# Symposium

## Scenario-Based Care Robot Development and User-Centered Innovation in Korea

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**Participants***:* Won-Kyung Song (Korea), Woo-Joung Shim (Korea), Se-Jin Park (Korea), Kyung-Hwan Kim (Korea). **ISSUE** Korea is experiencing a rapid increase in care needs due to accelerated population aging and a growing number of older adults and persons with disabilities. However, the availability of the care workforce continues to decline as the working-age population shrinks, resulting in a widening gap between care demand and supply. In response, the Korean government has established an inter-ministerial collaboration between The Ministry of Trade, Industry and Resources (MOTIR) and the Ministry of Health and Welfare (MOHW) to reduce care burden, improve quality of life, and foster the care-technology industry. Through this framework, MOTIE supports the development of commercializable care robot technologies, while MOHW promotes translational research, field-based pilot studies, and the development of service models under an integrated "Package-type R&D" program. To develop devices and service models suitable for Korean contexts—both in long-term care facilities and in-home environments—four major care robot areas have been prioritized: transfer support, pressure ulcer prevention and postural change, toileting and continence support, and eating assistance. Additional initiatives include autonomous mobility support, emotion- and communication-based companion robots, and technologies supporting human caregivers themselves. A central principle of this national R&D effort is participatory research, conducted "together with users." Care recipients, caregivers, companies, and policy experts participate throughout the entire research process. To support this, a Care Robot Network Forum has been established and is actively operating. In this symposium, researchers from four participating companies and institutions will present their development outcomes and discuss the results of integrated workshops and scenario-based approaches designed to ensure human-centered and user-driven development.. **CONTENT** Won-Kyung Song will present the operation of five Smart Care Spaces functioning as living labs to validate application scenarios for nine core care robots. He will share major operational methods and experiences derived from these applications, demonstrating how scenario-based testing bridges the gap between technology and real-world application. Woo-Joung Shim will present the results of scenario-based voice interaction development for autonomous mobility support. This presentation will highlight how conversational scenarios were designed and implemented to enable natural and intuitive human–robot interaction within autonomous mobility devices. Se-Jin Park will present a radar-based non-contact vital-sign monitoring system that provides real-time tracking of respiration and heart-rate signals and automatically detects early signs of physiological instability or hazardous situations in older adults. The presentation will highlight how automated early-risk detection, bed-exit alerts, and continuous monitoring can enhance safety management and improve operational efficiency in long-term care settings. Kyung-Whan Kim will discuss the development of a scenario-based feeding robot. By analyzing and structuring the interaction processes between the robot and the user during mealtime, Kim will illustrate how these interaction scenarios were utilized to guide the technical design and development of the feeding robot. **CONCLUSION** The scenario-based approach demonstrates its value in anticipating the wide range of events that may occur during research and development, enabling more effective and efficient interactions among devices, users, and caregivers. Scenario development that incorporates the experiences and perspectives of diverse participants—such as end users, family caregivers, and care facility staff—helps refine and advance prototypes through real-world validation in the Smart Care Space. This symposium will illustrate how such participatory scenario-based processes contribute to more precise, user-centered, and practical care robot development.

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# Symposium

**Implementation Insights from Smart Care Spaces: Focusing on the Bathing Care Environment**
W.-K. Song, J.-E. Baek, G.-Y. Kim, M.-J. Lim, J.-K. Lee. *Gerontechnology* 25(s*)*

**Purpose** With the increasing demand for care due to population aging, it is essential to validate the practical utility of care robots in real-world environments. The purpose of this study is to present the development of "Smart Care Spaces" [1], which serve as living labs to verify the application scenarios of nine key types of care robots derived from national R&D priorities [2]. This paper outlines how these spaces were designed to test specific care scenarios and analyzes their implementation from 2019 to 2024. **Method** We derived application scenarios for nine core care robots: Transfer, Repositioning, Excretion, Feeding, Mobility, Bathing, Communication, Monitoring, and Wearable Muscle Support. To validate these scenarios in realistic settings, we constructed five distinct testbeds reflecting various residential and institutional environments (general home, caregiver-user shared space, single-person rental housing, smart patient room, and bathing facility). **Results and Discussion** The Smart Care Spaces were established to facilitate effective validation of the nine robot scenarios. Specifically, the Bathing Care Space (Hygiene Model) (36.4m²) was established to validate mist-spray automatic bathing robots. Constructed in November 2024, this space simulates facility and shared living environments, featuring a design that prioritizes privacy with a changing room and a planned powder room. Expert consultations in September 2024 refined the drainage system and trench size, incorporated sliding doors for spatial efficiency, and strategically placed safety bars and storage units. Usability evaluations with 6 caregivers and 8 care recipients revealed that caregivers experienced significantly improved comfort. However, users expressed safety concerns regarding the use of electricity in a humid environment. Functional feedback highlighted the need for oscillating water nozzles (similar to bidets) rather than fixed ones for better coverage, and a desire for the commode chair to be self-propellable like a wheelchair to enhance autonomy. Additionally, the mesh backrest of the commode remaining wet after bathing was identified as a major discomfort during transport back to the room. This suggests that while the system successfully reduced the physical burden on caregivers, future designs must prioritize addressing the reported anxiety regarding electrical safety and carefully consider user autonomy (self-propulsion) and psychological stability. First, regarding psychological safety versus functional efficacy, it was observed that while caregivers reported significantly improved physical comfort, care recipients expressed high affective anxiety regarding electrical usage in humid environments, suggesting that future designs must prioritize "psychological reassurance" through specialized insulation and intuitive safety interfaces. Second, in terms of user agency and functional requirements, recipients identified a critical need for functional upgrades, such as oscillating or rotating nozzles for personalized hygiene and self-propellable commode chairs to enhance autonomy. Third, to ensure workflow continuity and address service delivery bottlenecks, the identification of discomfort caused by wet mesh backrests during the transport phase proves that environmental design must consider the entire care workflow—including pre- and post-task transitions—rather than focusing solely on individual device performance. In addition to the bathing space, the remaining four testbeds focused on specific care contexts: the 1st Space (General Home Model) validated Transfer, Communication, and Monitoring scenarios; the 2nd Space (Caregiver-User Shared Model) was designed for one caregiver and one care recipient, focusing on securing a dedicated rest area for the caregiver and streamlining Transfer and Mobility workflows to reduce caregiver burden; the 3rd Space (Single-Person Rental Model) tested non-intrusive Transfer and Feeding scenarios for independent living; and the 4th Space (Smart Patient Room) specialized in bedridden care to verify Monitoring and Repositioning scenarios. Collectively, the validation across these five distinct environments demonstrates that scenario-based living labs are essential for identifying context-specific workflow bottlenecks and unmet user needs that isolated device testing often fails to capture.

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# Symposium

## Scenario-Based Voice Interaction Development for Autonomous Mobility

W.-J. Shim. *Gerontechnology* 25(s)

**Purpose** The integrative and life-centered foundations of gerontechnology were articulated by Bouma, Fozard, and van Bronswijk, who conceptualized gerontechnology as the study of dynamic interactions among aging, technology, and human life contexts[2,3,6]. When operating care or mobility robots, joystick manipulation poses significant challenges for older adults and users with limited experience. Although coordinated interaction among the robot, user, and caregiver is essential, real-world environments often constrain effective collaboration due to limited hand availability, inexperience, or attentional demands. In such contexts, voice-based interaction serves as an important alternative that can reduce digital literacy barriers and enable hands-free robot control. However, reliance solely on speech recognition accuracy can introduce safety risks. Misrecognition or non-recognition becomes particularly problematic in noisy, multi-speaker environments, making accurate inference of user intent critical. This study aims to develop and validate a safety-based voice–HRI (Human–Robot Interaction) framework for autonomous mobility.
**Method** ISO 13482[5] safety requirements for personal care robots were first analyzed, and risk categories were restructured from a voice-interaction perspective. Grounded Theory[4] and Speech Act Theory[1] were then applied to design a graded risk-response framework, specifying procedures for intent confirmation and system actions according to three risk levels (none/low/high). Using the Crowd-aware Voice–HRI Recovery Model, a four-stage interaction structure—integrating user commands, robot actions, and bystander responses—was developed. A standard blueprint separating the roles of Human, LLM-based dialogue application, and Robot was created for three operational modes: joystick + safe driving, voice-button joystick + safe driving, and voice-based autonomous mobility. All conversation datasets were reviewed by a panel of seven experts (care workers, persons with disabilities, older adults, and family members). Content Validity Index (CVI) scoring was performed for interaction quality, safety, efficiency, and appropriateness. After three iterative revisions, only scenarios with CVI > 0.78 were retained. **Results and Discussion** As shown in Figure 1, voice–HRI scenarios were structured according to ISO 13482 risk categories and mapped to a graded action strategy for safe autonomous mobility. Analysis yielded 100 voice–HRI scenarios corresponding to nine ISO 13482 risk categories, including mobility hazards, interaction risks, malfunction, environmental risks, and misinterpretation. A graded action strategy (maintain–slow–stop) and a triadic voice-response model (user–robot–bystander) were established. Through the expert validation process, 80 scenarios were confirmed as appropriate. These findings demonstrate that a robot can operate as a mobility device under passenger authority while maintaining safety and naturalistic interaction. Future studies will focus on selecting a subset of approximately 30 high-priority scenarios and implementing them in a mobile application mounted on an electric wheelchair to evaluate functional performance, usability, and safety in real-world contexts.

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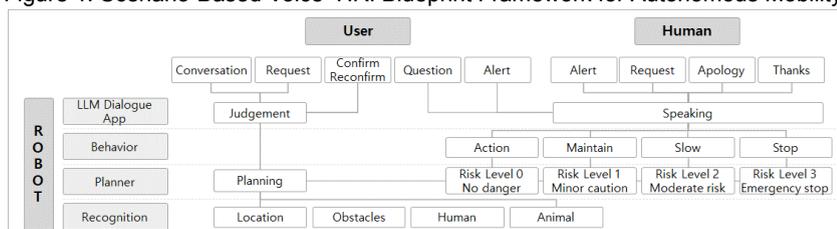
Figure 1. Scenario-Based Voice–HRI Blueprint Framework for Autonomous Mobility Robots.



This framework illustrates user intent processing, human–robot multimodal interactions, LLM-based judgement, robot planning modules, and risk-level-based behavioral responses used in scenario-based autonomous mobility control.

# Symposium

**Non-contact Vital-Sign Monitoring and Early Risk Detection for Safety Management in Older Adults**
S.-J. Park. *Gerontechnology* 25(s*)*

**Purpose** Growing populations of older adults and persistent caregiver shortages make continuous monitoring of core vital signs such as respiration and heart rate increasingly difficult in long-term care settings. Acute physiological changes during nighttime or other unmonitored periods may lead to serious health events if not detected promptly. In addition, certain bed-bound older adults may occasionally experience unintended bed exit, which increases fall-related risk. However, conventional care models relying on periodic rounds have limited ability to capture such events in real time. This situation creates a critical need for non-contact vital-sign monitoring and automated early warning systems that can identify high-risk events without continuous human observation. **Method** This presentation introduces a radar-based non-contact monitoring model designed to continuously track respiration and heart-rate signals and detect acute changes or hazardous situations in older adults. (1) Early detection of physiological abnormalities The system continuously measures respiration and cardiac activity and automatically identifies: sudden fluctuations, irregular rhythms, signs of physiological instability These indicators support rapid detection of potential acute events and enable timely response even during nighttime or monitoring blind spots. (2) Bed-exit detection for high-risk individuals When the patient remains within the sensing area, respiration and heart-rate signals are reliably captured. A sudden loss or displacement of these signals is interpreted as a bed-exit event, which may indicate elevated fall-related risk. Immediate notification allows caregivers to intervene quickly before severe incidents occur. (3) Enhancing operational efficiency in care facilities Because measurement is fully automated and non-contact, the system reduces the burden of repetitive nighttime checks and supports efficient allocation of caregiver resources. This improves both safety outcomes and operational workflow. **Conclusion** The integration of non-contact vital-sign monitoring with automated early-risk detection provides a practical, scalable solution for long-term care environments. This approach enables early recognition of physiological instability, reduces fall-related risks, and strengthens overall monitoring efficiency. The proposed model aligns with ISG's focus on innovative ageing-society technologies and supports future clinical deployment and policy-level implementation.

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# Symposium

**Scenario-Based Development of an Assistive Feeding Robot**

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**Purpose** Identifying individuals who require substantial assistance with eating remains challenging due to the multifactorial nature of eating independence. Upper-limb function, swallowing ability, cognition, sensory and oral function, and caregiver availability all influence self-feeding, yet integrated statistics across these factors are limited. As a result, existing assistive feeding technologies have primarily targeted four user groups: individuals with severe upper-limb impairment, those with limited reach or lifting ability, those affected by tremors or involuntary movements, and those with cognitive or behavioral challenges. To address this diverse and underserved population, this study introduces *IndiMeal*, a modular assistive feeding robot platform. IndiMeal allows users or caregivers to configure customized systems by selecting from three modules: a manual system with low-friction horizontal motion and adjustable spring-based vertical support; a powered system with motorized vertical assistance and sensor-based intent detection; and a fully automatic system capable of autonomous food scooping and delivery via button or voice commands. This modular architecture accommodates a wide spectrum of functional abilities—from individuals with severe physical disabilities to older adults with sarcopenia—while supporting scalable, cost-adaptive commercialization in domestic and global markets. **Method** A scenario-based usability evaluation was conducted by classifying users into two functional groups, each requiring different levels of robotic support. *Group A* (C5–C7 spinal cord injury, mid-stage ALS, severe traumatic upper-limb impairment, etc.) used a fully automated feeding robot capable of independently performing food scooping, trajectory planning, and safe oral delivery. Five real-world scenarios were evaluated: (1) initiation via chin switches; (2) dynamic mouth-position compensation through vision-based re-detection; (3) safety interruption during coughing or respiratory discomfort; and (4) controlled waiting and retraction when the user does not open the mouth. *Group B* (sarcopenia, adults ≥75 years, mild-to-moderate muscular dystrophy, etc.) used manual or powered arm-support systems to reduce muscular load and improve endurance. Evaluated scenarios included: (1) spring- or motor-assisted arm-weight compensation; and (2) intent-based vertical assistance triggered by subtle forearm movements detected via embedded optical or pressure sensors. **Results and Discussion** The scenario-based evaluations demonstrated that a modular design framework can effectively respond to heterogeneous user needs by enabling scenario-specific system configurations. Key design implications include (1) the usefulness of determining manual, powered, or fully automated operation modes according to the user's disability type and the robot's usage environment, and assembling only the necessary modules accordingly; and (2) the importance of control strategies that move the robot based on user intent while incorporating safety mechanisms to respond to involuntary user conditions, such as delayed mouth opening. These findings highlight how scenario-driven development can translate diverse functional requirements into practical design decisions, supporting safe and adaptable deployment across home-care, hospital, and long-term care environments.