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Concept Design of Bathing Aids for Long-Term Care Institutions

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ABSTRACT

Due to the shortage of care service personnel in Taiwan and persistent time pressure, assisting residents with bathing in long-term care facilities is one of the most physically demanding caregiving tasks. Bathing requires a series of labor-intensive actions, including transferring, repositioning, washing, rinsing, drying, and dressing, which impose substantial physical strain on caregivers. This study first investigated these occupational risks through an empirical assessment involving 15 Taiwanese care service personnel. Using the Rapid Entire Body Assessment (REBA) method and a musculoskeletal discomfort questionnaire, the results clearly classified bathing tasks as high-risk operations. Both posture risk scores and reported pain were most concentrated in the lumbar region, indicating significant lower-back strain and a clear need for intervention. Based on these findings, the study proceeded to develop a specialized bathing assistive device. The product development followed a standard design workflow, beginning with direct observations and needs analysis from frontline caregivers, which were translated into concrete design objectives and technical specifications. The design process integrated functional design, mechanical structure, human factors (ergonomic) considerations, and appearance design. The final product key functions include safe transfer between bed and device, assisted mobility between bedroom and bathroom, usability for both sitting and lying down, hygienic temporary waste management, and simplified operation and maintenance. Overall, the device effectively reduces physical and mental burden on caregivers while improving bathing efficiency and safety.

Keywords: Product development, Product design, Bathing assistive device, Long-term care institutions

INTRODUCTION

Currently, the long-term care (LTC) industry in Taiwan is facing severe challenges due to labor shortages. As Taiwan transitions into a super-aged society in 2025, the population requiring care is increasing rapidly. According to Taiwan's LTC policy, care needs are classified into Levels 1 to 8. Individuals who are expected to be or have been unable to care for themselves for over six months may apply for LTC services, provided they are assessed by local Long-term Care Management Centers as meeting LTC Need Level 2 or higher. In 2024, the population in need of care reached

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390,000 (see Table 1), while the existing workforce stood at approximately 310,000. Notably, 60% of this labor force is composed of foreign migrant caregivers (see Table 2), highlighting a critical deficit in caregiving personnel.

Table 1: Number of people in need of long-term care.

Level	2021	2022	2023	2024
CMS 2	44,266	53,126	66,034	8,048
CMS 3	46,975	57,884	71,400	82,974
CMS 4	3,289	62,787	72,935	80,812
CMS 5	42,142	48,001	52,329	53,660
CMS 6	28,166	31,564	32,070	31,765
CMS 7	24,472	29,475	31,330	30,985
CMS 8	25,106	30,562	33,192	33,031
Total	266,437	315,421	361,313	393,299

Table 2: Demographic characteristics of participants.

Year	Foreign Social Welfare Migrant Workers	Care Service Workers	Total
2024	214,667	97,526	312,193
2023	200,985	93,364	294,349
2022	187,962	91,653	279,615
2021	192,828	74,601	267,429
2020	217,519	73,700	91,219

In long-term care facilities, caregivers identify bathing as one of the most physically demanding activities (Hui et al., 2001; Nevala et al., 2004; King et al., 2020). Assisting with bathing is typically performed in slippery, confined spaces and involves high-risk postures such as bending, twisting, and lifting (Qareeballa et al., 2018; Hsieh et al., 2021), which often leads to musculoskeletal discomfort or chronic injuries over time.

Bathing tasks are divided into two categories: patient transfer and postural maneuvers during the bathing process. Although most facilities are equipped with assistive devices—including lateral transfer beds, patient lifters, transfer boards, and sliding mats—to reduce physical strain, research shows that actual utilization rates among frontline staff remain low. Regarding transfer methods, manual handling accounts for 79.23%, while non-powered assistive devices are used in only 18.58% of cases (Shih, 2016). In other words, even though caregivers are aware of the physical toll of manual handling, they often prefer it for its perceived speed and efficiency. In scenarios requiring the care of multiple residents daily, completing tasks early allows for more rest time, leading to a continued reliance on manual methods (Lin, 2020).

RESEARCH METHOD

This study recruited 15 professional caregivers (3 males and 12 females) from licensed long-term care facilities in the Yunlin and Chiayi regions of Taiwan. The participants' ages ranged from 20 to 64 years, with a mean

age of 44.1 years. In terms of physical characteristics, the maximum and minimum weights were 73 kg and 37 kg, respectively (mean = 57.1 kg), while the maximum and minimum heights were 172 cm and 148 cm (mean = 157.1 cm). Regarding professional experience, the participants' seniority in the caregiving industry ranged from a minimum of five months to a maximum of 21 years, with an average tenure of 7.3 years.

The research objective was to develop and design a specialized bathing assistive device. This study systematically performed product development and design as follows: design research, design development, testing and verification, and another three stages. Design research includes both practical observation and theoretical research. Design development included conceptual design, functional mechanism design, human factor design, and integrated design.

Research Tools and Projects

The Rapid Entire Body Assessment (REBA) was employed to observe the operator's body posture, joint angles, and muscular load. These data were mapped onto specific scoring tables to evaluate the ergonomic risk level of the working postures (Hignett, 2000). The assessment procedure is as follows:

(1) Score A (Figure 1): Analysis of Neck, Trunk, and Legs: Individual scores are determined for the neck, trunk, and legs based on their postural angles. By cross-referencing these scores with Table A, Posture Score A is obtained. The total Score A is then calculated by adding the force/load score.
(2) Score B (Figure 2): Analysis of Upper Arms, Lower Arms, and Wrists: The range of motion for these three segments is evaluated to derive individual scores. These are cross-referenced with Table B to obtain Posture Score B, which is then adjusted by the coupling score to reach the total Score B.
(3) Integrated Scoring (Figure 3): The total scores from A and B are cross-referenced with Table C. An additional activity score is added to determine the Final REBA Score.
(4) Risk Level Assessment: A higher score indicates a greater ergonomic risk. The risk levels are categorized as follows: 1 point: Negligible (no action required); 2–3 points: Low (change may be needed); 4–7 points: Medium (change necessary); 8–10 points: High (investigate and implement change soon); 11+ points: Very High (implement change immediately).

SCORES

Table A		Neck											
		1				2				3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Figure 1: Score A.

Table B		Lower Arm					
		1			2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Figure 2: Score B.

Score A (score from table A +load/force score)	Table C: Score B, (table B value +coupling score)											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Figure 3: Integrated scoring.

This study utilized the Nordic Musculoskeletal Questionnaire (NMQ), an instrument originally developed by Dickinson et al. (1992) to assess general musculoskeletal conditions among various occupational groups, including data entry clerks, technicians, administrative staff, and supermarket cashiers. The questionnaire evaluates 15 body regions—including the upper back, lower back, neck, shoulders, elbows/forearms, hands/wrists, hips/thighs, knees, and ankles/feet (distinguishing between left and right sides)—using a 0–5 point scale to assess the level of soreness and joint mobility.

REBA AND NMQ ASSESSMENT RESULTS

The Rapid Entire Body Assessment (REBA) was conducted to evaluate the bathing postures of 15 caregivers. The results yielded a mean risk score of 11.7 (SD = 1.0), which falls into the 'Very High Risk' category. This score indicates an urgent need for immediate intervention and postural adjustments to prevent long-term musculoskeletal injuries.

Among the 15 caregivers, lower back discomfort was perceived as the most significant (mean = 1.8, SD = 1.61), followed by discomfort in the left forearm/elbow (mean = 1.66, SD = 1.52).

DESIGN RESEARCH AND FEATURES

Most bathing aids currently available on the market are designed for single functions and generally lack care-related features such as automatic foam dispensing and rinsing. Consequently, they are insufficient in effectively addressing the operational workload of caregivers in real-world bathing care contexts. This study adopts an observational approach to directly document and analyze caregivers' operational procedures and behaviors during bathing care. The findings are then translated into explicit design goals and functional plans, leading to the design of a bathing aid device suitable for use in long-term care facilities.

The design features and solutions to the problems of this product are as follows:

1. Design Feature: Safe transfer between bed and device, assisted mobility between bedroom and bathroom (as shown in Figure 1).
   Issue Addressed: Mitigates patient fall risks and caregiver fatigue by streamlining the transfer process and reducing the physical load of manual lifting.
2. Design Feature: Usability for both sitting and lying down (as shown in Figure 2).
   Issue Addressed: By enabling seamless transitions between sitting and lying, it enhances user autonomy and activity range while optimizing spatial efficiency in care environments.
3. Design Feature: Hygienic temporary waste management (as shown in Figure 3).
   Issue Addressed: This feature implements non-contact hygiene management to mitigate cross-infection and odors.
4. Design Feature: Simplified operation and maintenance.
   Issue Addressed: Streamlined interfaces and maintenance reduce accidents from misuse and lower cognitive load. The easy-to-clean structure eliminates hygiene dead zones, extending product service life and ensuring long-term usability.

Overall, the device effectively reduces physical and mental burden on caregivers while improving bathing efficiency and safety.

Figure 4: Transfer between bed and device.

Figure 5: Usability for both sitting and lying down.

Figure 6: Hygienic temporary waste management.

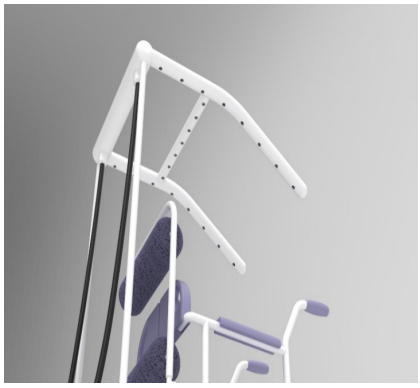

Figure 7: Water spray & body wash outlets.

CONCLUSION AND SUGGESTIONS

This study has completed the overall design concept construction of the bathing aid, based on the aforementioned observations and needs analysis, considering the main functions and usage scenarios of the device, and proposing specific functional plans. However, this study is still in the design concept and functional design stage and has not yet entered the physical

development and verification phase. Future research suggests further 3D modeling and prototype production of the device, as well as verifying its feasibility, operability, and practicality through actual operation testing and user feedback, to serve as the basis for subsequent design optimization and application promotion.

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