading to regional hypoperfusion (24).

While some patients are diagnosed with identifiable causes such as cerebellopontine angle tumors or neurological diseases, the majority remain idiopathic (20, 25, 26). Systemic corticosteroids are currently the most accepted treatment, although other therapeutic approaches—including antivirals, vasodilators, anticoagulants, and anti-inflammatory agents—have shown limited benefit (27). Metabolic syndrome components (e.g., diabetes, hypertension, hyperlipidemia), advanced age, and cardiovascular disease have been frequently cited as associated risk factors (17, 22, 23, 28–30).

Study Objective

Given the clinical importance of SSNHL, its rising prevalence, and the lack of comprehensive national studies, the present study was conducted to assess the prevalence and associated factors of sudden sensorineural hearing loss in audiology clinics across Mazandaran Province during the years 2022–2023.

Materials and Methods

This descriptive cross-sectional study aimed to investigate the prevalence of sudden sensorineural hearing loss (SSNHL) and its associated factors. The study population included all patients diagnosed with SSNHL who visited audiology and otolaryngology clinics in Mazandaran Province between March 2023 and March 2024.

A census sampling method was employed, meaning that all patients who met the inclusion criteria were enrolled in the study. Ultimately, 300 patients were included as the final sample.

Inclusion criteria for participation in the study were as follows: age between 18 and 90 years; provision of informed consent;

adherence to treatment follow-ups and completion of required diagnostic tests; absence of comorbid conditions that could influence the disease process (e.g., cancer); and availability of complete medical records. Exclusion criteria included any case with incomplete medical documentation.

Researchers received ethical approval and began data collection. Collected information included demographic characteristics (age, sex, and place of residence), laboratory findings, and history of underlying conditions such as diabetes and dyslipidemia. A specialist confirmed SSNHL through audiometric testing.

Data were analyzed using SPSS software, version 22. In the descriptive analysis, quantitative variables were reported as mean and standard deviation, while qualitative variables were expressed as frequency and percentage. For inferential statistics, the Chi-square test was used to assess associations between variables. A significance level of $P < 0.05$ was considered statistically significant.

Results

The study included 300 patients who experienced sudden sensorineural hearing loss (SSNHL). Prevalence was highest among 40-59 year-olds (35%), then 20-39 year-olds (30%), those 60 and over (20%), and those under 20 (15%). The study population was 55% male and 45% female. Regarding place of residence, 60% lived in urban areas and 40% in rural areas.

However, no statistically significant association was found between residence and SSNHL ($\chi^2=3.00$, df=1, P=0.083).(Table 1)

A significant association was found between diabetes and SSNHL. Among patients with diabetes, 80 experienced hearing loss, compared to 60 in the non-diabetic group ($\chi^2=11.59$, df=1, P=0.001). (Table 1)

Similarly, a significant relationship was observed between LDL levels and SSNHL. Patients with elevated LDL levels had a higher prevalence of hearing loss compared to those with normal LDL (50 vs. 40 cases; $P < 0.05$). (Table 1)

Furthermore, HDL levels were strongly associated with SSNHL. Among patients with low HDL levels, 50 had hearing loss, compared to 70 in the group with normal or high HDL. This association was statistically significant (χ^2=22.01, df=1, P <0.001). (Table 1)

Table 1. Analyze Statistical Association Between SNHL and Medical Risk Factors

Variable	χ^2	df	p-value	Significant
Residence	3.00	1	0.083	No
Diabetes	11.59	1	0.001	Yes
LDL Level	~3.33*	1	<0.05	Yes
HDL Level	22.01	1	<0.001	Yes

Discussion

The present study investigated the prevalence of sudden sensorineural hearing loss (SSNHL) and its associated factors in audiology clinics in Mazandaran during 2022-2023. The findings revealed that the highest prevalence of SSNHL was observed in the 40-59 age group, while the lowest prevalence was in individuals under 20 years old, indicating the significant impact of aging and related factors on hearing function. This aligns with previous studies reporting an increased risk of SSNHL with advancing age (31).

Findings revealed no statistically significant association between sex and sudden sensorineural hearing loss (SSNHL). This suggests that sex may not be a major independent risk factor in the onset of SSNHL within our study population. One possible explanation is that the pathophysiology of SSNHL is multifactorial and may not be strongly influenced by biological sex alone. This finding aligns with Lien et al. (32), who reported similar results and emphasized that the role of gender in SSNHL remains inconclusive. Their study, along with ours, underscores the need for further investigation using larger, more diverse cohorts to clarify potential sex-related differences.

Significant associations were found between lipid profile factors—specifically low-density lipoprotein (LDL) and high-density lipoprotein (HDL)—and the occurrence of sudden sensorineural hearing loss (SSNHL).

These findings support the results of Chang et al. (33) and Chau et al. (34), who identified dyslipidemia as a contributing risk factor, potentially through vascular and metabolic pathways. Elevated LDL levels may promote atherosclerotic changes in the cochlear microvasculature, leading to impaired blood flow and ischemia, while reduced HDL levels may diminish protective anti-inflammatory effects. The observed associations underscore the relevance of lipid metabolism in SSNHL pathophysiology and suggest that lipid profile screening could be considered in clinical risk assessment.

In contrast to the findings of Yen et al. (35), who reported a higher prevalence of SSNHL among urban women with better socioeconomic status, our study did not reveal a significant association between place of residence and SSNHL incidence. This discrepancy may stem from differences in population demographics, regional healthcare accessibility, or variations in socioeconomic definitions across studies.

A significant association was found between diabetes and SSNHL, aligning with previous research by Tripathi et al. (36) and Umesawa et al. (37), who identified diabetes as a key metabolic risk factor for sudden hearing loss. This relationship may be explained by the microvascular complications and neuropathic effects associated with diabetes, which can impair cochlear blood flow and auditory nerve function. The consistency of this finding across studies reinforces the importance of metabolic health in auditory system integrity and suggests that diabetic patients may benefit from routine hearing assessments.

Overall, while our findings are largely consistent with previous research, differences across studies can be attributed to factors such as sample selection, study settings, sample size, methodology, and confounding factors.

Conclusion

Findings from this study revealed a significant correlation of increasing age, diabetes, lipid profile (HDL and LDL), and sudden sensorineural hearing loss. However,

no significant relationship was found between sex, place of residence, and SSNHL.Considering the influential role of these factors, the findings of this study can inform planning for lifestyle interventions aimed at promoting healthy hearing in adults.

Limitations and Recommendations

The major limitation of the present study was the limited availability of similar regional studies for comparison within our country. To allow for comparative analyses, similar studies should be carried out in various cities and settings. Such studies would provide more comprehensive evidence to guide clinicians and specialists in early diagnosis and timely intervention for SSNHL.

Acknowledgments

Conflicts of Interest

The authors declare no conflict of interest.

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Intelligent Routing Algorithm in the Vision of Futuristic Hospital

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Abstract

Background and Aim: Hospitals serve as vital pillars within the healthcare system, playing a unique and multidimensional role in maintaining and improving community health. Beyond providing treatment, hospitals significantly contribute to education, research, and social welfare. As lifestyle changes drive evolving health needs, hospitals face transformations in how services are delivered. To meet growing public expectations and improve healthcare outcomes, hospitals are increasingly adopting smart technologies and health navigation algorithms.

These intelligent models enable timely, efficient access to services and guide the healthcare system toward a future where hospitals function as smart, integrated centers, ultimately enhancing patient care and the overall effectiveness of health services. Therefore, the present review study aims to examine smart navigation algorithms in the vision of the hospital of the future.

Materials and Methods: This systematic review was conducted according to the PRISMA guidelines. The databases PubMed, Scopus, Web of Science, Google Scholar, SID, Magiran, and IranMedex, Up to Date, Embase ،were searched. And it includes Persian and English articles from 2011 to 2025.

Results: The findings show that intelligent routing algorithms play a key role in reducing waiting times, improving the quality of care, and increasing the efficiency of the health system by optimizing patient guidance and resource management processes.

Conclusion: The conclusion is that the integration of intelligent technologies and routing algorithms into the structure of new and future hospitals can lead to a fundamental transformation in service delivery, so that hospitals, as smart and automated centers, significantly improve the efficiency and effectiveness of the entire health system while enhancing the patient experience. Therefore, the development and implementation of such algorithms is a strategic necessity to achieve smart health goals.

Keywords: Smart Hospital, Futuristic Hospital, Routing Algorithm, Smart Routing.

Introduction

Health centers, clinics, health bases, and hospitals are recognized as the main centers of health service providers and meet the most important health needs of society. These centers play a significant role in improving individuals' health by offering a variety of services such as prevention, diagnosis, treatment, and post-treatment care. Each of these centers is categorized based on their facilities, specialties, and the level of services provided, enabling people to benefit from health and medical services according to their needs. Among the centers providing health and medical services Hospitals are one of the most important centers for providing health and medical services in countries. Hospitals, as vital pillars of the healthcare system, have an unparalleled, multidimensional, and influential role in maintaining and improving community health. The position of hospitals extends beyond merely providing treatment services; their impact also spans education, research, and even social issues, because Over time, with changes in lifestyle, health and medical needs have also evolved. These

changes have caused serious transformations in the method and nature of health service delivery. For example, with the introduction of Health Promoting Hospitals , the health system demonstrated that the concept of a hospital is not just about treating patients. Health Promoting Hospitals is a concept and movement—supported by the World Health Organization —that expands the traditional role of hospitals from merely treating illness to actively promoting health and preventing disease. These hospitals aim to enhance the well-being not only of their patients but also their staff and the broader community in which they operate (1).

Timely access to health and medical services, supported by smart technologies and health navigation algorithms, is crucial for guiding healthcare systems toward the future hospital vision. Major changes in healthcare delivery are expected soon, driven by increased public expectations and technological advancements like AI, the Internet of Things, and digital health. Hospitals play key roles beyond treatment so to optimize healthcare delivery; hospitals must modernize and adopt innovative approaches aligned with regional needs. Their effectiveness relies on quality management, technology upgrades, and evolving therapeutic methods, making them dynamic centers essential for sustaining community health and wellbeing, But what has forced hospitals to change rapidly and adapt to technology is artificial intelligence, which has accelerated the achievement of healthcare system goals.

Nowadays, the use of smart technologies and their application in electronic markets has become widespread across many fields, including finance, commerce, health, tourism, and other sectors.(2) The healthcare system has also prioritized the use of artificial intelligence in the current era. Therefore, all aspects of the use of artificial intelligence and somatization need to be examined and analyzed. Challenges and weaknesses must be carefully examined because hospitals are service centers that are directly related to the health of the community. Although the successful implementation of smart navigation algorithms in hospitals requires

overcoming challenges through infrastructure development, data standardization, workforce training, information security assurance, and fostering a culture of technology acceptance within the healthcare system, these issues do not prevent implementation. This is because rapid and fundamental changes in hospital service delivery are expected in the near future, and ignoring them will lead to losing effective opportunities in healthcare services (3).

The goal of the global "Digital Health" strategy in the "Global Digital Health Strategy 2020-2024" is stated as follows: to promote healthy lives and well-being for all, everywhere, and at every age, so that the realization of national or regional digital health plans and the utilization of their potential must be guided by a strong strategy that provides financial, organizational, human, and technological resources (4-5). Artificial intelligence plays a very important role in the digital health strategy. To achieve a desirable and healthy healthcare approach, all aspects must be carefully examined. The path to achieving goals in the future vision of hospitals is not possible without the use of artificial intelligence and digitalization. Because the medical and health industry is no exception to this rule, and the impact of transformative technologies on longer and healthier lives cannot be denied. The emergence of smart hospitals, smart devices, and surgical robots has brought about a major transformation in patient care and experience (5). So It is expected that the Internet of Things (including all internet-based, digital, and advanced technological applications) will reduce costs in quality-based healthcare services, enhance quality of life, and improve overall performance by enriching the user experience (6).

Although there is still information High costs and economic pressure of medical care, the aging population, increased prevalence of chronic diseases, and shortage of specialized personnel are reasons that indicate that the main trend to address these challenges is moving towards digitalization (5) and The healthcare sector has been reported as one of

the most benefited industries from the applications of IoT technology (7-9).

Ten years ago, the Future Hospital Programme was created following the publication of the Future Hospital Commission report, which made recommendations for providing patients with safe, high-quality, sustainable care that they deserve. There had been growing concerns about the standards of care and it was seen that change needed to occur (10). Changes that have occurred over time have jeopardized the health system, so adopting the use of artificial intelligence in hospitals is necessary and essential to achieve the desired level of health and medical services. This is more important in developing countries and public hospitals because these hospitals have significant referrals and need to update and make themselves more efficient. Public hospitals designed for the past are not changing rapidly enough to meet the needs of the future (11).

Currently, when treatment is concentrated in public hospitals and changes do not occur quickly, there is a need for short-term, medium-term, and long-term plans that have the power to be flexible and transformative. Urban travel, especially in Iran, really needs to equip and modernize the centers that provide health and medical services and hospitals to better meet the needs of the people.

The Iranian health system, like other health systems in the world, is exploring the process of digitalization and somatization. In Iran, there are also projects and initiatives underway to make hospitals smart, Smart and systematic routing helps patients and visitors in hospitals to achieve their health and treatment goals conveniently, quickly and accurately. Smart routing will be considered a health road in the future. Accordingly, the present study has been conducted with the aim of presenting a smart navigation algorithm in the vision of the forward-looking hospital.

Methodology

This systematic review was conducted according to the PRISMA guidelines. The databases PubMed, Scopus, Web of Science, Google Scholar, SID, Magiran, and IranMedex, Up to Date, Embase ،were searched. Keywords were selected according to Table 1 and searched using Boolean operators. And it includes Persian and English articles from Beginning of the year 2011 to 2025. In the initial search, the titles and abstracts of the articles were screened by researcher number one. Relevant articles were selected for full-text review. In the second stage, the content reading of the selected articles was carried out by researcher number two. After extracting the eligible articles, general data, study characteristics, and results were extracted from the articles and summarized in Table two. Data extraction was performed by researchers one and two together. The extracted data was subjected to content analysis. After reviewing and analyzing the extracted articles, the approach of utilizing smart hospitals was identified and extracted. Finally, the results obtained were categorized and presented in the form of this article.

Table NO 1: Search strategy

Variable	Keywords
Smart Hospital	"Smart Health Center*" OR "Smart Medical Center*" OR "Smart Clinic*" OR " Smart Health and Medical Center *" OR "Smart Emergency Room*"
Futuristic Hospital	"New hospital*" OR " future hospital *" OR " AI hospital *"
Routing Algorithm	" Health Algorithm *" OR " Health Routing Algorithm" OR " Routing Algorithm" OR " Network *" OR "Cause*" OR " Optimal Route *"
Smart Routing	"Artificial Intelligence*" OR "Route Optimization*" OR "Spatial Data Analysis*" OR "Automatic Routing*" OR "Smart Routing*" OR "Systematic Routing".

Results

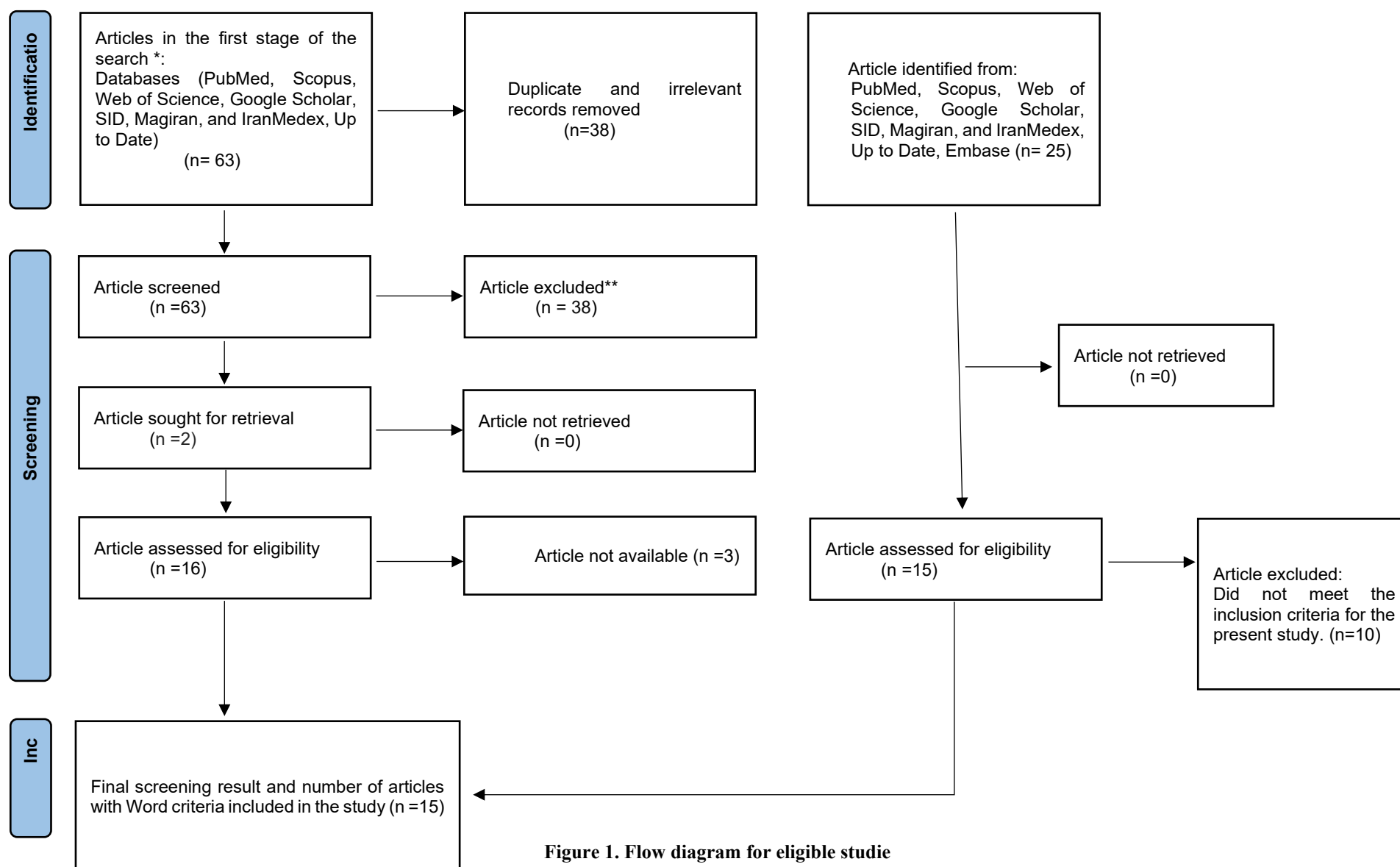The search and screening results were 8 articles, which are mentioned in the table of findings below.

Figure 1. Flow diagram for eligible studie

Table 2: The Eligible Studies Characteristics

Study	Year	Title	Main findings
Jovy-Klein F, et el.(12)	2024	Forecasting the future of smart hospitals: findings from a real-time delphi study	Jovy-Klein and colleagues' study, "Forecasting the future of smart hospitals," concludes that smart hospitals are likely to become a reality within the next 20 years. Advances in artificial intelligence will improve operational efficiency, patient-centered care, sustainability, and collaboration in healthcare. However, overcoming challenges such as staff shortages, ethical issues, and the demand for strong digital skills is crucial. A combination of expert healthcare professionals, clear ethical guidelines, and robust digital competencies is essential to fully achieve the smart hospital vision and meet future healthcare delivery needs.
Pascale F, Achour N.(13)	2024	Envisioning the sustainable and climate resilient hospital of the future	The healthcare system is undergoing transformative changes due to evolving healthcare delivery, patient expectations, emerging technologies, climate change, and sustainability. However, current hospital strategies often fail to consider the interrelationship between the hospital estate and its socio-environmental context. Policymakers, healthcare system leaders, and hospital leaders need a clear vision of the hospital of the future to implement transformational strategies.
Bhagat SV, Kanyal D.(10)	2024	Navigating the Future: The Transformative Impact of Artificial Intelligence on Hospital Management- A Comprehensive Review	Integrating AI in administrative functions, clinical operations, and patient engagement holds significant promise for enhancing efficiency, optimizing resource allocation, and revolutionizing patient care. However, this evolution is accompanied by ethical, legal, and operational considerations that necessitate careful navigation.
Sukin DF, et al.(14)	2024	Building the smart hospital of the future with technology bets	Central to this Houston Methodist, a leading hospital system, is the 'Smart Hospital DNA', a framework that marries technological innovation with collaboration. Within this structure, the institution has incorporated predictive artificial intelligence, integrated ambient intelligence for heightened patient safety, leveraged service robots for diverse operations, and initiated remote monitoring through advanced wearables.
Golpira R, et el.(3)	2023	Prerequisites of Implementing Smart Hospitals in Iran.	Implementing a smart hospital in Iran requires providing infrastructure and technological prerequisites and overcoming existing challenges. Given the current situation, it is suggested that this should be started gradually and with a focus on some specific areas or processes. It is also necessary to carry out detailed strategic planning with the participation of all stakeholders.
Hosseini SH, et al.(15)	2023	Design and Standardization of Smart Hospital Evaluation Checklist	Smart hospitals try to reduce costs and increase the speed and accuracy by creating connection among service provider, care giver and equipment. Due to the lack of related tools for evaluating the level of smartness in hospitals, we presented this checklist.
Mirsaeidi Farahani Sh M, et al.(16)	2021	Providing the Model of Deployment of Smart Services in Iranian Health Sector: A Qualitative Study	Providing the model for deploying smart health care and use of these technologies help to significantly improve the quality of health services, improve access to these services, reduce costs and thus improve health of society.
Hosseinpour M, et al.(17)	2021	Identify and Prioritize Internet of Things Technological Applications on Hospital Quality Management Using a Structural Interpretive Approach	Applications of controlling the vital signs of the patient, caring for patients without the need for the presence of the person on site, checking the inventory of equipment and essentials, tracking and monitoring the performance of staff, patients and inventory, intelligent monitoring and regulation of environmental conditions of patient care and medication, road visits patient turnover in acute and special times, reduction of hospital waste, monitoring of physical activity of the elderly and launching online communities and online medical consulting were identified as the key factors
Mahmoodi S, et al.(18)	2020	Modeling a Smart Hospital Information Architecture Based on Internet of Things and Recommender Agent	Utilizing the IoT in medical processes reduces errors, although the extent of its effectiveness varies at different stages of treating various diseases. Since some disease-specific IoT devices overlap in their functions, and given the limited number of these devices in hospitals, it is recommended that a recommender agent be used to ensure maximum effectiveness. Recommender agents make informed decisions as to how IoT devices can be efficiently allocated to patients at each stage of their treatment.

Table 2: The Eligible Studies Characteristics

Study	Year	Title	Main findings
Jamil F, et al.(19)	2020	Towards a Remote Monitoring of Patient Vital Signs Based on IoT-Based Blockchain Integrity Management Platforms in Smart Hospitals	propose a novel platform for monitoring patient vital signs using smart contracts based on blockchain. The proposed system is designed and developed using hyperledger fabric, which is an enterprise-distributed ledger framework for developing blockchain-based applications. This approach provides several benefits to the patients, such as an extensive, immutable history log, and global access to medical information from anywhere at any time.
Ronaghi MH.(20)	2020	A Conceptual Framework for Smart Hospital towards Industry 4.0	According to research results the main components of smart hospital are eight technologies: Internet of things technology, robotic, blockchain technology, cloud computing, big data, augmented and virtual reality technology, additive manufacturing and artificial intelligence.
Helmy Elhefnawy M.(21)	2020	A Proposed Methodology for Integrated Architectural Design of Smart Hospitals	The research conceived a proposed methodology for the architectural design of smart hospitals and identified mechanisms for utilizing smart materials and systems in developing hospital designs
Fischer G, et al.(22)	2019	Towards evaluating proactive and reactive approaches on reorganizing human resources in IoT-based smart hospitals	ElHealth was simulated on a hospital environment using data from a Brazilian polyclinic, and obtained promising results, decreasing the waiting time by up to 96.4% and 96.73% in reactive and proactive approaches, respectively.
Amidi M, et al.(23)	2014	Intelligent scheduling for emergency room(ER) personnel to improve productivity	Objective of this research is to design an intelligent schedule for ER personnel in order that waiting time is reduced and hospital management constraints are fully considered. First , patient flow in ER is simulated. Secondly, Gentic Algorithm(an Intelligent approach) is applied to solve the multi objective problem. Results show that average and standard deviation of patients waiting time for first visit is reduced by 74% and 53% respectively.
Darvish N, et al.(24)	2011	Modeling and scheduling intelligent method's application in increasing hospitals' efficiency	Research various models can be used as a suitable tool for scheduling and determination staffs optimized number needed in several parts of a hospital which has a vital role. In case that the designed system in the current project is limited to the achieved and collected data from educational center of Booali attached to Tehran Islamic Azad university, it is need to make changes in programming based on data for generalizing it and optimized utilization in other hospitals. So it is recommended to make the prepared program close to the real world for make these systems utilizable in other hospitals and increasing restrictions.

Discussion

Domestic and international research shows that the successful implementation of intelligent routing algorithms will bring about a remarkable transformation in the management of healthcare service centers, productivity, and the quality of services in forward-looking hospitals. However, it should be noted that this field still requires practical research, precise simulations, and field tests to correctly identify and address the specific challenges of healthcare environments. Moreover, paying attention to both human factors and information technology together can ensure the acceptance and sustainable impact of healthcare systems. Continuous interaction among researchers, hospital managers, and IT experts is essential so that routing algorithms are optimized not only technically but also from a usability perspective, thereby creating a smarter and more efficient healthcare environment. This process can significantly contribute to improving the quality of services for patients, reducing hospitals' operational costs, enhancing the satisfaction of patients, their companions, and visitors, and lay the groundwork for a novel, attractive, and effective transformation in the healthcare system.

But why is the routing algorithm important in hospitals?

The intelligent routing algorithm is a computational method that determines the optimal path for transferring data or goods from the source to the destination by analyzing traffic data. These algorithms, by employing artificial intelligence technologies, evolutionary algorithms such as genetic algorithms, ant colony optimization, game theory, and adaptive methods, are capable of simultaneously and intelligently considering multiple factors such as time, cost, traffic, obstacles, and network conditions, and providing the best possible path in real-time (25).

Because hospitals have multiple sources and destinations for providing health and medical services, intelligent routing for accessing services is a critical necessity for patients. Intelligent routing in hospitals means utilizing modern technologies to improve the routing process, traffic management, and enhance the quality of health and medical services. Since hospitals have various sources (patient entries, companions, staff, and equipment) and multiple destinations (inpatient wards, operating rooms, laboratories, emergency departments, etc.), smart management of routing in these centers holds special importance so,

Smart health system, by providing healthcare professionals with real-time access to medical data, these systems can help improve patient outcomes and reduce the risk of medical errors. However, it seems indispensable to ensure that patient data is protected and that healthcare professionals receive proper training in the use of these systems. With these considerations in mind, interactive intelligent health information systems have the potential to revolutionize the way healthcare is delivered, improving the lives of patients around the world (26).

Hospitals, as the most important centers for delivering health services, have been influenced by generational revolutions, and significant advancements have also occurred in hospital management and clinical care (27). As a result, today the concept of a smart hospital is recognized as one of the key foundations in the health revolution and is globally considered an important area in the health sector. Considering the current situation of the country, the establishment of fully smart hospitals in Iran in the short term and all at once is impossible. However, with proper planning and a gradual, phased approach, effective and safe steps can be taken toward a progressive path (18, 20).

The search results have shown that some experts in some fields are against the use of new technology, artificial intelligence, and smartization, and some other experts are in favor of the introduction of new technology in the field of health. For example, Davari (28) in his study mentioned the model of integrating the Internet of Things and smart vehicle routing, as well as Sangeetha (29) et al, Fallah (30) et al, Ma (31) et al, Masmoudi(32) et al, Bahadori-Chinibelagh (33) et al. In this regard, the Amidi M, et al study the data for research was collected from the ED of Show-Chwan Memorial Hospital in Central Taiwan utilizing simulation and a genetic algorithm (GA) that by making appropriate adjustments to the nurses' schedules, the patients' queue time is shortened, thereby raising the quality of patient-care and patient-satisfaction. This shows that health-oriented intelligent routing can be of great help both in transporting patients to the hospital and in providing healthcare services (34).

In this regard, some studies have been conducted on machine learning algorithms and intelligent routing using real-time data (such as hospital status and traffic) to optimize ambulance routing (35). Studies Nahata et al, Indoria, Abdeen et al, Karkar, also point to this issue (36-39). For example, in the study Shaban and Golshannavaz, The conducted study concludes a promising potential of AI-based machine learning algorithms in devising predictive healthcare systems capable of initial diagnosis and preliminary decision makings to be relied upon by the clinician. What is more, the availability of biometric data and the features of the proposed system significantly contributed to primary care assessments (40). Some other studies also point to similar results (41-42).

In the health routing algorithm, some studies refer to automatic routing of hospital service robots (43), while path planning for hospital robots is also approved and used in several studies (44-45).

These sources have introduced and analyzed various methods and algorithms, with an emphasis on optimizing and intelligentizing routing in hospitals and health-related environments. Based on the type of application (health logistics, robotics, EMS, etc.), there are different algorithms and models.

Smart hospitals can influence health and medical policies and create new medical value by defining and quantitatively measuring detailed indicators based on data collected from existing hospitals. Simultaneously, appropriate government incentives, consolidated interdisciplinary research, and active participation by industry are required to foster and facilitate smart hospitals (27).

The above is only a part of the existing findings in the field of routing methods and algorithms in the health field, but the future outlook is very broad and vast, and the hospital environment itself can have many health routes, each of which will have its own separate and specific algorithm.

The future outlook of forward-looking hospitals in providing health and medical services

In the very near future, some of the world's health systems will rapidly rush towards smart hospitals. Smart hospitals provide health and medical services in an organized and systematic framework. The rate of errors in providing health and medical services in these hospitals will be very low. Although nothing can replace human-based health and medical services, in order to optimally deliver services in the present era, a serious reconsideration of the health system is necessary. Intelligent and accurate examinations and history-taking, smart patient monitoring, precise consultation for patients and their companions, data management and electronic archiving, monitoring patient conditions, alerting patients based on disease symptoms, electronic health records, remote patient care, remote visits and consultations, telemedicine, disease follow-up, timely and smart care, creation of digital infrastructures, cybersecurity, etc. are among the approaches of smart hospitals. For the future outlook of smart hospitals, special attention must also be paid to market growth, as the health system is one of the cost-intensive systems and the optimal integration of new technologies greatly helps in achieving the operational goals of the health system. Paying attention to market growth in parallel with the rapid advancement of technology, moving toward patient-centered treatment and home care, distancing from collective and hospital-centered treatment, developing an ecosystem and intersectoral collaboration that enables effective communication between physicians and other health centers are key points on this path (12, 46).

The future outlook of smart hospitals is their transformation into fully digital and intelligent centers that utilize modern technologies to provide high-quality preventive, therapeutic, and managerial care. In the coming decade, smart hospitals will be the focal point of healthcare system transformation, relying on technologies such as artificial intelligence, the Internet of Things (IoT), automation, and communication infrastructures. These centers will not only improve the quality and efficiency of services but also play a decisive role in reducing costs, increasing safety, and enhancing sustainability in the health sector (12). Smart routing algorithms will play a key role in the evolution of hospitals and future service delivery centers. By leveraging advanced technologies such as artificial intelligence, intelligent electronic machines, and an effective and efficient workforce, these algorithms can determine the optimal routes for transferring patients, medical equipment, and personnel within the complex hospital environments.

Conclusion

The health system in developing countries is more important because these countries face serious challenges such as poverty, lack of financial resources, weak infrastructure, educational and gender inequalities in health, infectious diseases, maternal and child health problems, and malnutrition. Poor public health hinders economic growth, and economic development alone cannot improve health indicators. Therefore, the health system in these countries plays a vital role in disease prevention and control, improving maternal and child health, reducing poverty, and supporting sustainable development.

In contrast, developed countries, due to stronger infrastructure and greater financial resources, assign less importance to the health system in terms of basic needs and widespread diseases. Overall, the importance of the health system in developing countries stems from its key role in addressing fundamental and infrastructural health challenges, which form the foundation of their social and economic progress and development

Therefore, developing countries need to adopt modern technology to advance their goals, as technology, in some cases, accelerates the achievement of objectives. One of the modern technologies is the smartification of hospitals. In developing countries, future hospital planning must be based on realistic and attainable goals to improve the quality of healthcare services, increase equitable access to medical care, develop infrastructure, and maintain financial sustainability. Hospitals with a modern and smart technology approach are one of the important goals in the future outlook of these countries.

Smart and technology-driven hospitals can play a very important role in strengthening the health system of developing countries. These types of hospitals, by utilizing technologies such as advanced databases, intelligent resource management systems, the Internet of Things (IoT), artificial intelligence (AI), and telemedicine systems, are capable of improving the quality of healthcare services, increasing the accuracy of diagnosis and treatment, reducing medical errors, and facilitating patients' access to specialized services even in remote areas.

The use of intelligent routing algorithms in forward-looking hospitals not only enhances the level of healthcare services and improves patient experience but also significantly increases operational efficiency and resource management. These technologies constitute an essential infrastructure for smart and forward-looking hospitals and play a vital role in realizing the vision of digital health.

Conflict of Interest
The authors declare no competing interests

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