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A Study about 3D Printing Technology and its Effects on Organ Transplant

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ABSTRACT

Background and Objectives: *Technological advancement is one of the most significant achievements in healthcare, particularly in the twenty-first century, where it has become an integral part of our daily lives; we are more reliant on technology than we were four decades ago. According to recent advancements in healthcare technology, 3D Printing technology has emerged as a valuable tool and resource for doctors involved in organ transplantation. This paper looks into the applications and effects of 3D printing on human organ transplantation.* ***Methods:*** *To conduct the survey and collect data, structured questionnaires were used, as well as random sampling techniques. Secondary data were also used to draw information and compare effects.* ***Results:*** *This study included a total of 84 doctors and other healthcare providers (n=84 respondents). As a result of the research, the mean was 3.15, and the overall level of our study was moderate, with the highest mean being 3.55. The majority of respondents agreed that 3D printing is truly beneficial to human organ transplantation, and comparison with other secondary data validated the statement.* ***Conclusion:*** *3D printing is regarded as one of the most effective techniques for organ transplantation. It has been discovered that using this technology, 3D printing has the potential to reduce and eliminate the risk associated with human organs and give humans a second chance at life.*

Keywords: Health technology, 3D printing in healthcare, Organ transplant by using 3D printing

INTRODUCTION

Technology has evolved dramatically over the last three decades, particularly in the twenty-first century, where it is now an integral part of our daily lives. The healthcare industry has also seen significant advancements in the technological world, but there are still many difficulties and challenges in the healthcare industry because it deals with human life and death. Throughout all of these advancements, 3D technology has emerged as a great technique and useful tool for an organ transplant. 3D bio-printer has gone through many phases and improvements to make it with high quality and high expectations. The 3D printer is considered a form of revolution, and it is still growing and expanding to include other fields and sectors. Simply put, you can use a 3D printer to create toys, guns, and machine parts, as well as advance in more sophisticated technology by entering the medical field and creating medical instruments such as 3D printed retainers, 3D printed bandages, 3D prosthetics, and bio-printing organs. Due to a scarcity of donors and organ transplants, bio-printing is regarded as the most intriguing field. Many countries and organizations around the world are concerned with technological innovation and change, particularly in areas of high priority to them. As we all know, organ transplantation is becoming a major issue in many countries, so advancing and utilizing such technology will lead to the development of your country. In 2013, US President Barack Obama praised 3D bio-printing, saying that it has the potential to change the way everything is made. While quality is an important aspect of any scope, 3D printers reduce manufacturing stages and work on reducing production time, so a product that took two weeks is completed in 48 hours. Three-Dimensional (3D) printing is the process of creating a solid Three-Dimensional (3D) object of virtually any shape from a digital model. A 3D printer is similar to any other printer, except that instead of ink, you can use whatever material you want to create a real 3D object that looks exactly like the original [1]. Bio-printing is all about the biomaterial that appears in liquid form and is converted to solid form after leaving the printer to print the desired shape [2]. There is no single type of 3D printer; instead, there are numerous

variations and types based on the field of use, needs, and materials. To print a 3D object, various materials such as living cells (for human organs), metal, and plastic must be used [3]. Custom-made dentures, hearing aids, surgical and medical models are examples of common 3D printer applications in the medical field [4]. 3D printers can be a useful technology by increasing production, saving patient lives, resolving the issue of organ donor shortages and organ rejection, and allowing doctors to treat a large number of patients in a short period [5]. Organs cannot survive in the absence of accessible environments that provide blood, oxygen, and essential nutrients. 3D printing technology can create comfortable environments for transplanted organs to survive [6].

The impact of 3D printer technology on the health care industry is divided into two categories: positive and negative.

The industries that will benefit are as follows:

- Computer-Assisted Design software companies (CAD)
- Hospitals and insurance companies that saving expenses related to transplant
- Storage and gathering of stem cell companies

The Industries that will be affected negatively are:

- Dialysis centers
- Companies that manufacture pacemakers and heart valves
- Organ-replacement and transportation companies [7]

In the medical field, the 3D printer has a significant impact on organ replacement because they are bio-printed rather than waiting for a suitable donor. As a result, the outcome will be powerfully positive, particularly in terms of quality of life, with real societal implications. Customers who require organ transplants will go to hospitals that have this technology, so health insurance companies that invest in these hospitals will benefit the most [7]. Tissue Engineering and Regenerative Medicine (TERM) are other applications of 3D printing technology that aim to recognize, exchange, reform, rejuvenate, and restore damaged tissues, organs, and cells to treat patients who have suffered serious injuries [6]. Engineering, industry, and medicine have all been touched by 3D printing since its debut. Tissue engineering and regenerative medicine are advancing at a rapid pace, with significant implications for three-dimensional bioprinting (3D bioprinting) of tissues and organs. Artificial tissue and organ bioprinting are both promising applications of 3D bioprinting, which could revolutionize the area of regenerative medicine [8]. In the medical field, the 3D printer has a significant impact on organ replacement because they are bio-printed rather than waiting for a suitable donor. As a result, the outcome will be powerfully positive, particularly in terms of quality of life, with real societal implications.

The Aim of the Study

The study's goal is to investigate how 3D printing technology affects organ transplantation.

Specific Objectives

- To determine if the 3D printing technology is effective in organ transplant
- To identify possible challenges for printing organs
- To assess the acceptance of the 3D printer
- To explore the potential of implementing a 3D Printer in Saudi Arabia

Justification of the Study

To encourage healthcare organizations to use 3D printers in organ transplantation, as we all know that many patients have damaged organs and require transplantation. Because of the scarcity of live organ donors, screening may differ; however, 3D technology will eliminate this issue and assist healthcare providers in making informed decisions.

Literature Review

The research is carried out by searching for articles in the Saudi digital library, PubMed, Google Scholar, and other reliable sources using the keywords "3D printing technology," "new technology in healthcare," "3D printing effect

on the human body," "3D printing technology in organ transplant," "Smart health care," and "machine learning". We obtained approximately 96 research articles. We included original research and excluded articles that were not conducted in English as well as research articles that did not have access. 35 research articles were omitted, leaving 33 articles to be used. 3D printing began in the medical field as a tool for pre-planning complex surgeries, and it has since evolved to be used in prosthetics and hearing aids. With the advancement of technology in recent years, it is now possible to print life organs that can be implanted in the human body [9]. The difficulties of organ transplants include finding organ donors, which becomes more difficult in emergencies due to time constraints, and how to find organ donors who match the patient's body system. In 2009, more than 150,000 patients in the United States were on the organ transplant waiting list. However, only 27,996 patients received transplants, accounting for only 18% of the patients on the original donor list. Many others died of organ failure because they did not receive a transplant [5].

Applications of 3D Printing

- 3D printing technology is now being used to manufacture surgical instruments, which is a good thing because it will lower the cost of instruments while increasing their availability [5]
- In dentistry, it's easy to produce crowns, bridges, orthodontic appliances, and retainers [10]
- Printing pharmaceutical drugs, the first 3D printed drug, Sprintam (levetiracetam, for epilepsy treatment) have obtained U.S. Food and Drug Administration (FDA) approval. Lee Cronin's group also tries to print ibuprofen drugs [10]. The U.S. FDA establish a guideline about 3D printing for medical products [11]
- Facial surgery, in Belgium they did a full-face replacement [12]
- For soldiers, the army decided to scan the soldiers with the 3D printer and archive the data for a later time, so that when one of the soldiers was injured in his limbs or body parts, it's possible to reconstruct it [12]
- Hearing aids, bones, jawbone, and cranial bones, legs, lungs, heart, kidney, pancreas, and skin [12]

The 3D printer reproduces transcriptions that are similar in texture and size to the original organs, which aids physicians in practice and training on complex procedures. It can also be a useful tool for education and training to understand the human body [13].

Benefits of 3D-Printer

- Education purpose [14]
- Perfect training and practice [14]
- Surgical planning [5]
- Provide for surgeon practical advantages of the exact anatomy of the patient before the surgery [5]
- Increase the confidence of the medical team during the difficult procedures in the operation room [15]
- Participate patients and their relevance to achieving better-informed consent on their health [14]
- Improve outcomes and reduce time at operating room [15]
- Decreases the likelihood of transplant rejection [16]
- May remove the need for immunosuppressive drugs after transplant [16]
- Speed of productivity [17]

Challenges

- As we all know the microorganisms tend to survive on non-living surfaces, so it is necessary to keep the printer clean and sterilized continuously to ensure there is no possibility of contamination of materials, especially when using the printer in transplantation [18]
- There are many types of printers and each type has a certain use so before purchasing the 3D printer it is important to know the use and materials you will be needed, otherwise, the institution will be forced to use more than one type [18]

- Technique Challenge-The way of manufacturing and operating the 3D printer [19]
- Unknown costs and return on investment
- The probability of body acceptance when transplanting the printed organ and the response of the body and immunoreaction [19]
- Forming the vascular system, many organs are complex as the heart and kidney, so cells in these organs cannot maintain their function without blood vessels. Therefore, vasculature must be bio-printed to support the cells with oxygen, nutrients, and waste product removal, and so on [20]
- The continuous cell life and there are no harmful biological reactions [8]
- Safety and security, there is a possibility of using the 3D printer for illegal purposes such as printing weapons and can also be used for counterfeiting or commercial fraud in medications, but this does not mean the prohibition of their use, wherefore laws and regulations must be established [17]
- Getting approval from regulators [17]

Steps of Bio-printing

Step 1: Take a biopsy or stem cell from a patient who needs an organ transplant.

Step 2: The cells are stored in a viable medium for reproduction and growth.

Step 3: When enough amounts of cells are produced, they are formed in a spheroid.

Step 4: It is placed in the printer to be a bio-ink [8].

Developing a Functional Organ Requires Three Types of Technology

1. Cell technology, collecting functional cells.
2. Biomanufacturing technology, combining live cells with biomaterials.
3. Technologies for in vivo integration, solve the problem of Biomanufacturing immune acceptance, ensure the safety and health of organs after transplantation [21]

How does 3D Printing Work?

The method of 3D bio-printing organs begins with a large image of the patient organ created by Magnetic Resonance Imaging (MRI) or Computerized Tomography (CT), which is then translated into a digital model of the organ with the characteristics of the original organ by software. The next stage is to obtain material samples from the patient's body to configure the organ. Following that, it's critical to sustain the materials collected from the patient by delivering all components required to keep the cell alive [22].

Types of 3D Printing Technology

The different types of 3D printing technologies are given in Table 1.

Table 1 Types of 3D printing technology [5,23,24]

Type	Mechanism	Advantages	Disadvantages	Example
Fused Deposition Modeling (FDM)	Melting plastic material and set it layer by layer until the object is manufactured	Inexpensive Its material can be changed easily Ease to use	Slow processing Low precision	Kidney liver
Selective Laser Sintering (SLS)	Laser melt powder material layer by layer until forming the object.	Ability to produce a complex and functional object High productivity	Expensive Rough surfaces	Heart Brain

Stereolithography (SLA)	It uses ultraviolet (UV) light to form the object.	Accurate Moderate cost	It needs a supportive structure Prints are prone to slight distortions	Prosthetics
Digital Light Processing (DLP)	Display light in a repetitive way	Good precision Fast processing	Prints are prone to slight distortions It needs a supportive structure	Prosthetics

The Effectiveness of 3D Printing Technology

There is always a need for verification of 3D printing technology's safety and efficiency. Now that the 3D printing technology device has overcome all technical and production obstacles, it must demonstrate its clinical effectiveness [25]. Because 3D printing technology is still in its early stages of development or has just recently been introduced to several medical disciplines, there is a scarcity of research on its efficacy. Based on all medical areas' analyses of the efficiency of 3D printer devices, it has been established that the printer is clinically effective for some organs such as skin and others, but the effectiveness of the printer for a complicated organ is still unknown [26]. The difficulty is how to keep the cells alive during heating and printing, therefore the researchers came up with a good solution: after 3D printing, the cells are incubated in a convenient medium. Some organs, such as the skin, liver, neural tissue, muscle-tendon units, and cartilage, were successfully printed using this solution [27]. A bio-resorbable 3D printed tracheal splint made using microextrusion bio-printing was successfully implanted in a child with severe tracheobronchomalacia by researchers from the University of Michigan in the United States [27].

The below figure shows laboratory-developed organs already implanted into patients. World's first synthetic trachea implanted into a patient using nano-composite material implantation and implantation of first in the human synthetic lacrimal duct (Figure 1) [27].

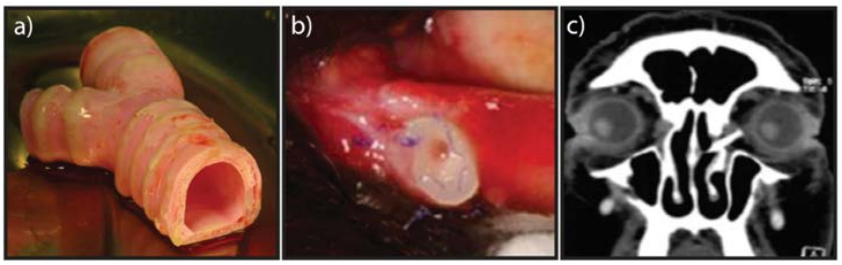

Figure 1 Laboratory-developed organs that have already been transplanted into patients include; (a): the world's first synthetic trachea placed into a patient utilizing nano-composite material [28]; (b, c): the first-in-human synthetic lacrimal duct implantation [29]

After the accomplishment of generating a human ear, researchers began to investigate the viability of 3D printing technology in plastic surgery for aesthetic reasons. After the success of making a human ear, researchers began to investigate the possibility of producing human organs [27]. Because of its extraordinary ability to manufacture complex creations with great accuracy of microscopic pieces and even organs, 3D printing has gotten a lot of interest, especially in the head and neck surgical specialties of maxillofacial, otorhinolaryngology, and plastic surgery [30]. Figure 2 illustrates the example of the bio-printed organ of ear [31].

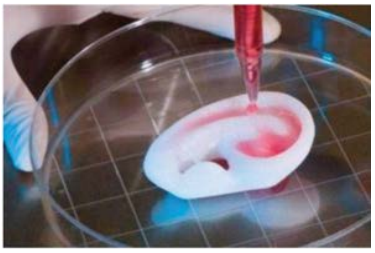

Figure 2 Bioprinted organ (Ear) [31]

Figure 3 shows one of the common stages of 3D printing to develop tissue mimetic devices. CAD (Computer Assisted Design) is used to create a 3D model from a medical image of the target (organ), which is digitally cut and includes ink and printing directions. The tissue mimic is created by the printer [32].

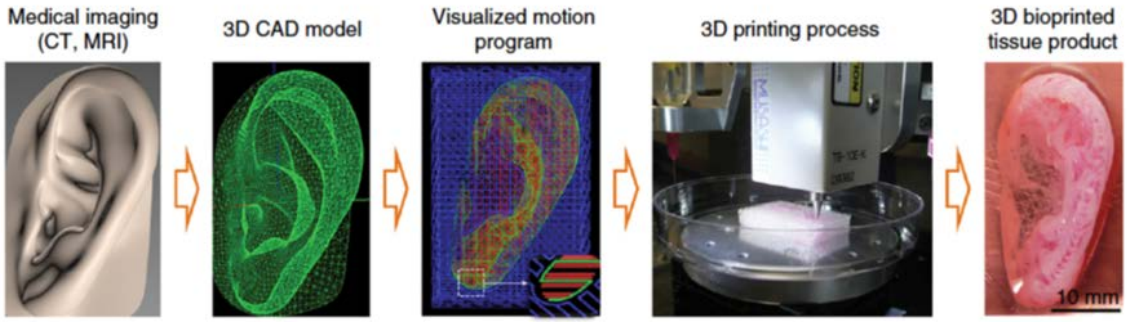

Figure 3 Typical phases of the 3D printing process for tissue-mimetic devices development; a medical picture of the target tissue is used to create a 3D Computer Assisted Design (CAD) model; text-based command lists, including ink parameters and printing directions, are created as digitally sliced pictures. The tissue mimic construct is created using a 3D printer

Figure 4 shows a 3D printed adult heart in a bioreactor providing oxygen, nutrients, mechanical and electrical stimulation, and other factors [22].

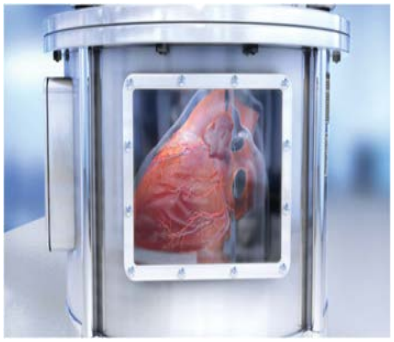

Figure 4 3D bioprint-a viable human heart suitable for transplant [22]

The Cost of Printed Organs

The cost of a printed organ is determined by the type of organ, its complexity, and the printer employed. The tracheal splint will set you back $100, while a prosthetic nose would set you back $40,000. Bio-printing of live cells with biological components will set you back between $280,000 and $300,000. Organ production combined with long-term immunosuppression is a tremendous costly burden on the global healthcare system. [27].

Some Companies that Made the 3d Printer

- **Formlabs:** Offers a variety of services, including dental care. They can 3D scan the patient's mouth and turn it into a 3D software file for printing to capture the features of the teeth. Furthermore, they provide an easy-to-use and quick orthodontic solution [33].
- **Materialize NV:** This company is well-known in the fields of orthopedics and cardiology, as it contributed to the use of a 3D printer in the anatomy of the heart and blood vessels at the King Faisal Specialist Hospital and Research Centre in Saudi Arabia, where it is possible to print an actual 3D model to evaluate treatment options.

King Faisal Specialist Hospital is one of the first institutions in Saudi Arabia to adopt 3D printing technology to treat structural heart disease. Dr. AlJufan realized that 3D-printed models of a patient's anatomy could aid the team in preparing for complex cases with an exact technique, reducing the required time in the operating room, and avoiding errors, particularly in complex interventional procedures.

Not only were we able to implant a unique large-size valve, but we were also able to reduce operation time, decrease recuperation time, and avoid open-heart surgery. Even though it was our first time performing this treatment, we were confident. We now see the need of using this technology in our cardiovascular treatment of structural heart disease. -Dr. Mansour AlJufan, Saudi Arabia's King Faisal Specialist Hospital and Research Centre [34].

- **Cyfuse Biomedical:** This company has been supporting the development of cellular structures made entirely of cells for the regeneration of numerous tissues and organs, such as bone and cartilage, blood vessels, neurons, and the liver [35].
- **Stratasys:** Provides training on customizable realistic anatomical models that mimic human tissue at any location [36].

A Successful Story About Implementing 3D Technology

Koen, a champion windsurfer, had been battling lateral compartment arthritis in his knee for years, preventing him from continuing his active lifestyle. Koen underwent ACL surgery and lateral meniscectomy, but doctors were unable to get him back into the water. Materialize created a 3D model of Koen's leg using CT pictures, allowing the surgeon and Clinical Engineer to construct a specific surgery plan.

The successful teamwork restored full movement and function to Koen's leg, eradicating the pain and discomfort associated with his arthritis. Prof. Dr. Victor is optimistic about the future, believing that complex situations will be treated with greater precision, allowing people like Koen to reclaim their lives (Figure 5) [37].

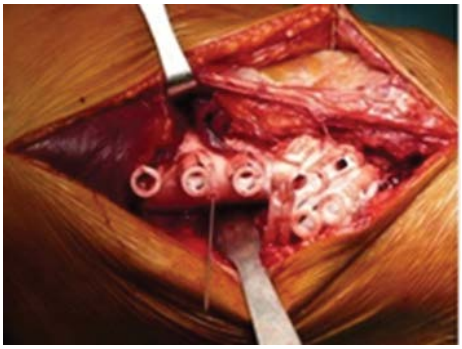

Figure 5 Materialize generated a 3D model of Koen's leg (Image courtesy of Prof. Jan Victor, UZ Gent, Belgium)

METHODOLOGY

Study Area

We used a questionnaire to gather information about the feasibility of using 3D printing technology for organ transplantation and the level of acceptability of this technology at various Saudi Arabian hospitals. We did a descriptive cross-sectional study.

Study Population

Saudi and non-Saudi medical practitioners working in a variety of healthcare industries in Saudi Arabia were included in the study.

Sample Size

We encouraged our healthcare pals to fill out the questionnaire on WhatsApp and forward it to their colleagues. We received 84 randomly selected responses, of which 77 were used and seven were removed since they did not belong to our target population.

Data Collection/Research Instruments

A well-organized questionnaire is distributed to medical practitioners, particularly physicians, using internet software, and feedback is gathered as needed.

Research Design

The research design is presented in Table 2.

Table 2 Research design

Qualitative Approach	Development of Questionnaire Modified of Questionnaire Send it to Health Practitioners Collect the Data Presentation and Analysis
Quantitative Approach	Literature review from published articles and valid website
Instruments	Organized Questionnaire
Data Collection	Online Software (Google Forms)
Method	Online through Google Forms
Sampling Techniques	Random
Analysis of Collected Data	SPSS Software
Interpretation of Results	Conclusive

Ethical Consideration

When we do research, we consider ethical considerations as a necessary component of the process. So we started by gathering data from reliable and approved journals, and then we moved on to distributing a questionnaire to clinical practitioners (participants) while maintaining their privacy and confidentiality. We asked clinical practitioners to engage in our questionnaire; we made it optional, so they could choose whether or not to participate (consent), and we provided our questionnaire with an answer key (anonymous feature). The questionnaire's responses were kept confidential by the research participants, and the information gathered was exclusively used for research purposes. The information is safe and secure against unwanted access. Whether or not we publish our findings, their information will be kept private. Regarding the data collected from the participant, we provide a high level of privacy and confidentiality.

DATA ANALYSIS AND RESULTS

General Data of Respondents

Total (84) questionnaires were distributed to random hospitals and due to incomplete responses, a total=7 were excluded. The public hospital had a response rate of (67%-87%) and the private hospital had a response rate of (9%-11.7%). On the contrary, there were (17%-22.08%) doctors, (11%-14.29%) family doctors, (9%-11.69%) emergency doctors, (8%-10.39%) surgeons, and other professionals. As a result, we may conclude that the majority of respondents (67%-87%) worked in a public hospital, and the remainder (17%-22.08%) worked in medicine. Table 3, Table 4, Figure 6, and Figure 7 below summarize the responses of the respondents.

Table 3 Hospital type; Source-primary data

Hospital type			
		Frequency	**Percent**
Valid	Public	67	87.0
	Private	9	11.7
	None	1	1.3
	Total	77	100.0

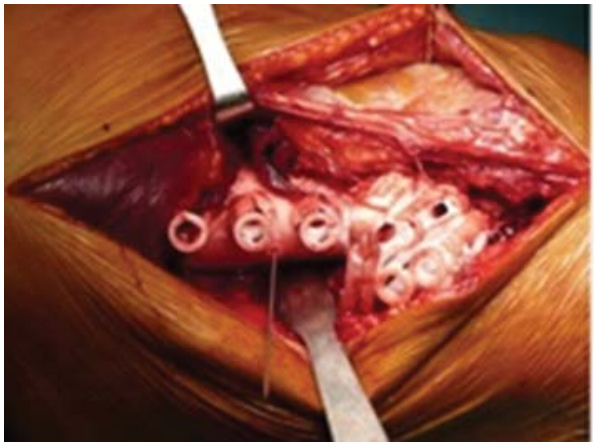

Figure 6 Pictographical representation of hospital type

Table 4 Department respondents, Source- primary data

Department Respondent			
		Frequency	**Percent**
Valid	Surgery	8	10.4
	Medicine	17	22.1
	Emergency medicine	9	11.7
	Family medicine	11	14.3
	OB/GY	5	6.5
	Laboratory	3	3.9
	Pediatric	5	6.5
	ICU	2	2.6
	Pediatric emergency	1	1.3
	Neurosurgery	2	2.6
	Pathology	1	1.3
	Nutritionist	1	1.3
	General practitioner	1	1.3
	Dentistry	1	1.3
	Consultant psychiatric	1	1.3
	Pediatric surgery	1	1.3
	Adult critical care	1	1.3
	Orthodontist	1	1.3
	Plastic surgery	1	1.3
	Radiology	1	1.3
	Nephrologist	1	1.3
	PICU	1	1.3
	None	1	1.3
	Biomedical physics	1	1.3
	Total	77	100.0

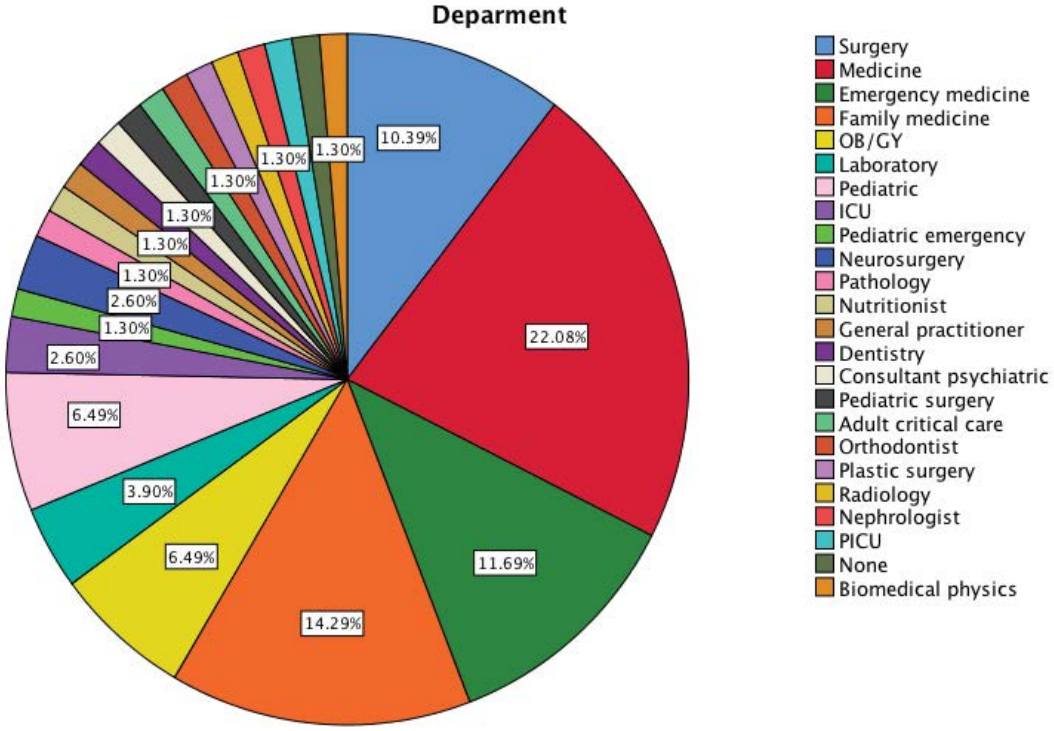

Figure 7 Pictographical representation of department respondent

Table 5 represents the cumulative analysis of all responses and rates. Table 6 represents the Likert scale.

Table 5 Cumulative Analysis of all response & rates, Source-Primary Data

Question	Strongly disagree N (%)	Disagree N (%)	Neutral N (%)	Agree N (%)	Strongly agree N (%)	Mean	Std. Deviation	Level
The 3D printer is effective in organ transplant	2 (2.6%)	3 (3.9%)	30 (39.0%)	35 (45.5%)	7 (9.1%)	3.55	0.82	High
The 3D printer considered a solution for organ transplant	1 (1.3%)	8 (10.4%)	36 (46.8%)	29 (37.7%)	3 (3.9%)	3.32	0.768	Moderate
The printed organ will operate like the original organ	10 (13.0%)	15 (19.5%)	35 (45.5%)	15 (19.5%)	2 (2.6%)	2.79	0.991	Moderate
It's possible for implementing 3D printer in Saudi Arabia at your facilities	10 (13.0%)	20 (26.0%)	22 (28.6%)	22 (28.6%)	3 (3.9%)	2.84	1.101	Moderate
The present of 3D printer will reduce the likelihood of medical errors	5 (6.5%)	13 (16.9%)	31 (40.3%)	23 (29.9%)	5 (6.5%)	3.13	0.991	Moderate
The cost of a 3D printer will be an obstacle for patients	8 (10.4%)	11 (14.3%)	21 (27.3%)	28 (36.4%)	9 (11.7%)	3.25	1.16	Moderate
The population and the patients will accept this new technology	4 (5.2%)	10 (13.0%)	33 (42.9%)	22 (28.6%)	8 (10.4%)	3.26	0.992	Moderate
The cost of the 3D printer will affect the salaries of staff	7 (9.1%)	23 (29.9%)	28 (36.4%)	17 (22.1%)	2 (2.6%)	2.79	0.978	Moderate
The hospitals and physicians will use 3D printers to easy the work	2 (2.6%)	10 (13.0%)	25 (32.5%)	29 (37.7%)	11 (14.3%)	3.48	0.982	High
Weighted mean	3.1573							
Std. Deviation	0.5678							

Table 6 Likert scale, Source- primary data

Description	Difference	Interval	Likert-Scale	Level
Strongly agree	0.8	4.20-5.00	5	High
Agree	0.79	3.40-4.19	4	
Neutral	0.79	2.60-3.39	3	Moderate
Disagree	0.79	1.80-2.59	2	Low
Strongly disagree	0.79	1.00-1.79	1	

Summarization of Open Questions

This question was answered by 77 medical practitioners, 53 of whom were unaware of the technique, 9 of whom believe it is a good technology, and one who believes it is difficult to apply (Table 7).

Other people's thoughts on it can be found in the table below, but there's more.

Table 7 Summary of open question response

S. No.	What is your overall idea related to 3D printing applications and effectiveness?
1	I think it will be a huge step for our country, to use this technology and it will help a lot of people
	It should be implemented in every big governmental hospital since it is not very expensive
2	Prints the organ to be used when there is a lack of donation
3	What we have achieved as humans in this matter is still not enough, so it is too early to think of implementing it, but I hope we reach a point where printing organs and limbs is a choice
4	I think it could be used as superficial for ex. skin or part of an organ but not for the internal whole organ
5	The 3D technology is important for diagnosing the problem and the management plan. Not only for organ transplants
6	3D printing is a newborn technology in the world, and it could play a role in the surgical Management of organs transplants like (bones, tissues, etc..) but not all organs can be printed as natural biological and physiological
7	It will help a lot especially in prenatal detection of congenital anomalies
8	It is going to be used in most healthcare sectors. Medical education, surgery, radiation oncology, prosthetics and orthotics, radiology, dentistry, clinical engineering, machine shops in hospitals, and other clinical fields

DISCUSSION

We sent out a survey to a random group of people to get their thoughts on a variety of topics relating to 3D printing technology. Our research's mean was 3.15, and the study's overall level was moderate; the highest mean was 3.55 for the question "The 3D printer is effective in organ transplant," which explains people's agreement. The mean score for the questions "The printed organ will operate like the original organ" and "The cost of the 3D printer will affect the salaries of staff" was 2.79, which reflects people's lack of enthusiasm.

We focused on our research objectives:

- The potential of implementing a 3D printer in Saudi Arabia
- The acceptance of 3D printer technology

These two topics were chosen to pique the public's interest and to be useful for the growth of other institutions in the healthcare business. The majority of participants agreed or were neutral about the potential of implementing 3D printer technology, which was exactly what we expected because our community has the full capability to implement this technology and the Saudi MOH gives higher priority to the healthcare industry with the potential to serve more patients and save money.

The majority of participants were neutral when it came to the acceptability of 3D printer technology, which was surprising because we expected them to strongly oppose it. As a result of people's reluctance to adopt new technology,

their fear of using it, as well as the complexity of it to the industry, they are concerned about how users will deal with it. C. Lee Ventolas mentioned a previous investigation in his paper [17]. He claims that a 3D printer can manufacture high-quality 3D anatomical replicas that resemble the genuine organ for doctors' training purposes, simulating the operating room atmosphere and allowing them to gain more experience, particularly in intricate surgery operations. As a result, medical errors will be reduced, and professionals will become accustomed to the increased complexity. This experiment provides new insight into the acceptance of 3D printers, as we saw our society can accept this technology if we gradually start using it by using anatomical models to assist physicians in training purposes, as mentioned by Ventolas, then use it in assistance tools for people with disabilities, then use it for aesthetic purposes, and finally use it for dentistry purposes. This will make it easier for the community to accept and use the new technology.

CONCLUSION/RECOMMENDATION

The majority of the findings of our questionnaire were both neutral and agree according to the response from medical practitioners, indicating that the potential of adopting the 3D Printer in Saudi Arabia and its acceptances, as shown by the analysis of the survey data gathered in this research. Participants cannot determine whether the population and patients will accept this new technology based on the study's findings. In terms of future research, we can see that the cost of the 3D printer is very costly, so we recommend that future studies look for other materials that are good and similar in quality but are less expensive. Furthermore, the 3D printer will not be appropriate in every hospital or country until medical practitioners are educated and trained to improve their knowledge and experience in this area. However, they may be able to design capabilities for the 3D printing device to address technological concerns. And, for society to embrace this technology, they could assemble previous trials to check if it is safe and successful, and then educate the public. To reduce the dread of new medical technology by transforming the 3D printer into a source of hope and optimism. And taking a look at the progress of the 3D printer and how it is being used after some preliminary research from simple to complicated applications. One of our suggestions is to enroll it in several health colleges to have a fundamental understanding of it.

Research Limitations

We encountered several challenges during our investigation; the following is a list of them:

- At first, we couldn't find enough articles on our topic, and when we did, they weren't all open to the public
- Bio-printing is still a new technology, so we don't know if it's completely effective or if it has any side effects
- When we switched from a tertiary to a primary study, we planned to hold a focus group with academic doctors from UQU Medical College, but we chose to alter it to a questionnaire since we were concerned that the doctors would be unable to attend due to their busy schedules
- The original plan was to send the questionnaire solely to physicians, but after receiving a few responses, we decided to send it to all medical practitioners
- Limited response

Summary

This study looked into the impact of 3D printing technology on organ transplants. It was a cross-sectional descriptive study with a sample size of 77 respondents and employed a simple random sampling procedure. The findings of this study will motivate public and private hospitals, consultants, doctors, and medical practitioners to learn more about 3D printing (Bio-printing) technology and begin working on applying it to improve the quality, safety, and eliminate the need for organ transplantation. The purpose of this study is to determine the impact and significance of 3D printer (Bio-printing) technology in developing and improving the quality and effectiveness of healthcare in Saudi Arabia, as well as the acceptance of this technology among health care practitioners, by providing them with a questionnaire. One of the specific questions asked was if they thought of the 3D printer as a solution for organ transplantation. According to the responses, 1.3 percent of medical practitioners strongly disagree, 10.4% disagree, 46.8% are neutral, 37.7% agree, and 3.9 percent strongly agree. As a result, based on information collected from them, the vast majority of people are undecided on this issue. A questionnaire was utilized as the research tool to examine the usefulness of a 3D printer in a variety of areas related to organ transplantation. In this descriptive study, frequency distribution, percentage, and data analysis were utilized to present the data and draw conclusions. SPSS was used to conduct the

statistical analysis. Our research investigates the 3D printer (Bio-printing) technology and how it benefits hospitals and healthcare practitioners to comprehend the significance of its application.

DECLARATIONS

Conflicts of Interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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