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The Role of Robots in Smart Health Care System: A Review

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Abstract - *In recent years, advanced robots has the potential to enhance healthcare with recent advancements in many modern technologies. This provides insights into cutting-edge research in the fields of care, hospital management, nursing robots, rehabilitation robots, and others, with modern technologies in great detail. Nowadays, robots in pharmaceuticals offers assistance by soothing doctors and medical staff from schedule errands, taking their time away from more pressing obligations, and making therapeutic methods more secure and less expensive for patients. The main focus of introducing robots in healthcare is that they can perform precise tasks and take care of patients, specifically the old age population. Many of the review papers available today lack the contextualization of active research projects on healthcare robots. After reviewing several successful research papers on the robot's development, we aimed to highlight the various aspects of robots in the healthcare system. This review paper highlights the various aspects of a healthcare robot and its ability to solve healthcare system challenges. We present a comprehensive contextualization of robots in healthcare by recognizing and characterizing active research projects on healthcare robots that can work effectively with medical services. We found out that healthcare robots are set to have a bright future. Currently, the most common applications of robots in practice are in aging and assisted living, where companion robots are employed to alleviate symptoms and improve patient quality of life and outcomes. Although there are few examples of healthcare robots in the literature, the opportunity for this type of robot will grow in the following decades as more tech-savvy people attend aged care institutions.*

Key Words: **Smart Healthcare, Modern Technology Robotics, Assistant Robot, Companion robot, Rehabilitation robot**

1. INTRODUCTION

Well-being care or healthcare is the support or change of well-being by means of the anticipation, determination, treatment, recuperation, or remedy of malady, sickness, harm, and other physical and mental disabilities in an individual. Healthcare is conveyed by well-being experts and partnered by well-being areas. Incorporates work wiped out giving essential care, auxiliary care, and tertiary care. Getting towards healthcare may change over nations, communities, and people, affected by social and financial conditions as well as well-being arrangements. In common, individuals who work in this division have hearts to serve others and mental interface in math and science. Since healthcare is one of the foremost delicate businesses that's specifically associated with us in nearly all conceivable ways, sincerely, physically, rationally, and fiscally, the effect of the modern economy and innovation in healthcare requires prompt consideration to address the challenge they bring.

Numerous industry bunches have anticipated a deficiency of around 100,000 specialists by 2030. Here, innovation can offer assistance in numerous ways, such as utilization of tele-health can enormously offer assistance. Live streaming, store-and-forward imaging, inaccessible quiet diagnostics can progress to get to healthcare indeed in inaccessible districts. Robotics is the crossing point of science, building, and innovation that produces machines, called robots, that substitute for (or imitate) human activities. A robot is the output of the mechanical autonomy field, where programmable machines are built that can help people or mirror human activities. Robots were initially built to handle dull tasks but have since extended well past their beginning employments to perform assignments like battling fires, cleaning homes, and helping with complex things.

In the last few years, the sector has witnessed huge growth in healthcare robots to be used for well-being and health improvement. We have come across a lot, whether it be the first surgical robot or the robots that imply artificial intelligence and machine learning. There are robots to mainly monitor vital signs that can detect illness and long-term monitoring of the patients. Also, some robots address all the safety measures of medication management, and these robots are mainly used for elderly people. There are also certain assistant robots for elderly people which help them in an indoor and outdoor environment. Hence the robots have a significant impact on the healthcare sector. Many of the review papers available today lack the contextualization of active research projects on healthcare robots [1-4]. So we aimed to highlight the various aspects of a healthcare robot after reviewing several successful research papers on the healthcare system. We present a comprehensive contextualization of robots in healthcare by recognizing and characterizing active research projects on healthcare robots that can work effectively with people.

In this paper, section 2 briefly summarizes the literature study of 24 research papers, followed by a brief discussion in section 3. The paper concludes in section 4.

2. LITERATURE REVIEW

With the use of new technologies, many researchers have worked on designing and developing advanced healthcare robots. These robots use technologies like Artificial intelligence, Internet of things, Computer vision, and many more. In this section, we have cited the details of various healthcare robots developed comprehensively and highlighted the main features of this developed healthcare robot.

Healthcare robots can perform several different features in the hospital environment. Hossain et al. [5] have presented an assistant robot named ADIO, which helps to reduce the person-to-person contact and see towards the cleanliness. Further, the robot can provide medication, automatic sanitization and check basic parameters like temperature, pulse rate, and oxygen saturation level through an android app to maintain the database. Different machine learning and AI techniques were used for the implementation of the system. To monitor patients' health, Huang et al. [6] have presented their work on a health examination robot to check height, blood pressure, cholesterol level, body weight, oxygen level, glucose level, ECG, and energy consumption. Then this data is transferred to the central control systems, for investigation and printing. Similarly, Kuo et al. [7] have presented the robot, which is mainly used to monitor vital signs. It can detect illness and alert if there is some emergency and long-term monitoring via data and event logging. The main aim was to make a robot that can operate in human presence and serve the people with vital sign monitoring facilities in the hospitals. It can also be used in aged care centres and for personal care. The main objective of this project is to combine all the medical parameters like monitoring of vital signs, such as SPO2, body temperature, BP, pulse rate, and galvanic skin response. Moreover, the second is to make a friendly environment and have two-way communication with the user. Many times doctors need to be very precise while performing any surgery. To help doctors, Lee et al. [8] have presented a robot with 3 degrees of freedom, used as a laparoscopic assistant. It is controlled by the motor and can zoom in and out using voice commands followed by automatic tracking. The main motto of this device is to maintain safety and adaptability. This can be easily attached to the side of the bed, and with the help of the laparoscopic holder, it can easily be operated. This is very handy and easy to use.

Further, healthcare workers need to keep maintaining data of various health parameters during patient care. Tasaki et al. [9] have developed the latest type of robot that accompanies the healthcare experts making therapeutic rounds in patients' rooms at hospitals. This robot mainly executes two assignments: carrying out all the methods and techniques required as a practitioner and storing all the healthcare-related data on the rounds. It contains omni-directional portable wheels and a human tracking control framework which is used as an assistant to medical professionals. With the help of the camera and recorder, all the health-related data is being automatically recorded. The main feature that makes this robot unique is communicating with humans and changing facial expressions. Not only this, Datta et al. [10] have presented the portable healthcare robot for medication management framework. It is based on an investigation of the medication management prepared in an elderly care facility. The main objective of this project was to make a robot that can interact easily and the software tools used to decrease the death rate and side effects caused by the treatment. These software tools are used to collect all the valuable data related to medication and reactions to the side effects. The development of a robotic system for healthcare that can modify itself according to the requirement was presented by Ahn et al. [11]. This proposed model can be divided into three systems: - a receptionist robot (ReceptionBot), a caretaker assistant robot (CareBot), and a medical server (RoboGen). The function of this robot is to help the human receptionist and the nurse to perform the required task. The healthcare robots transfer and download patient data through the medical server and give information outlines to human care providers through a web interface. So this methodology works in the following ways as the ReceptionBot first assists the patient, and this data is passed on to CareBot, and CareBot measures all the vital signs and gives this data to RoboGen. The proposed framework is also planned for multi-robot frameworks, so they will add more robots that will evaluate it in the future.

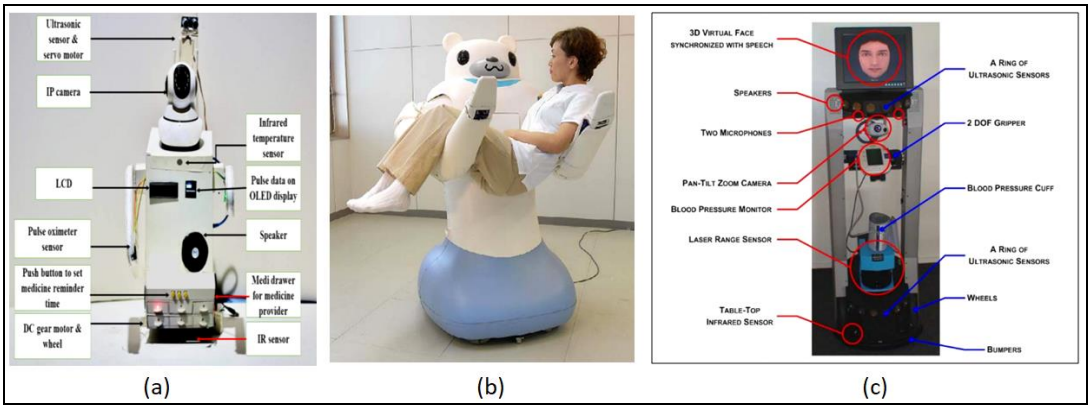

Fig -1: Healthcare robots (a) [5], (b) [14], and (c) [7]

Due to some unrecovered medical conditions, patients need assistance to perform particular tasks in their daily life. To solve such a problem, Sharkey et al. [12] have presented the development of the Paro seal robot, which is basically a baby harp seal-shaped robot. It is used for people who have the disorder to lose memory. This robot has different emotions and features as it cries and responds to the people by stroking. So, the objective is that to prevent close contact. The risk of using this robot is that some people get too involved and can get into artifice then this reduces the person's dignity. Hirose et al. [13] have presented the development of a robot that gives a hair washing facility for the patients with the help of scrubbing fingers. This robot helps wash hair in clinics and facilitates the burden of healthcare experts and care workers. It highlights the mechanical and control innovations required for touching somebody tenderly on the head. This incorporates the self-aligning instrument, which is around and hollow rack component of the robot's end-effector. It has a parallel-connected component with a squeezing arm and compliance control suitable for giving the required weight. This is the world's first hair washing robot with all the flexible facilities as described above. Similarly, to reduce the burden of healthcare workers, Mukai et al. [14] have presented the development of the nursing robot RIBA, which can lift the patient from the bed to the wheelchair and vice versa. To perform this operation smoothly in the environment, coordination between the caretaker and the robot is necessary. It is the responsibility of the caretaker to monitor the environment and keep track of all the actions when the robot is performing physical tasks. This paper has given RIBA's plan concept, its fundamental determinations, and the tactile guidance strategy. It is the first robot that uses a human-type arm concept to lift patients.

Taking medicine for a speedy and timely recovery is very important. Punetha et al. [15] have presented the design and manufacturing of a line following robot that can carry medicine to patients whenever required. It uses an electronic system that can detect and follow the line which is drawn on the floor. The sensors used in this robot are a light-dependent resistor, IR sensor, and proximity sensor. The IR sensor is used as a switch that acts as an interaction between the patient and robot. So, when the patient presses the switch, the robot follows the line and gives the required medicines. The proximity sensor is used for obstacle avoidance. This can be used as a substitute for expensive machinery in health care which is helpful and capable of handling more patients at a time and with minimum cost. Further, Hu et al. [16] have worked on the mobile robotic nurse assistant (RoNA), which is highly desired to upgrade the productivity and quality of care that the medical caretakers and their paraprofessional staff can give. Such a collaborator seems to move forward in a nurse's working conditions by off-loading a few of his or her most physically demanding duties. This subsequently diminishes the potential for self-injury or damage to the patient. Moreover, to make robots real like human beings, Igic et al. [17] have worked on the robot, which is used to communicate with the non-experts by using speech and creates the ability to express vocally. This robot has different emotions and can also speak in different accents with the help of a flexible speech synthesis system. It can also change the voice's nationality, which depends on the person who interacts with this robot.

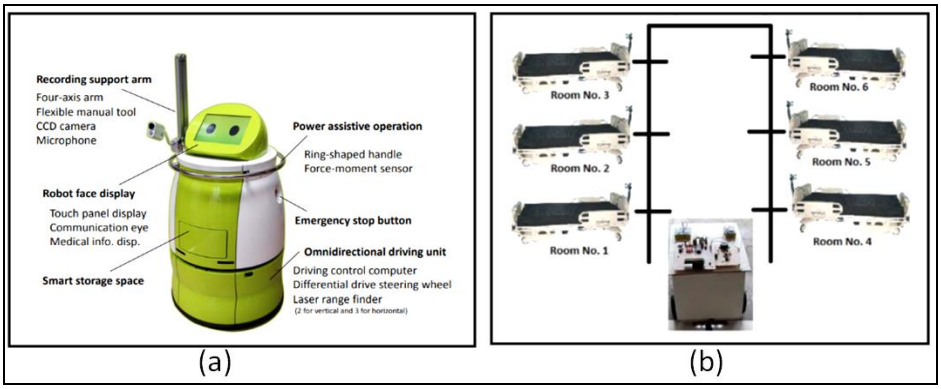

Fig -2: Healthcare robots (a) [9], and (b) [15]

The development of companion robots for lonely elderly people is a need of time. Vasavi et al. [18] have developed a robot named Mitthar, which acts as a partner for elderly people. It can be helpful for the following application: communication that empowers the elderly individual to be in touch with his family, friends, or care experts. This robot takes all the safety measures in case if the individual fails to take medicines, then it gives an emergency notification. It also keeps track of their daily routine and sets a timetable accordingly, also used for entertainment to freshen up their mood by playing their favourite media, which creates a healthy atmosphere. This robot's unique selling point highlights a versatile companion robot with that of a stationary "smart home" feature. This robot can move automatically as commanded by the user. The main goal of this robot is that it acts as a companion for the elderly and takes care of their daily needs. Similarly, Pollack et al. [19] have presented the development of the robot named Pearl. This robot has two essential features; one is that it helps older people follow their daily routine like taking medicines, drinking water, bathing, and eating. The other main feature is that it will guide them to move freely in the environment. It offers a brief outline of the hardware platform and portrays the major computer program frameworks that enable the robot to perform these two operations. The main objective was to create a mobile robotic assistant

for the elderly individuals living in their homes, particularly those with gentle cognitive disabilities. So, this robot was helpful for older people to keep track of their daily activities and their environment. Datta et al. [20] have developed a robot named RoboGen, which guides older people when there is a reaction or side effects of the medicines. It collects the entire patient's data, interacts appropriately with the patient, and then analyses any medical issue due to the treatment given. After analysing this, it also gives an alternative to the treatment. Overall, this robot provides a cost-effective treatment by reducing adverse drug reactions. Further, a robot whose primary purpose is to interact friendly with the elders was presented by Jayawardena et al. [21]. The robot was implemented in a retried village where the older people were living independently in their apartments. The robot interacted with the people by synthesized speech and with the touch screen. This robot provided various services like gestures, checking body temperature, blood pressure, serving medicines scheduling diet, and guiding the environment, and this data was collected for further monitoring. The result was that it is entirely feasible to keep the robot in such a retirement village so that it helps the older to live their life independently.

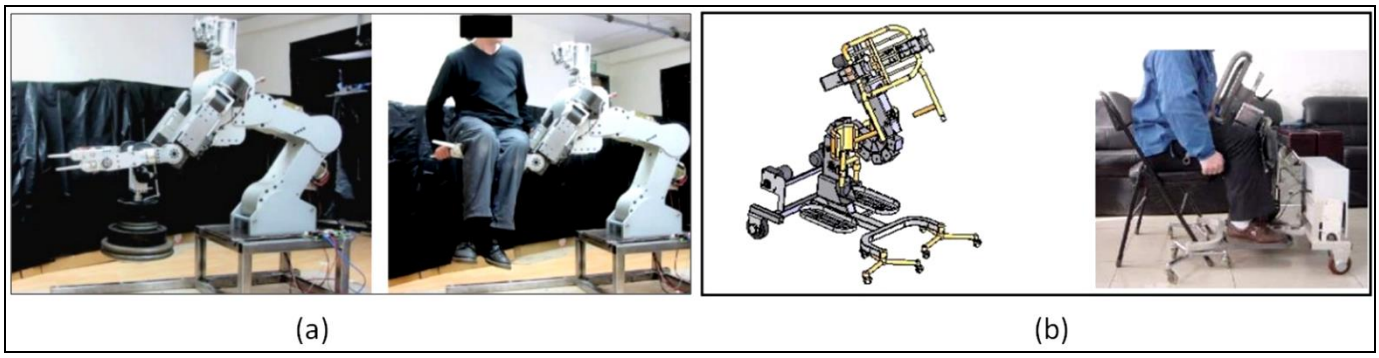

Fig -3: Rehabilitation robots (a) [16], and (b) [23]

The development of rehabilitation robotics has given new hopes to many people. It helps people achieve their lost physical movements with the use of advanced mechanisms and machine intelligence. Lenzi et al. [22] have presented a mechanical robot knee prosthesis design, development, and testing, which helps perform activities like walking, climbing stairs, and jogging. This prosthesis uses a spring-damper mechanism and an electric motor. It also uses a transmission system that can be locked into and supplies a stair ambulation capability. This hybrid knee prosthesis weighs 1.7kg, including all the components' weights, and provides a repetitive torque of 125N-m. Execution of the proposed hybrid knee prosthesis illustrates the potential for a critical weight lessening compared to entirely powered prostheses that control all ambulation exercises. To the most excellent of our information, the hybrid knee is the lightest fueled knee prosthesis that has been created and can give physiological torque and controls over stair ambulation. The development of an assistant robot with standing-up devices was presented by Xiong et al. [23]. The system helps paralyzed people who have difficulty standing and sitting. It can also carry the patient and move them from one place to another. The design and prototype were made by using SolidWorks design software. Then with the help of a neural network algorithm, the speed and path control were accessed. This robot also helps the person do small exercises that are beneficial or provide ease to sit and stand. So, this feature helps them to reduce their diseases and help them to live long. Further, Shim et al. [24] have developed the Silbo robot, a walking assistant robot for the elderly. The robot was developed with the shared control strategy. The architecture of a walking robot can be used for both indoor and outdoor environments. The application of this robot is that it has a handle that can be pulled and pushed. So, when the handle is pushed forward, the robot will move in the forward direction, and when the handle is pulled, the robot moves in the backward direction. There is also an option for rotation, i.e., if the handle is rotated, the robot can turn accordingly. This robot initiates power assistance and creates a collision-free operation by the system architecture implemented in it.

3. DISCUSSION

The goal of this review paper was to evaluate current robotics trends in healthcare literature. We found almost 80 research papers on healthcare robots. Many of the papers we found in the early phases of our search method mentioned robots in clinical care settings, but they were not research papers. These papers provided overviews of robotic technology and its application in the field of healthcare. From those 80 papers, we sorted out 24 research papers that were relevant and which focused more in the development of healthcare system. Information regarding how this topic has been transmitted throughout the field and other fields were examined using descriptive studies. While there is a scarcity of research on this subject, this review paper on healthcare robots includes descriptions of robot usage in patient care settings.

In table 1, the papers are arranged in the order of development in recent years to the development in older years. In recent years, the robots developed were used for the applications like sanitization of hospitals, monitoring the health parameters of the patients, hospital management, performing regular hospital tasks, assisting the doctors and medical staff. Furthermore, the assistant's robots and companion robots were developed, which were very useful for taking care of the elderly for remote health monitoring, reminding them to take medicines, washing hair, helps for walking, and performing daily routine tasks.

Study shows that assistant's robots and companion robots are beneficial to accompany them and were also used for entertainment if they feel insecure and lonely. Nevertheless, the performance of these robotics systems are examined multiple times to make them user-friendly, safe and then are used for the medical applications such as a helping hand in the health care system. Now a days, modern technologies are the innovation that's changing each walk of life. Technology like robotics is modifying the world and solving critical questions for society, economy, and administration.

Table -1: Healthcare robot applications

Ref.	Year	Application
[5]	2020	Helps for sanitization of hospital and monitors health parameters.
[22]	2018	Knee prosthesis, which helps in walking, running, and many more.
[18]	2017	Companion robot for elderly to perform daily activities
[9]	2015	Helps hospital assistants for routine checkups.
[11]	2015	Modifies itself as a caretaker robot and receptionist robot.
[6]	2014	Monitoring health parameters.
[12]	2014	Emotion-changing robot for the disorder to lose memory.
[15]	2013	Line following robot to carry medicine.
[13]	2012	It is a hair washing robot assistant.
[20]	2012	Guide elderly to take medicine and also provides the treatment.
[10]	2011	Medication management and easy interaction with elderly
[16]	2011	Works as a nurse to perform regular tasks.
[14]	2010	Lifts patients from bed to wheelchair and vice versa.
[21]	2010	Interact friendly with the elderly and check body parameters.
[17]	2009	Interacts with people in different languages with various expressions.
[7]	2008	Monitoring health parameters.
[23]	2007	Helping assistant for paralysed people.
[24]	2006	Walking assistant for elderly.
[8]	2003	Laparoscopic assistant for doctors.
[19]	2002	It helps the elderly to perform daily routine tasks.

4. CONCLUSIONS

Modern technologies are very effective in the development of healthcare robots. Healthcare robots are set to have a bright future. Currently, the most common applications of robots in practice are in aging and assisted care living, where companion robots are employed to alleviate symptoms and improve patient quality of life. Although there are few examples of healthcare robots in the literature, the opportunity for this type of robot will grow in the following decades as more tech-savvy people attend aged care institutions.

Researchers and engineers must examine clinical regions' needs and design robots to satisfy those needs. Engineering ideas must be grasped to encourage robotics in personal care and assist patients in selecting the most appropriate type of healthcare technology. As more healthcare robots are used in clinical settings, improvements will drive further advancements in nursing robot technology, eventually improving nursing care efficiency, quality, and perception. In the future, with this study, we aimed to study various biomedical sensors, controllers, and actuators in detail.

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