

# Consideration of Safety Management When Using Pepper, a Humanoid Robot for Care of Older Adults

Misao Miyagawa<sup>1</sup>, Yoshihiro Kai<sup>2</sup>, Yuko Yasuhara<sup>3</sup>, Hirokazu Ito<sup>3</sup>, Feni Betriana<sup>4</sup>, Tetsuya Tanioka<sup>3</sup>, Rozzano Locsin<sup>3</sup>

<sup>1</sup>Department of Nursing, Faculty of Health and Welfare, Tokushima Bunri University, Tokushima, Japan

<sup>2</sup>Department of Mechanical Engineering, Tokai University, Kanagawa, Japan

<sup>3</sup>Department of Nursing, Institute of Biomedical Sciences, Tokushima University, Graduate School, Tokushima, Japan

<sup>4</sup>Graduate School of Health Sciences, Tokushima University, Tokushima, Japan

Email: miyagawa@tks.bunri-u.ac.jp

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## Abstract

Pepper, a humanoid robot, is 1.2 m in height and is designed to move its limbs. There are risks of the older adults experiencing falling and collision accidents when they interact with Pepper. When physical interaction happens between a humanoid robot and human beings, potential harmful physical contact might occur. The aim of this report was to examine the safety management aspects when using Pepper, a humanoid robot for the care of older adults. The older adults' reactions to Pepper's functions cannot be predicted. Hence, it is necessary to clarify methods to guarantee its safety in advance and to increase the safety and properties of the robots. The benefits of introducing support robots such as Pepper for aging medical and nursing care settings are obvious. Therefore, engagement in robot development while considering both the risks and benefits is critical. Our academic initiatives have just begun. Through information exchange among researchers, users, engineers, and law specialists, we need to identify latent and prominent risks in situations where Pepper and the older adults interact and deepen our examination of measures against such risks.

## Keywords

Elderly Care, Humanoid Robots, Pepper, Safety Management, Older Adults

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## 1. Introduction

In Japan, the number of older people is increasing. In 2019, more than 28% of the

population comprises those aged 65 years and more, and this is expected to surpass 35% by 2040 [1]. On the other hand, the number of healthcare practitioner is decreasing because of the decrease in the working population associated with the declining birthrate [2]. As a countermeasure against these issues which will only increase in severity, the Japanese government proposed implementing “Japan’s Robot Strategy” in the five-year period from 2015 to 2020. Part of this strategy is to promote the use of robots in the nursing and medical fields. In particular, there has been a push in recent years toward the use of communication robots for elderly individuals who have low levels of social participation (e.g. older adults living alone) to help them maintain their social activities, promote communication, prevent dementia, and for positive therapeutic effects [3] [4].

In Okayama City, Okayama Prefecture, Japan, PARO (a seal-shaped robot [5]) has been on loan since 2013. PARO is used to prevent dementia in persons requiring nursing care and to reduce caregivers’ burden [6] in this context.

In Saijo City, Ehime Prefecture, Japan, a free service using artificial intelligence robots is provided to support the monitoring of the elderly and engage in communication [7] with these individuals. In Kawasaki City, Kanagawa Prefecture, Japan, a demonstration test using Pepper (a robot brand manufactured by SoftBank Robotics Corp; namely, “Pepper”) is being conducted for communication with the older adults, maintenance and improvement of their physical functions [8]. Examples of where Peppers had been introduced include hospitals in which the robot performs guidance tasks for outpatients and is used for robot therapy [9], and at nursing facilities for recreation activities during day care [10].

PARO [5], a therapy robot, and Kabochan [11], a communication robot, are both small robots for the elderly with minimal movement. Therefore, there are virtually no risks of physical harm to older adults [12].

Another example is the Telenoid [13], a tele-operated robot with the function to communicate with older adults with Alzheimer’s disease [14]. The majority of older adults reported a positive opinion of using Telenoid, and all older adults who interacted with Telenoid gave it a hug without being given any suggestion to do so. This suggests that older adults find cute robots, like Telenoid, to be acceptable use with older adults [15].

On the other hand, Pepper, a humanoid robot, is 1.2 m in height and is designed to move its limbs [16]. With this movement, there are risks for older adults, such as experiencing falling and collision accidents when they interact with Pepper.

Our research team conducted clinical experiments that used Pepper for rehabilitation and communication purposes at a Long-Term Care Health Facility. In some cases of older adults with dementia care, these older adults approached, touched, and hugged Pepper. Developers might not have expected this reaction to Pepper.

When physical interaction happens between robots and humans, potential harmful physical contact may occur [17]. Although no major accidents have been reported at this time, it is necessary to assume that such situation can occur

when introducing Pepper, therefore supporting the need to estimate the risks and secure the safety of older adults.

The development of humanoid robots with various functions has been reported in the literature. However, little is known about the safety of human-robot interactions, particularly when dealing with the unpredictable reactions of older adults, especially those with dementia. With the active promotion of introducing humanoid robots, it should not only be an engineering perspective that influences the development of human-robot interactions in the healthcare fields. Providing safe healthcare for patients is the mission of healthcare professionals, therefore, it is an important role for them to provide informed data regarding patient safety especially in human-robot interactive activities.

This review article provides the following content: 1) the definition of a robot and its functions in Japanese settings, 2) safety issues of Pepper to use in older adult care, 3) ways of increasing the safety management of Pepper robot, and 4) future issues regarding the introduction of Pepper into the clinical settings.

The aim of this report was to examine the safety management aspects when using Pepper, a humanoid robot for the care of older adults.

## **2. Methods**

The research group, comprised of the authors of this paper, has been conducting research studies from 2017. Our studies focus on the promotion of communication and rehabilitation of older adults by using Pepper [18] [19]. Pepper is a humanoid robot that is equipped with rehabilitation and communication functions. It is usually used for residents in a nursing home and for older adults attending the day service. During this process, we held two expert meetings (in April and July 2019) involving nursing, physiotherapy, and engineering researchers, as well as lawyers to ensure the patients' safety.

## **3. Results and Discussion**

### **3.1. Definition of Robot in Japan**

The Ministry of Health, Labor and Welfare, Japan, defines a robot as an intellectualized mechanical system that possesses three technological capabilities: “perceiving information (sensor system)”, “making judgments (intelligence and control system)”, and “operating (drive system)” [20].

Among various types of robots are industrial and human-friendly robots. Industrial robots are mostly automated and used in industrial settings to improve the manufacturing process. Human-friendly robots are placed in the spaces in which people live, and support the so-called self-expression of humans, such as the actions in their work and daily life. Care assistance and communication robots are included among these robots [12].

### **3.2. Safety Issues of Pepper to Use the Elderly Care**

This study focused on the physical safety of older adults facilitated by introduc-

ing Pepper into nursing homes.

Pepper has interaction functions such as talking to older adults to encourage participation, and shake its hands thereby encouraging older adults to touch it [21]. In addition, a language program emulating a six-year-old child is integrated into the program of Pepper, creating the feeling of interacting with a grandchild. Therefore, these are some elements that make older adults want to approach and touch Pepper.

Even in the clinical experiments on conversation with older adults using Pepper, it was observed in many instances that they touched Pepper's hand or head and hugged it during the middle or at the end of their conversation.

In addition, a self-propelling function is being considered for the next generation of Pepper [22]. Although not reported thus far, there is a possibility that an older adult could approach Pepper, resulting in a collision accident such as a fall.

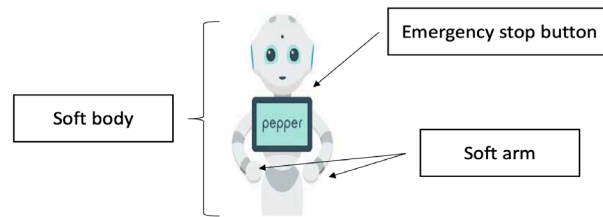
### 3.3. Ways of Increase the Safety Management of Pepper

In industrial robots, safety of humans is guaranteed by isolating the robots from humans with safety measures such as safety guards [23], a contraption that ensures safety when the robot is operating to prevent humans from coming into contact with robots. However, this environmental concern is not possible with Pepper, when used in elderly care settings. Therefore, it is necessary to ensure a systematic safety feature of this robot.

It would be desirable to guarantee that people do not enter the operational range of the robot. Thus, it is important to consider supervisory control when using robots [24]. However, it is not possible to avoid robots and people close contact in the case of Pepper and other robots used in nursing care and rehabilitation sites. Hence, it is necessary to implement a system to minimize the possible harm to the user.

Pepper is controlled by a computer so that its upper limbs will stop moving if a person approaches the turning range of its upper limbs. An emergency stop button, that people in close proximity with Pepper can press when the computer malfunctions, is also installed on Pepper's main body. Moreover, it is also installed with precautions such as covering its arm with a soft material. In addition, the fingers on Pepper's hands have an extremely breakable structure. Therefore, even if an older adult touches or holds Pepper's hands, it is equipped with a safety function that reduces any potential physical harm to people. The existing safety features of Pepper are shown in the following **Figure 1**.

In the risk management process, it is vital to identify the potential harm and determine the associated risks [17]. In this case, even though Pepper is equipped with safety features, some safety risks still remain. For example, if an older adult suddenly and carelessly comes too close or touches Pepper on different parts of its body: 1) Pepper might fall and potentially drag the older adult or 2) the older adult might get caught in Pepper's arms or joints. Furthermore, there is a risk of Pepper causing a collision accident with older adults, 3) when the robot becomes



**Figure 1.** The safety features of Pepper.

uncontrollable because its computer or sensors malfunction and the people in close proximity are unable to press the emergency stop button. In particular, if Pepper's hands are operated at a rapid speed while in an uncontrollable state, its fingers might ram into people's eyes even though they are made to break easily. In addition, if Pepper was to become uncontrollable, there is a risk that its arms will collide people at a high-speed or that a person might get caught in Pepper's arms or joints. Furthermore, when Pepper is able to self-propel using wheels, it will be required to operate on slopes, and not just on a flat floor. In this case, should Pepper's battery run out on a slope, 4) there is the potential risk of it plummeting downward at a high speed because of gravity, and consequently colliding with someone at a high speed.

As a safety measure against the abovementioned 1), namely getting dragged down when Pepper falls down, measures such as "widening the installation area with the ground" and "widening the space between the wheels" are proposed to make Pepper less likely to fall. As a countermeasure to 2), namely people getting caught in Pepper's arms or joints, installing pressure sensors on the surface of the Pepper's body to make it stop by detecting if someone has been caught in its arms or joints is proposed [25] [26].

In addition, as a countermeasure against 3), namely Pepper becoming uncontrollable because of a malfunction of its computer or sensor, and the people around Pepper being unable to press the emergency button, equipping speed-based and contact force-based mechanical safety devices [27] is proposed. The speed-based mechanical safety device mechanically detects when Pepper's joint moves at an unexpectedly high speed and stops the Pepper's movement. The contact force-based mechanical safety device detects and stops Pepper mechanically when it comes into contact with a person with an unexpectedly high contact force. Both speed-based and contact force-based safety devices use no battery, controller, or motor and are composed only of passive mechanical elements such as a panel. Therefore, they operate even if Pepper's computer is not functioning, or its battery dies. Additionally, wearing goggles is proposed in order to prevent Pepper's fingers from ramming into people's eyes. As a countermeasure against 4), namely that if Pepper's battery dies on a slope, there is a risk of Pepper going down the slope at a high speed because of gravity and colliding with a person at a high speed, a possible proposal is to use the abovementioned speed-based mechanical safety device for the wheels. As it was described earlier, a speed-based mechanical safety device does not require a battery and

will function when a high-speed event occurs on a slope.

The following table (**Table 1**) exhibits the summary of the safety management for Pepper.

Furthermore, we should not forget the additional measures required in terms of users' movements when utilizing Pepper in caring for older adults. For example, sometimes, elderly individuals with dementia move in ways that cannot be predicted by medical practitioners. As such, Pepper's safety functions and the abovementioned safety countermeasures alone are possibly not enough to handle such movements. As a current countermeasure, a procedure is necessary whereby Pepper's safety is ensured by having only nurses handle it, becoming intermediaries between Pepper and older adults. In addition, all intermediaries are required to know all of Pepper's usage rules and instructions. It is important that the intermediaries receive safety education (e.g., measures required during an emergency), and not only operating training. It is indispensable to train personnel with the skills to deal with and resolve any types of problems with the robot, allocating them as intermediaries between the robots and the elderly to develop a human safety management system.

### 3.4. Future Issues Regarding the Clinical Introduction of Pepper

Medical staff members are required to fulfill their duty of care. This duty of care includes predicting risks and intervening by establishing measures to avoid such risks. Nurses working in hospitals make efforts to prevent medical accidents by undergoing training to increase risk sensitivity and reflection, even in the case of a minor incident (an accident that has not caused injury to the patient).

**Table 1.** The safety management for Pepper.

The physical safety risks	The countermeasures
1) Pepper falls and older adults get involved	Widening the installation area with the ground. Widening the space between the wheels.
2) Older adults getting caught in Pepper's joints	Installing pressure sensors on the surface of Pepper's body.
3) Pepper becoming uncontrollable	
<ul style="list-style-type: none"> <li>• Pepper's hands and fingers move at high speed, hit to human eyes at high speed.</li> <li>• Pepper's arms collide with an older adult at high speed.</li> <li>• Older adult caught between Pepper's arms and joints.</li> <li>• Pepper's fingers ram into people's eyes.</li> </ul>	<ul style="list-style-type: none"> <li>Equipping speed-based and contact force-based mechanical safety devices.</li> <li>Wearing goggles.</li> </ul>
4) Pepper's battery dies on a slope	
<ul style="list-style-type: none"> <li>• When the battery of Pepper runs out on the slope, it descends at a high speed due to gravity and collides with people at a high speed.</li> </ul>	Speed-based mechanical safety device for the wheels.

In medical settings, the risk management approach of foolproof, fail-soft, and fail-safe measures is starting to permeate.

**Foolproof:** To avoid accidents and incidents, any organization should have multiple layers of controls or defenses in place. However, controls are never foolproof [28].

**Fail-soft:** It is defined as a failure in the performance of some component part of a system without immediate major interruption, or failure in the performance of the system as a whole and/or sacrifice in the quality of the product [29].

**Fail-safe:** This is a strategy to mitigate hazards, and an approach that works to avoid incidents, for example, automatic instant shut down mechanisms [30]. Also, a fail-safe relies on the idea that should anything fail, safety is not jeopardized, for example, the use of electrical switches that cut power when they fail [31].

Furthermore, when introducing new systems and machines into a clinical setting, it is important to introduce them after estimating the risk and to adopt countermeasures against such risks using methods such as the Failure Mode and Effects Analysis (FMEA) [32]. In Japan, the use of the Pepper Robot in aging care sites has just begun. Therefore, it is necessary to increase the efficacy of robot-provided care while performing risk management and accumulating sufficient evidence.

## 4. Conclusions

Older adults' reactions to Pepper's functions cannot be predicted. Hence, it is necessary to clarify methods to guarantee its safety in advance and to increase the safety and properties of the robots. The benefits of introducing support robots such as Pepper for aging medical and nursing care settings are obvious. Therefore, engagement in robot development while considering both the risks and benefits is critical.

Our academic initiatives have just begun. Through information exchange among researchers, users, engineers, and law specialists, we need to identify latent and prominent risks in situations where Pepper and the older adults interact and deepen our examination of measures against such risks. This study provides new insights into safety management concerns using Pepper over the existing safety features that equip the recent Pepper version. The information obtained from this study is expected to be taken into consideration for further and future development of Pepper.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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