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Robots in Medicine

A future member of the healthcare team?

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Optimus Prime, R2D2, and Wall-E, are examples of how we envision future robots. Though it is difficult to distinguish robots from other machines, robots can be defined as machines that are capable of performing a variety of tasks with a degree of autonomy from humans. In this article we will focus primarily on service robots: robots which perform services for human well-being and are found outside of manufacturing operations.¹ The innate qualities of robots—their tirelessness, physical robustness, and immunity to emotional stress—may make them a promising addition to healthcare teams. We will explore contemporary examples of how service robots are being used in healthcare and the potential role of these robots as members of the interdisciplinary healthcare team.

The push towards having robots assist future healthcare workers is arguably driven in part by the projected demographics of industrialized countries. A handful of countries such as Germany and Japan are facing aging populations: It is expected that by the year 2060, 40% of Japan's population and 34% of Germany's population will be over 65.^{2,3} Furthermore by the year 2060 it is estimated that the ratio of nurses to patients in Germany will change from 1:9 to 1:174. The need to ease the workload faced by future nurses has fuelled the development of robots to principally assist nurses in physically and emotionally demanding tasks.⁴

The robotic nurse assistant (RoNA) prototype designed by Hstar technologies was created to eliminate the repeated strain nurses experience in lifting and transporting patients.⁵ Although RoNa moves on a set of wheels, the upper portion of the robot appears humanoid, with large bent padded arms that can be used to lift and transfer individuals from a bed to a stretcher.⁵ Boasting the ability to carry and transport patients weighing up to three hundred pounds, RoNa shows promise to decrease the injuries suffered by nursing staff and patients resulting from lifting accidents.⁵

Service robots may also be assigned repetitive tasks, such as dispensing and distributing medication. In a case study by Beard and Smith, the installation of a medication dispensing machine was found to reduce the time hospital staff needed to spend in the dispensary and significantly reduce dispensing error.⁶ If robots were able to autonomously dispense and distribute medication to patients, it would reduce the workload of nursing staff and pharmacists. Having an entirely automated medication handling system would potentially allow pharmacists to focus purely on their roles as consultants and patient educators.

Even more intriguing than the use of service robots as nursing aids or medication dispensaries, is their use as patient companions. Paro is a companionship robot designed by Intelligent Systems Research Institute that mimics the appearance of a baby harp seal and is primarily used in patients with dementia.⁷ Despite the robot's light-hearted appearance, Paro uses sophisticated machinery which allows it to sense sight, sound, balance, and touch.⁷ Paro responds to the touch and actions of patients by blinking, moving its tail, and making affec-

tionate noises.⁸ Though further studies are needed to explore the possible long term effects of using Paro on the disease process in patients with dementia, studies have found that Paro can improve the mood of patients and facilitate social interaction.⁸ Unlike most caretakers, Paro has infinite patience, unlimited time to give, and is non-judgmental. In addition, companion robots like Paro may prevent caretakers from developing compassion fatigue by bringing about positive responses in patients that might otherwise seem unreachable.

It should be emphasized that although Paro can elicit genuine human emotions from patients—it is by no means a substitute for human interaction. Psychologist Sherry Tuckle points out that Paro may fulfil a patient's desire to tell stories and have conversations with it, however it cannot reciprocate the care it receives.⁹ She also notes that if a person constantly interacts with robots rather than humans, they will become accustomed to the limited range of responses to emotions that robots have to offer.⁹ Ethicist Christopher Calo puts Paro's true designed function quite eloquently writing, "Paro's purpose is to grease the gears of social interaction."⁹

If the capacity of robots increases, they may one day have a future role in diagnosis and screening. In the book *Complications*, Atul Gawande described a study by Edenbrandt et al. involving an EKG "competition" between a computer and an experienced cardiologist.¹⁰ The computer made 20% more accurate diagnoses of myocardial infarction since the machine was less likely to be biased by previous diagnoses, or past experiences. With increasing technological advancements, it is not unrealistic to presume that the robot will eventually become a valuable diagnostic tool. At the same time, the clinical experiences, and the gestalt, that every seasoned physician rely on to see the patient beyond numbers and statistics, will be invaluable to make the final treatment decisions and work together with patients to achieve their treatment goals.

We have already discussed some contemporary examples of healthcare service robots and their potential future role as members of the interdisciplinary healthcare team. However, if these robots eventually become fully-fledged members of the healthcare team, the issue of their appearance is certainly significant. Japanese roboticist Masahiro Mori proposed a much cited theory, the "uncanny hypothesis," proposing that our affection for our robots increases the more human-like they are. However, our affection soon turns to disgust as soon as the robot becomes almost realistic, such as in the case of a corpse-like or prosthetic-like robot. Then, as the appearance of the robot becomes more human-like, there is a sharp rise in our affection, approaching human-to-human empathy levels (Figure 1).¹¹ In short, the ideal health care robot in the future would either look like robots, or completely life-like to the point that we may mistake them for a person on first glance.

Despite the many potential benefits of incorporating robots into the healthcare team, there are also several notable limitations and

INTERDISCIPLINARY

Figure 1. A depiction of the 'Uncanny Valley'

barriers. In the realm of companionship robots, current research challenges include programming personality, empathy, interpretation of patient's physiological signals, and behaviour adaptation into the robot's social functions. Research into these areas is currently in its infancy.¹² Moreover, while many studies report positive effects of companionship robots in elderly care, the scientific value of the evidence is limited due to low methodological quality.¹³ It is also important to note that even if companionship robots are eventually programmed to display empathy, the depth of the bond between humans may be impossible to reach. Additionally, while many people believe that technology such as robotics will improve health care quality, safety, and efficiency, fewer people stop to consider that they can also introduce errors and adverse events. In *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*, the authors recognize four common reasons why the benefits of new technology may not be realized: "(1) poor technology design that does not adhere to human factors and ergonomic principles, (2) poor technology interface with the patient or environment, (3) inadequate plan for implementing a new technology into practice, and (4) inadequate maintenance plan."¹⁴ Certainly, there may be many unforeseen circumstances where robots may cause harm to patients. More studies need to be conducted with every new application of robotics in medicine. Another issue is the potential for robots to cause lost jobs. It is unknown whether robots will eventually replace healthcare workers in order to lower personnel costs or only function in an assistive capacity.

The strengths of many contemporary healthcare robots, such as *Paro* and *RoNa*, are geared towards aiding patients with limited mobility or declining mental function. This seems highly appropriate in the face of the aging populations in many developed countries. However, we have yet to tap into the capacity for logic that robots can be programmed to have. In the future, robots may be more actively involved in the distribution and dispensing of medication, patient screening, and diagnoses. At the same time, advancements in the function and appearance of robots should be done in a way that mitigates any initial uneasiness that patients may feel while interacting with a robot. From the examples cited thus far, robots have proven useful when it comes to lessening demands on healthcare staff and increasing the quality of life of patients. Robots will likely continue to modify the roles of various healthcare professionals within the interdisciplinary healthcare team,

especially as our interactions with robots become increasingly sophisticated. Eventually, they may become fully-fledged members of the healthcare team. Nevertheless, in spite of the enthusiasm surrounding robotics in medicine, caution should always be exercised. The benefits and potential pitfalls of robotics usage need to be further explored.

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