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Intelligent Physical Robots Adoption in Hospitals: A Technology-Organization-Environment View

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Short Research Paper

Intelligent Physical Robots Adoption in Hospitals: A Technology-Organization-Environment View

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Abstract: Recently intelligent physical robots have received considerable attention of practitioners and academics in the healthcare field. Although studies have investigated the adoption of intelligent physical robots in different healthcare contexts, prior research has mainly investigated the adoption of intelligent physical robots based on the factors related to either technology, organizations, or business environments, few studies have investigated the adoption of intelligent physical robots from the combined view of the technology-organization-environment (TOE) view in the context of hospitals. To address the research gap, this study used the TOE framework to investigate what technology, organizational, and environmental factors affect intelligent physical robot use. The proposed model will be validated with data collected via questionnaires in the hospital context. The research is expected to enrich the literature on intelligent physical robot adoption by exploring the determinants of intelligent physical robot adoption from the integrated view of TOE at the organizational level.

Keywords: Intelligent physical robots, healthcare, technology-organization-environment framework, organizational adoption

1. INTRODUCTION

Across the world, the healthcare industry is facing considerable pressures, such as the aging population, funding challenges, and human resource shortages. These changing societal needs and the limited capabilities of health systems pave the way for robots to enter the healthcare field [1]. Especially in the post-COVID-19 era, the application of service robots in the healthcare field has grown significantly.

In this study, we focus on physical robots with intelligent capabilities in a healthcare environment based on artificial intelligence (AI) (hereinafter intelligent physical robots). Intelligent physical robots refer to robots with visually observable bodies and intelligent perception, thinking, and manipulation capabilities (e.g., humanoid robots, android robots, and animal-like robots), which can interact with humans in different environment [2]. Intelligent physical robots can assist healthcare staff and patients in complex tasks in a variety of ways, reducing the workload of healthcare staff and improving the health and well-being of end-users [3]. From a business perspective, the adoption of intelligent physical robots may improve the efficiency and cost-effectiveness of healthcare services in healthcare organizations [4]. However, organizational adoption of intelligent physical robots in healthcare appears to be much slower than in other business field [5].

Studies on intelligent physical robots have increased in the past a couple of years. Prior studies have investigated various factors influencing the adoption of intelligent physical robots in healthcare, such as users' age, gender, experience with technology, and robotic design [6]. Although prior research provides diverse views on the adoption of intelligent physical robots in healthcare, these studies have largely been drawn from an individual user perspective and have ignored the importance of understanding the adoption of intelligent physical robots from the organizational view.

In order to fill this gap, this study aims to investigate what factors affect intelligent physical robot adoption

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in the hospital context. Specifically, this study develops a research model to examine the technology, organizational, and the environmental factors influencing a hospital's decision to adopt intelligent physical robots based on the technology-organization-environment (TOE) framework. Surveys will be conducted to collect data from the nurses, doctors, and management teams in a hospital. The findings will contribute to a deeper understanding of the adoption of intelligent physical robots from an organizational view and will provide some practical guidelines to hospitals on their intelligent physical robot adoption decisions.

The present paper proceeds as follows: First, a theoretical background composed of acceptance of intelligent physical robots and the TOE framework is presented to provide the theoretical support for this study. Second, the proposed model and research hypotheses are discussed. Then, the planned research method is explained. Finally, the paper concludes with the expected contributions and limitations.

2. BACKGROUND

2.1 Acceptance of intelligent physical robots

Prior literature has investigated the acceptance of intelligent physical robots from different views. From an individual perspective, social, cultural, psychological, and ethical factors have been found to affect the adoption of intelligent physical robots by end-customers [7]. For example, gender, age, and education of end-customers have been found to affect their acceptance of intelligent physical robots in the healthcare context [7]. In addition to individual views, the appearance, function, and implementation environment of intelligent physical robots have also been identified as important factors affecting robot use in the healthcare context [8]. Research has shown that anthropomorphic design, such as appearance, voice, name, and ethnicity of intelligent physical robots, can stimulate people's intention to use the robots [8].

For the success of intelligent physical robots, research from an organizational perspective is important. Some researchers have examined the use of intelligent physical robots among healthcare professionals in organizations [9-10]. Prior literature indicated that intelligent physical robots can be applied as a means to improve productivity and healthcare delivery. Even though the attitudes of healthcare professionals are positive, healthcare organizations are still reluctant to use robots [11]. For example, technical failures and limited intelligence capabilities are the concerns which impede intelligent physical robot use [11]. The regulations and ethical and privacy issues are the others concerns affect intelligent physical robot use, such as the potential reduction in the amount of human contact [12], loss of control [13], and loss of privacy [14].

Previous studies have focused on individual adoption of intelligent physical robots in healthcare contexts, but there is a lack of knowledge on the adoption of intelligent physical robots in hospitals from an integrated view of technology, organization, and environment. To enrich the literature on robots use in the healthcare context, it is necessary to explore the adoption of intelligent physical robots in hospitals from the TOE view at the organizational level.

2.2 Technology-organization-environment (TOE) framework

The TOE framework is one of the most widely applied theories for explaining the adoption and implementation of technology innovations in organizations [15]. This framework explians how an organization makes its decision to adopt a technology from the three facets of an organization: technology, organization, and the environment. Technological context includes both existing technologies applicable to the organization and the technology to be adopted by an organization [16]. Organizational context refers to the internal organizational characteristics or resources that constrain or facilitate its adoption decision, such as personnel, organizational culture, management support, organizational readiness, and size [17]. Environmental context consists of the external factors regarding the industrial settings in which the organization conducts its business, such as industry characteristics, government regulations, level of competition, and the existing IT infrastructure supplied by

others [18].

The TOE framework provides a general theoretical basis for studying the adoption of different types of innovations at the organizational level and has been applied in different contexts, such as cloud computing [19], big data [20], eCRM systems [21], electronic business, and virtual worlds [15]. The TOE framework investigates adoption decisions at the organizational level rather than the individual level. Therefore, the TOE framework is an appropriate theoretical framework for evaluating organizational decision making regarding innovative technology use, such as intelligent physical robots in hospitals. Therefore, the TOE framework is applied in this study to understand hospitals' adoption of intelligent physical robots.

3. THE PROPOSED RESEARCH MODEL AND HYPOTHESE

3.1 The proposed research model

A research model was developed based on the TOE framework to explain the adoption intention of hospitals regarding intelligent physical robots. Specifically, relative advantage, compatibility, complexity, and security, and ethical concern are conceptualized as technological factors, top management support, organizational readiness, and organizational culture as organizational factors, and government support and consumer readiness as environmental factors influencing hospitals' intentions to use intelligent physical robots. The research model is depiched in Figure 1.

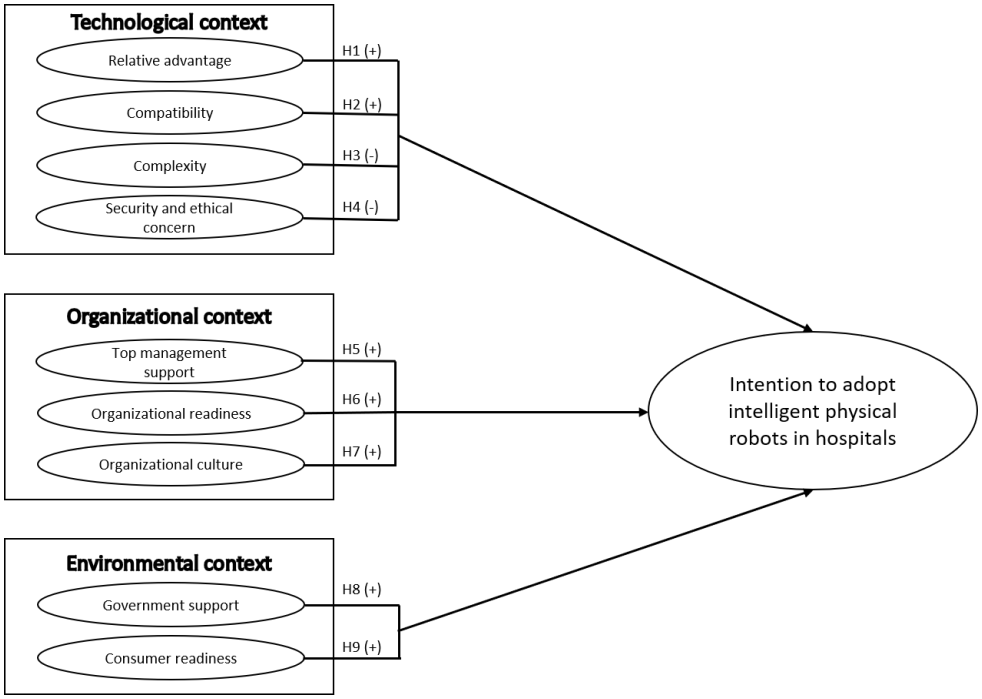

Figure 1. The proposed technology-organization-environment framework

3.2 Hypotheses

3.2.1 Technological contexts

Relative advantage is defined as the degree to which potential adopters in an organization perceive technological innovations to be superior to the precursor [22]. Based on the review of the intelligent physical robot literature, intelligent physical robots might provide potential benefits to hospitals in terms of the quality of patient care, health improvement, reducing healthcare providers' workload, and improving job satisfaction. For example, healthcare professionals in hospitals expressed strong expectations for the animal robot Paro about its advantages in facilitating nursing care and reducing patients' aggressive behaviors [23]. Intelligent physical

robots were also perceived to reduce healthcare providers' workload and help them concentrate on more essential nursing work [24]. Based on the above ground, the following hypothesis is postulated:

H1. Perceived relative advantage of intelligent physical robots is positively associated with hospitals' intention to adopt the robots in hospitals.

Compatibility refers to the degree to which a technological innovation is deemed to fit with the organization's needs, past experience, and existing values [22]. When considering the adoption of intelligent physical robots, the ICT (information and communications technology) infrastructure in the organization might need to be improved to facilitate the optimal operation of the robots [25]. Nurses, as potential adopters of intelligent physical robots in hospitals, worry that intelligent physical robots might not meet their work needs or help them perform tasks effectively after being adopted into the practical environment [26]. The high level of compatibility of intelligent physical robots will allow the hospital to make minimal adjustments and changes, thereby reducing the risk of organizational adoption. Thus, the following hypothesis is proposed:

H2. Perceived compatibility of intelligent physical robots is positively associated with hospitals' intention to adopt the robots in hospitals.

Complexity is defined as the degree to which a technological innovation is perceived as relatively difficult to understand and to be used in an organization [27]. New technology can be easy or complex to operate and handle. If intelligent physical robots are complex, healthcare professionals will keep using traditional tools and will be relunctant to use new technologies in their work. Potential adopters in hospitals are often reluctant to devote much of their time and efforts to training themselves to use or implement a new technology [26]. Based on the discussion, we assume that the more complex it is to use intelligent physical robots, the less likely that hospitals will use the robots. Thus, the following hypothesis is assumed:

H3. Perceived complexity of intelligent physical robots is negatively associated with hospitals' intention to adopt the robots in hospitals.

In this study, safety, and ethical concerns are defined as the degree to which intelligent physical robots are considered unsafe and unethical for conducting healthcare services in hospitals, such as technological disruptions, unexpected accidents, privacy breaches. Generally, nurses have expressed concerns about safety and responsibility issues arising from robot malfunctions, reduced social interaction between patients and nurses, and limitations of robots in personalized care [24]. When adopting intelligent physical robots for healthcare work, hospitals have to consider whether the robot respects ethical principles, such as autonomy, non-maliciousness, benevolence, and justice [28]. Based on the above discussion, the following hypothesis is put forward:

H4. Perceived security and ethical concerns of intelligent physical robots is negatively associated with hospitals' intention to adopt the robots in hospitals.

3.2.2 Organizational contexts

Top management support has been found to be an important factor in facilitating the adoption of new technologies by organizations [19]. In hospitals, top management support means that decision-makers in hospitals express their opinions, expectations, and beliefs about the use intelligent physical robots in hospitals and support it. Some hospitals organize project leaders' meetings to receive support and to exchange knowledge and experience from people who have used robots, which will undoubtedly create a positive environment for intelligent physical robots [29]. Additionally, strong top management support will reduce the resistance to the adoption of intelligent physical robots, as top management support can provide long-term strategic vision, initiatives, and support for technology use [30]. Based on the above discussion, the following hypothesis is assumed:

H5. Top management support is positively associated with hospitals' intention to adopt intelligent physical robots in hospitals.

Organizational readiness refers to the level of financial and technical resources an organization has available to implement intelligent physical robots, including financial readiness and technical readiness [19]. In this study, financial readiness refers to the financial ability of a hospital to afford the installation, implementation, and subsequent maintenance of intelligent physical robots. Greater financial readiness will facilitate hospitals' decision to adopt intelligent physical robots [31]. Technical readiness refers to a hospital's access to tangible and intangible technical resources for successful adoption of intelligent physical robots, such as technical hardware, staff and training support. The successful implementation of intelligent physical robots also requires preparations, including instruction training by robots, availability of helpdesk, and WIFI connection [29]. Therefore, the following hypothesis is proposed:

H6. Organizational readiness is positively associated with hospitals' intention to adopt intelligent physical robots in hospitals.

Organizational culture refers to the collectively held values, shared beliefs, and symbolic ideals regarding intelligent physical robot use in an organization, such as organizational climate, job satisfaction, and goal integration [32]. If hospitals have open and positive attitudes toward the introduction of robots in healthcare, the decision to adopt intelligent physical robots will become easier. For example, if hospital employees are exposed to technological innovations in healthcare, they could gain a better understanding of using robots in work, such as in nursing practice [29]. Additionally, employees who are more satisfied with their jobs and whose goals align with the organizational culture are open to new ideas [33]. The following hypothesis is therefore put forward:

H7. Organizational culture is positively associated with hospitals' intention to adopt intelligent physical robots in hospitals.

3.2.3 Environmental contexts

Government support often has a significant impact on technology adoption. Forms of government support usually include laws and regulations, incentives, infrastructure preparation, advocacy, and training. For example, the U.S. federal government has created a National Resource Center for Health IT to help some providers adopt, implement, and use e-health technologies, while also providing ongoing financial support for e-health projects through grants and contracts [34]. These resources and support from governments may assist healthcare providers in embracing and utilizing innovations like intelligent physical robots to improve healthcare systems.Therefore, we propose the following hypothesis:

H8. Government support is positively associated with hospitals' intention to adopt intelligent physical robots in hospitals.

Customer readiness reflects potential market capacity, which is closed related to the extent to which the new technology can be translated into profitability. In this study, customer readiness is expressed as the willingness of customers to accept intelligent physical robots. Sreejith et al. indicated that patients, representing the hospital's main customers, receive and experience healthcare services directly, so their perceptions and intentions of using innovations will motivate organizations across the industry to adopt new technologies [35]. Accordingly, customer readiness may encourage hospitals to adopt intelligent physical robots. The following hypothesis is thus put forward:

H9. Consumer readiness is positively associated with hospitals' intention to adopt intelligent physical robots in hospitals.

4. PLANNED RESEARCH METHOD

To test the above hypotheses, this study plans to use a survey method to collect data. Measurement items for the variables will be adapted from previous studies, with some modifications to fit the context of intelligent physical robots. Items adapted from Racherla et al. and Lee et al. will be used to operationalize relative

advantage, compatibility, complexity, secure, and ethical concern [22][24]. The items of constructs top management support, organizational readiness, and organizational culture will be taken from the research of Al-Jabri [19]. The construct of government support and consumer readiness will be measured with the items taken from the research of Suwa et al. [32] The items of adoption intent will be taken from the research of Clegg et al. [37] Multiple-item scales measured with the Likert five-point scale will be adopted for the measurement.

Since the dependent construct in this study is the hospital's intention to adopt intelligent physical robots, the unit of analysis is hospitals that have not yet adopted intelligent physical robots. We choose the hospital as the targeted organization for the following reasons: First, there is a lot of potential for intelligent physical robots to be used in healthcare services, but currently the use of intelligent physical robots in Finnish hospitals is still in its initial stage. Second, the implementation of intelligent physical robots might become popular in hospitals in the post-COVID-19 era due to the heavy workload of hospitals and less human interacdtion with robots support. We plan to contact a university hospital in Finland to help with data collection. The hospital will distribute the questionnaire to employees of the hospital. Since some of the questions in our questionnaire are realted to hospital management and operations, it is appropriate to target the sample of the survey at the nurses, doctors, and management team in the hospital. We plan to collect about 200 responses to test the proposed model. The data will be analyzed using structural equation modeling (SEM) via the software SmartPLS.

5. EXPECTED CONTRIBUTION

The expected contributions of this study include both theoretical and practical aspects. First, we use the TOE framework to explore the determinants of hospital adoption of intelligent physical robots, allowing researchers to effectively assess organizational adoption behavior regarding intelligent technologies in hospitals. In addition, this research will provide suggestions on how to improve the adoption of intelligent physical robots in organizations, which can help to persuade healthcare professionals to use intelligent physical robots. Hospital managers could get aware of the barriers to the adoption of intelligent physical robots in hospitals, and to make strategies to reduce these barriers to technology adoption if the hospitals would like to use intelligent physical robots.

There are certain limitations in the current study. This study considers the limited factors influencing the adoption of intelligent physical robots in hospitals, which needs to be further expanded in future research. Second, all organizations in our dataset are hospitals, so the results of this study may not be applicable to other healthcare organizations, such as nursing homes or old care facilities.

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