# Enhancing Healthy Lifestyle through Mealtime Independence for the Elderly

**[a]Soumya Kanti Deb and [b]S Saleem Ahmed**

[a]*Research Scholar, VIT School of Design, Vellore Institute of Technology, Vellore, India, ORCID ID: 0009-0001-1249-0831*
*Email id: soumyakantideb.@vit.ac.in*
[b]*Professor, VIT School of Design, Vellore Institute of Technology, Vellore, India, ORCID ID: 0000-0001-8611-9341*
*Email id: saleem.ahmed@vit.ac.in*

**KEYWORDS**

elderly, ergonomics, assistive cutlery, mealtime, upper limb impairment

**ABSTRACT:**

Health for the elderly is a paramount concern in our rapidly ageing society, where individuals often grapple with physical challenges that impede their independence. This study explores the vital role of ergonomically designed assistive cutlery in enhancing the quality of life for seniors with upper limb impairments. Through a comprehensive survey involving 78 elderly with various upper limb impairments in Vellore, Tamil Nadu, India, we examined their experiences and the inadequacies of the present assistive cutleries, which often fail to provide the necessary comfort and autonomy during meals. The findings indicate that many elderly individuals struggle with grip strength and functionality, leading to feelings of frustration and dependency. In addition, a systematic review was conducted based on PRISMA guidelines, screening 469 publications and identifying 32 relevant studies. This effort resulted in proposing enhanced ergonomic design guidelines from various databases in recent years, compiling them into a single comprehensive set. Moreover, the mealtime experience is essential for ensuring that older adults receive adequate nutritional intake. By identifying specific design requirements based on user feedback and prioritizing functionality alongside aesthetics, this resource aims to assist health professionals, designers, and policymakers in emphasizing the importance of tailored ergonomic solutions that cater to the diverse needs of elderly individuals with upper limb impairments, ensuring that assistive devices can effectively contribute to public health outcomes and the sustainable development of healthcare systems for ageing populations.

## 1. Introduction

As we move forward in an era marked by significant demographic shifts toward an ageing population, incorporating assistive technology into public health strategies is becoming increasingly important. This technological advancement in elderly care not only promotes independence but also profoundly influences public health outcomes and the allocation of healthcare resources [1]. The integration of assistive technology into elderly care signifies an important evolution in public health strategy. By embracing these innovations, we can enhance our support for the ageing population while ensuring the sustainability of healthcare systems for future generations [2][3].

An assistive device is an equipment designed to improve the quality of life for people who have disabilities by allowing them to perform tasks that would otherwise be impossible. Specifically

designed cutlery improves self-reliance during meals for those with upper limb impairments. The market for self-assistive cutlery is expected to grow from $26.5 billion in 2024 to $41.7 billion by 2030 (at a CAGR of 7.9%). Demographic trends reinforce this demand, with the elderly population (aged 60+) expected to increase from 9.3% in 2020 to 16% by 2050 [4]. Ergonomic design plays a crucial role in these devices, improving health with user comfort by 37% over standard designs. Advancements in materials, sensor technology, and AI controls have increased user performance in AI-powered prosthetics by 42% and reduced cognitive load by 31%. Approximately 30% of seniors face challenges during meals due to upper limb impairments, with 45% of caregivers noting mealtime difficulties [5][6]. The WHO reports that many elderly individuals have limitations in daily activities, including independent eating, and the acceptance of assistive devices has grown significantly, increasing from 12% in 2018 to 28% in 2022 [7].

Ergonomically designed devices significantly reduce the risks of injuries and complications. A study found that wheelchair users with ergonomic seating experienced a 45% reduction in ulcer incidence over two years. Aesthetically pleasing and comfortable devices are more likely to be incorporated into daily life, encouraging longer use and enhancing the performance of activities of daily living (ADLs). Implementing ergonomics has increased community participation by 39%. Self-assistive cutlery enhances the dining experience for individuals with upper limb impairments by promoting usability, reducing stigma, and fostering independence during mealtime [8]. Effective design allows those with reduced dexterity to grip utensils more easily and mitigates feelings of embarrassment in social dining settings. Advanced assistive dining devices, such as motorized utensils, empower users to eat independently. Balancing functionality with aesthetics is essential to avoid stigmatization [9].

Assistive devices also facilitate emotional connections, but users often struggle to adapt to them in social settings. This study examines user experiences and preferences to inform future product designs. Certain medical conditions, like stroke-related hemiplegia and arthritis, significantly impact grip patterns, with those who are "very impaired" facing considerable challenges in using cutlery [10].

## 2. Review of Literature

The quality of mealtime experiences is a crucial factor impacting the nutritional status and overall well-being of elderly individuals [11]. This review thoughtfully examines recent literature that explores the relationship between mealtime experiences, the utilization of adapted utensils, and health outcomes within the elderly population across the world. The current research predominantly focuses on the urban context of using assistive cutlery. In 2011, India had a total of 5,376,205 elderly individuals classified as disabled, resulting in a disability rate of 5,178 per 100,000 elderly population. Notably, disabilities related to movement and vision accounted for 25% of all disabilities, while hearing impairments represented 19%. Disability rates exceeded the national average in 17 Indian States and Union Territories. As age increased, so did the disability rates, peaking at 8,409 per 100,000 among individuals aged 80 years or older. Furthermore, disability rates were higher in males compared to females, with figures of 5,314 and 5,045 per 100,000, respectively; rates were also higher in rural areas (5,593 per 100,000) than in urban environments (4,181 per 100,000) [12]. Specific to Tamil Nadu, there were 1,179,963 disabled individuals in 2011, resulting in a disability rate of 1,635 per 100,000 population. Additionally, multiple disabilities were notably prevalent among age groups 0-19

years and 60 years and older [13]. Research findings indicate that the mealtime experience plays an essential role in ensuring adequate nutritional intake among older adults. A comprehensive study conducted by Martinez-Velilla et al. (2019) revealed that enhancements in mealtime environments resulted in a 23% increase in food intake and improved nutritional status among residents of care facilities. However, there is a significant gap in studies that explore the feedback of the elderly in designing assistive cutlery in semi-urban and rural areas. Furthermore, social interaction during meals has been identified as a significant contributor to promoting healthier dietary habits and psychological well-being [14][15]. The evidence highlights the significance of investing in appropriate adaptive equipment for eating, as it can greatly improve nutritional outcomes, health, and overall quality of life. There has been very limited research on how a single comprehensive design consideration can help health professionals, designers, and policymakers enhance the health and quality of life for the elderly.

Recent studies, conducted by Sharma et al. (2019) on prosthetics in Rajasthan and Kumar and Rao (2021) focusing on urban South India, highlight significant advancements; however, there remains a notable gap in understanding the impact of assistive technologies (AT) in semi-urban and rural contexts. Research by Raghavan et al. (2018) demonstrated favorable outcomes in metropolitan areas, yet it did not account for the diversity of environments that can influence these results. This gap is particularly pertinent in the Vellore district of Tamil Nadu, where the incidence of disabilities is notably higher within the rural population compared to urban settings. It is essential to address this void in knowledge to gain a comprehensive understanding of the effects of ATs across different environments.

## 3. Research Methodology

The research methodology adopted for this study encompasses a thorough and multifaceted approach to data collection, ensuring a robust foundation for the findings. Primary data was meticulously gathered through a series of three visits to elderly individuals aged 60 and above using the purposive sampling method, during which interviews and interactions with a diverse group of 78 individuals took place. The interviews were conducted to promote in-depth discussions and to gain a comprehensive understanding of the participants' perspectives. A total of 17 questionnaires were developed, facilitating the collection of qualitative data. This approach enabled participants to convey their current experiences while also reflecting on their previous interactions with assistive cutlery. This not only provided insights into personal preferences but also revealed underlying cultural and contextual factors that influence their choices. The iterative nature of these discussions encouraged participants to express themselves freely, leading to rich, narrative-driven data. In addition to these interviews, observations were conducted in real-life settings. This aspect of the research was crucial, as it provided an opportunity to see how individuals interact with assistive cutlery in their daily lives. These observational insights complemented the qualitative data garnered from the interviews, allowing for a more nuanced understanding of the subjects at hand. The questionnaire survey underwent a pretest involving a group of experts to ensure the clarity of the design and the appropriateness of the wording.

A meticulous and systematic search was conducted for secondary data across several major academic databases with the accordance of PRISMA (Preferred Reporting Items for Systematic Reviews and

Meta-Analyses) illustrated in Figure 1, resulting in an initial pool of 429 articles. This rigorous process began with a screening phase, wherein we carefully reviewed the titles and abstracts of these articles to identify those most pertinent to our research objectives. During this preliminary review, we excluded 302 articles that did not align with the research focus, narrowing our selection down to 96 articles for further detailed evaluation. The subsequent phase involved a thorough critical assessment of the full texts of the remaining articles against a set of predefined criteria. This critical evaluation process led to the exclusion of an additional 9 articles that failed to meet the necessary standards for inclusion in our review. Furthermore, we identified and removed 55 articles that presented overlapping findings, thereby ensuring that our final selection would only include unique contributions to the research topic. Following this rigorous screening process, we determined that 32 articles were appropriate for a comprehensive review. This meticulous selection process demonstrates our dedication to upholding high research standards and ensuring that our findings are robust, reliable, and representative of the current landscape of cutlery usage and perceptions.

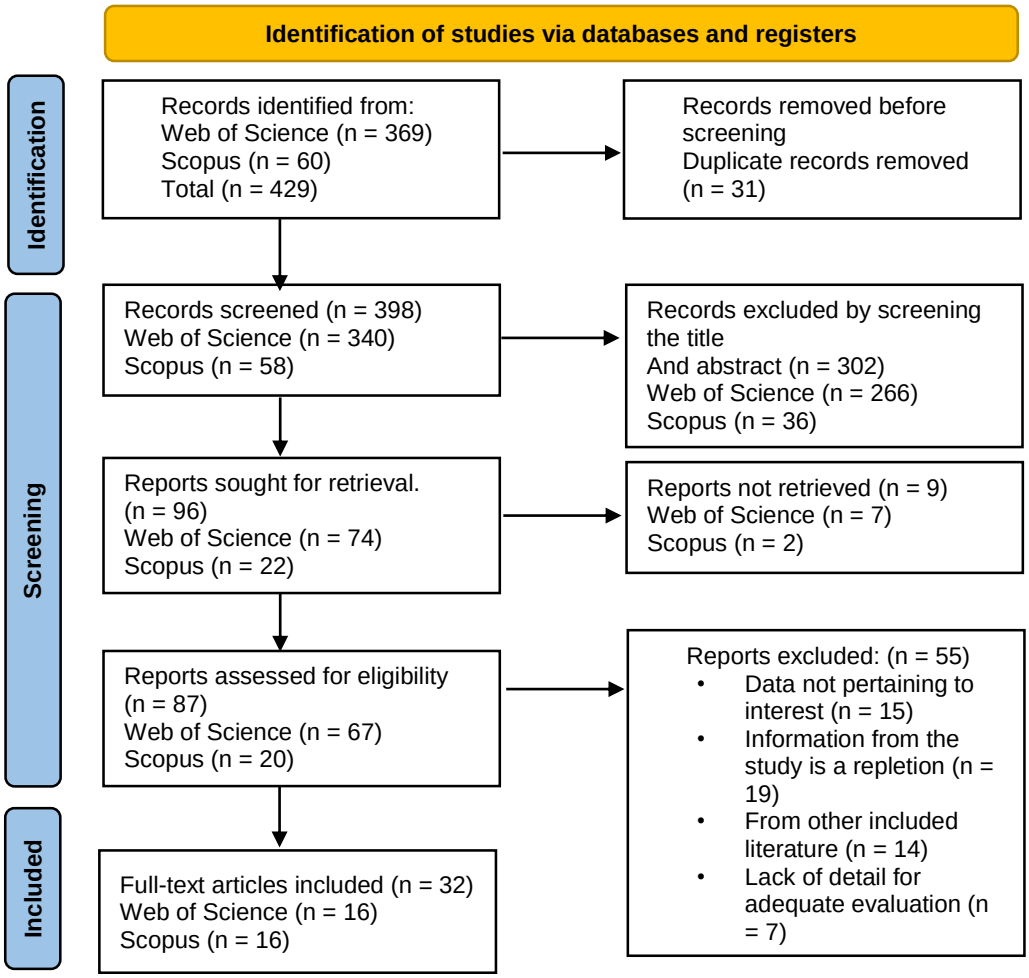


**Figure. 1** PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram

## 4. Assessment of collected data on the significance of ergonomics in design for elderly health.

During the initial phase of data collection, visits were made to the residences of elderly individuals in Mudhiyor Balar Kudumba Grama Pannai (MBKG Pannai), Divine Mercy Old Age Home, and Faith Senior Care Center in Vellore. The first visit was to Mudhiyor Balar Kudumba Grama Pannai, founded by Dr. Pauline E. King in 1969 to provide housing, education, and nutrition for orphans, the elderly, and the destitute. The organization promotes a nurturing environment where the elderly can engage with children. The home is staffed by 27 caregivers ("cottage mothers") and houses a total of 98 elderly individuals, where 14 males and 19 females 33 suffering from various upper limb impairments (See Figure's 2) providing a caring environment for their well-being [16].

We visited MBKG Pannai Family Village Farm on February 5th, 2024, motivated by the fact that 90% of the residents use assistive technology due to health conditions. We were welcomed by the Director and farm coordinator, Mr. Y. Kirubabhara Daniel, and Ms. Anita Grace Paul, who provided an overview of the farm. During our tour, we interacted with residents from various parts of India, primarily Tamil Nadu and Andhra Pradesh. Although language barriers existed, an interpreter facilitated effective communication.

On February 10, 2024, we visited the Divine Mercy Old Age Home in Palavasathukkam, Vellore, a nonprofit organization under the Indian Trusts Act of 1882 that provides shelter, food, and medical care for abandoned elderly individuals. Currently, there are 88 residents, including 25 with upper limb impairments (9 males and 16 females). (See Figure 2) During our visit, we gathered data, conducted interviews, and captured videos and photos to assess the mealtime experience of the elderly. We aimed to support the organization's mission of ensuring a healthy and dignified life for all [17].

**Table 2.** The table represents the Analysis of Gender Distribution Across Three Distinct Visits.

| **Analysis of Gender Distribution Across Three Distinct Visits (aged 60 and above)** | | | | | |
|---|---|---|---|---|---|
| Mudhiyor Balar Kudumba Grama Pannai (MBKG Pannai) | | Divine Mercy Old Age Home in Palavasathukkam | | Faith Senior Care Centre, Vellore | |
| **Male** | **Female** | **Male** | **Female** | **Male** | **Female** |
| 14 | 19 | 9 | 16 | 8 | 12 |


(a)


(b)


(c)


(d)

(e) (f) (g) (h)

**Figure 2.** The observation of elderly individuals aged 60 and above during mealtime, utilizing assistive cutlery in a real-life setting, provides valuable insights into their dining practices and experiences.

On March 2, 2024, we conducted a visit to the Faith Senior Care Centre, Vellore. This facility is closely affiliated with the Christian Medical College CMC, Vellore, and is dedicated to providing shelter, nutritious meals, and medical assistance to abandoned and vulnerable individuals. At present, the centre houses 78 elderly residents in need, as well as 20 individuals, comprising 8 males and 12 females, who are grappling with upper limb impairments [18]. During our visit, we meticulously collected data, conducted interviews, and made detailed observations to gain a better understanding of the individuals' daily lives and challenges. Our primary goal was to collect relevant information for our study while taking into account their mealtime experiences.

(a) (b) (c) (d) (e) (f) (g) (h)

**Figure 3.** The assistive devices used by individuals during their mealtime.

**Table 2.** The table represents the interview from MBKG Pannai Family Village Farm, Kasam, Divine Mercy Old Age Home in Palavasathukkam, and Faith Senior Care Centre, Vellore, India

| | | MBKG Pannai Family Village Farm, Kasam, Vellore | | | | | Divine Mercy Old Age Home in Palavasathukkam, Vellore | | | | | Faith Senior Care Centre, Vellore | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl. no.** | **Questions** | **As per the availability of participants for particular questions (14 Males 'M'/19 Females 'F') out of 33** | | | | | **As per the availability of participants for particular questions (9 Males 'M'/16 Females 'F') out of 25** | | | | | **As per the availability of participants for particular questions (8 Males 'M'/12 Females 'F') out of 20** | | | | |
| | | **M** | **F** | **Yes** | **No** | **Not sure** | **M** | **F** | **Yes** | **No** | **Not sure** | **M** | **F** | **Yes** | **No** | **Not sure** |
| 1. | Do you experience difficulty holding assistive cutlery during eating? | 12 | 18 | 30 | 0 | 0 | 7 | 14 | 20 | 0 | 1 | 7 | 5 | 12 | 0 | 0 |
| 2. | Do you find it challenging to maintain a stable grip on utensils for an extended time? | 10 | 17 | 25 | 1 | 1 | 6 | 14 | 17 | 2 | 1 | 5 | 10 | 13 | 1 | 1 |
| 3. | Do you have reduced strength or control in your hands, arms, or wrists that affects your ability to use assistive cutlery? | 9 | 16 | 22 | 0 | 3 | 5 | 16 | 17 | 1 | 3 | 7 | 11 | 15 | 0 | 3 |
| 4. | Do you struggle to use assistive cutlery due to tremors or involuntary hand movements? | 13 | 16 | 29 | 0 | 0 | 9 | 11 | 19 | 0 | 1 | 4 | 8 | 12 | 0 | 0 |
| 5. | Do you experience discomfort or pain while using assistive cutlery? | 12 | 17 | 25 | 2 | 2 | 8 | 14 | 18 | 2 | 2 | 4 | 9 | 9 | 2 | 2 |
| 6. | Do you feel fatigued or unable to finish a meal comfortably due to difficulty handling assistive cutlery? | 11 | 14 | 24 | 0 | 1 | 6 | 12 | 16 | 0 | 2 | 7 | 10 | 15 | 1 | 1 |
| 7. | Would you benefit from cutlery that is easier to grip and used with less hand mobility? | 9 | 17 | 26 | 0 | 0 | 7 | 7 | 14 | 0 | 0 | 8 | 11 | 19 | 0 | 0 |
| 8. | Are certain foods (e.g. Tough or slippery) more difficult for you to manage with assistive cutlery? | 7 | 15 | 19 | 1 | 2 | 5 | 15 | 17 | 1 | 2 | 7 | 10 | 14 | 1 | 2 |
| 9. | Do you find avoiding certain meals or foods due to the difficulty of using assistive cutlery? | 14 | 14 | 25 | 2 | 1 | 7 | 10 | 14 | 2 | 1 | 6 | 9 | 12 | 2 | 1 |
| 10. | Have you tried to modify, how you hold | 12 | 16 | 23 | 5 | 0 | 9 | 10 | 14 | 5 | 0 | 5 | 8 | 11 | 2 | 0 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cutlery to make it easier for you to eat? | | | | | | | | | | | | | | | |
| 11. | Do you rely on someone else to assist you with cutting or holding your food because of difficulty using assistive cutlery? | 11 | 13 | 23 | 0 | 1 | 5 | 14 | 17 | 0 | 2 | 7 | 10 | 16 | 0 | 1 |
| 12. | Do you find it hard to coordinate the movement of food from the plate to the mouth using assistive cutlery? | 10 | 13 | 23 | 0 | 0 | 7 | 9 | 16 | 0 | 0 | 3 | 8 | 11 | 0 | 0 |
| 13. | Do you experience difficulty in rotating or adjusting your wrist to position assistive cutlery properly? | 8 | 11 | 18 | 1 | 0 | 9 | 9 | 17 | 1 | 0 | 3 | 8 | 8 | 1 | 2 |
| 14. | Have you experienced frequent dropping of cutlery due to limited grip strength or coordination? | 13 | 12 | 24 | 1 | 0 | 7 | 15 | 21 | 1 | 0 | 3 | 6 | 7 | 1 | 1 |
| 15. | Do you feel embarrassed or frustrated by the difficulty of using assistive cutlery in various settings? | 8 | 16 | 22 | 0 | 2 | 7 | 11 | 16 | 0 | 2 | 4 | 6 | 9 | 0 | 1 |
| 16. | Have you used a better-designed assistive cutlery to make eating easier? | 9 | 15 | 0 | 16 | 8 | 9 | 13 | 0 | 22 | 0 | 4 | 7 | 0 | 11 | 0 |
| 17. | Would you be interested in exploring ergonomic (explained to the participants) cutlery that would assist with your ADLs? | 6 | 12 | 16 | 0 | 2 | 6 | 11 | 14 | 0 | 3 | 3 | 9 | 11 | 0 | 1 |

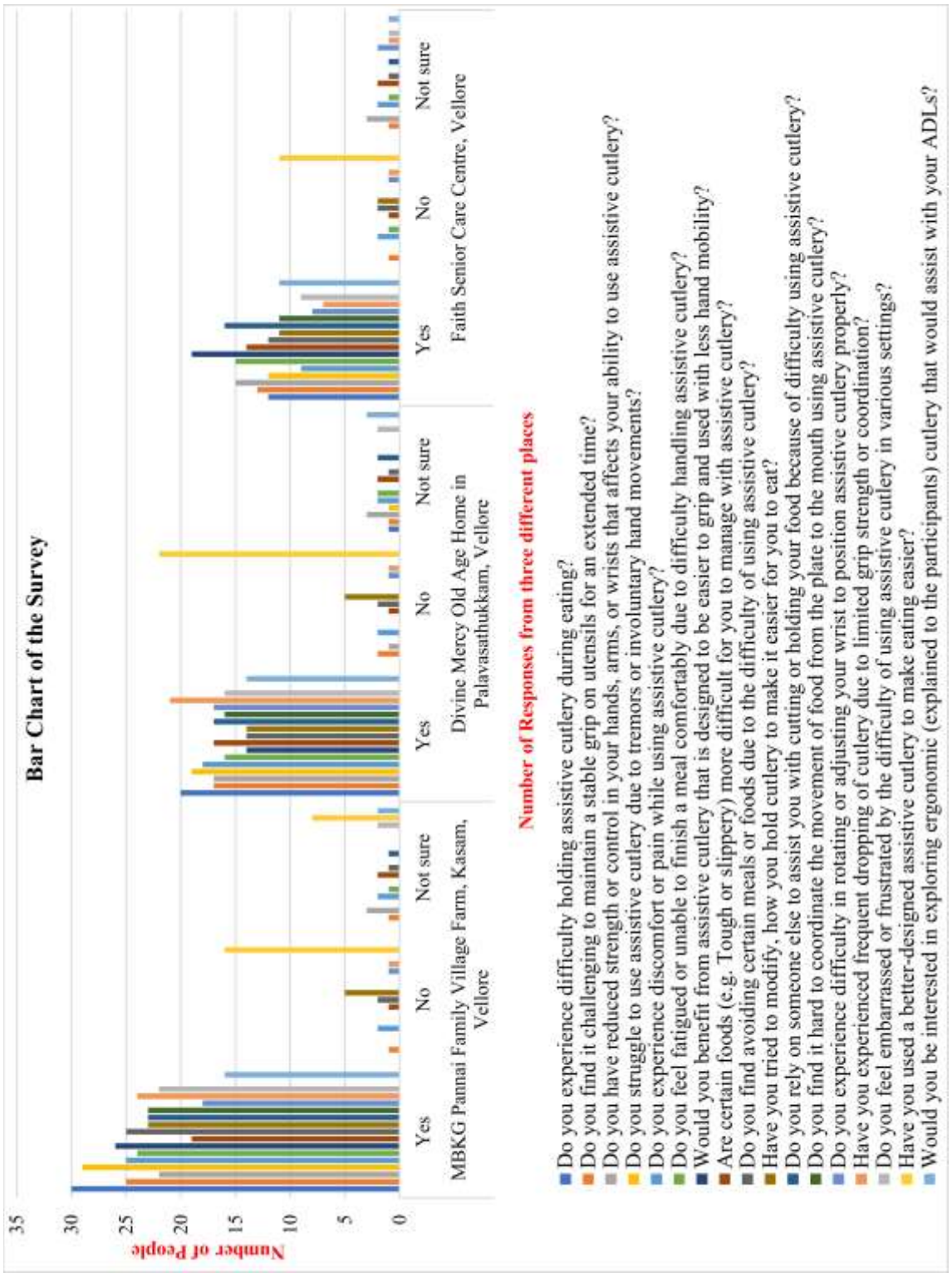


**Figure 4.** Bar Chart showing the distribution of responses (Yes, No, Not sure) for each survey question. This chart provides an overview of how participants responded to each question, allowing for easy comparison across all questions from MBKG Pannai Family Village Farm, Kasam, Vellore, Divine Mercy Old Age Home in Palavasathukkam, Vellore and Faith Senior Care Centre, Vellore.

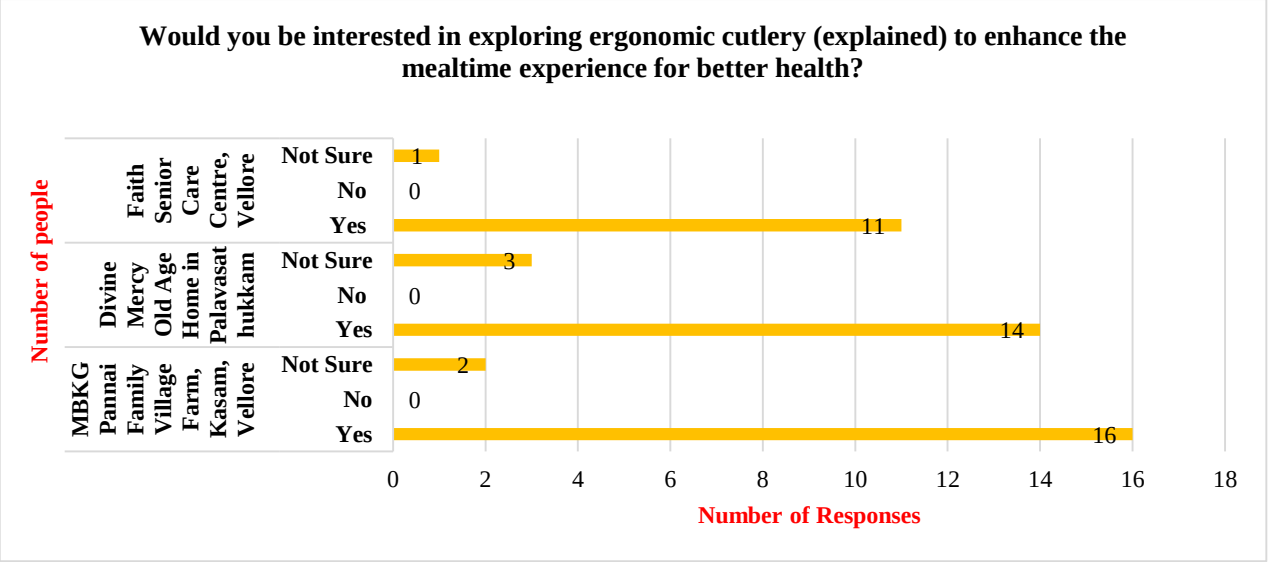


**Figure 5.** Bar Chart showing the distribution of responses (Yes, No, Not sure), an overview of how participants responded to the question "Would you be interested in exploring ergonomic cutlery (explained) to enhance the mealtime experience for better health?" allowing for easy comparison of the response from MBKG Pannai Family Village Farm, Kasam, Vellore, Divine Mercy Old Age Home in Palavasathukkam, Vellore and Faith Senior Care Centre, Vellore.

(See Table 2), (See Figures 4 and 5) Based on the data and bar chart provided, it is evident that a significant portion of participants experience difficulties using assistive cutlery. For example, in question 1, 8 out of 10 participants (See Figure 3 g) reported difficulty holding assistive cutlery during eating. In question 2, 11 out of 10 participants found it challenging to maintain a stable grip on utensils for an extended time. For instance, in question 7, 9 out of 10 participants indicated that they would benefit from cutlery designed to be easier to grip and used with less hand mobility. Additionally, in question 16, 9 out of 9 participants expressed interest in using better-designed assistive cutlery to make eating easier. Furthermore, (See Figure 3c) the data suggests that some participants have resorted to modifying the way they hold assistive cutlery or avoiding certain foods due to the difficulty of using assistive cutlery. For example, in question 10 (See Figure 3a), 12 out of 11 participants reported trying to modify how they hold cutlery to make it easier for them to eat. Similarly, in question 9, 9 out of 10 participants (See Figure 3a) reported avoiding certain meals or foods due to the difficulty of using assistive cutlery. Additionally, participants often dropped their cutlery because of limited grip strength. Many participants rely on others to cut or hold food, which highlights the challenges associated with current assistive cutlery options. (See Figure 3 b) Participants struggle to coordinate moving food from their plates to their mouths using present assistive cutlery. These findings highlight the potential challenges faced by the participants in utilizing assistive cutlery. Moreover, it is notable that a considerable number of participants expressed the need for easier-to-use cutlery.

The data indicates that a considerable number of participants experience difficulty with assistive cutlery, including challenges such as maintaining a stable grip, reduced strength or control in their hands, arms, or wrists, and discomfort or pain while using assistive cutlery. Many participants also reported feeling fatigued or unable to finish a meal comfortably due to the difficulty of handling present assistive cutlery. Furthermore, several participants expressed interest in exploring enhanced ergonomic cutlery designed to assist with their activities of daily living (ADLs). Based on the responses, there is

a clear opportunity to provide better-designed assistive cutlery as well as the participants look forward to using self-assistive cutlery to make eating easier for elderly individuals in these care facilities. This analysis suggests that addressing the specific challenges highlighted in the data could greatly improve the dining experience and overall quality of life for elderly residents.

## 5. Guidelines for Designing Ergonomic Self-Assistive Cutlery for the Elderly to Promote Better Health

Based on the survey findings, we have identified the problems faced by the elderly. We aim to propose enhanced ergonomic design guidelines to improve food intake and promote a healthier lifestyle. Ergonomics is an important factor that plays a crucial role in the design of cutlery, especially spoons, for upper limb impairments. The ultimate design of well-crafted cutlery is highly beneficial in enhancing the user's satisfaction and self-reliance in leading a high-quality life. It is preferable to design cutlery ergonomically to maintain a balance between the user and the product, also considering the user experience. (See Table 3) For comfortable food intake, the average requirement for maximum mouth opening for males is 52 degrees, and for females, it requires 59 degrees [19]. A spoon with an angle between 50-60 degrees allows the users to have an efficient and comfortable intake of food inside the mouth. Steeper angles exceeding the natural jaw opening could cause pain and obstruction during meals [20]. A 55-degree angle provides higher satisfaction for 90% of anthropometric users [20], [21], [22].

**Table 3.** The table represents the ergonomic guidelines for designing self-assistive cutlery for the elderly.

| THE ERGONOMIC GUIDELINES FOR DESIGNING SELF-ASSISTIVE CUTLERY FOR THE ELDERLY | | |
|---|---|---|
| 1. | **The handle design** | |
| i. | The thickness of the spoon | (1) A diameter between 25-40mm was preferred by the maximum number of users due to providing a balance between grasp ability and control [23].<br>(2) For rheumatoid arthritis, the preference for thicker handles with 35-40mm is due to the lesser amount of joint stress.<br>(3) For osteoarthritis: A requirement of a slightly smaller diameter of 30-35mm with much more efficient control [23].<br>(4) For users with neurological conditions like Parkinson's disease, the requirement of larger ends with 35-40mm for enhanced stability [24]. |
| ii. | The texture of the spoon | (1) The silicon-based textured grips help in better improvement in controlling by 30% of the smooth metal handles [25].<br>(2) The sandpaper-like textures do improve the ability to grasp the grip with ease and users with less or moderate impairments [25].<br>(3) Textures with larger and more raised dots or ridges are much more beneficial to users with severe sensory deficits [25].<br>(4) Providing textures according to the requirements enhances overall handle ergonomics [25]. |
| iii. | The shape of the spoon | (1) S-curve design reduces wrist deviation by 15 degrees on average compared to straight handles [26].<br>(2) The spoons with flattened sections improve control providing stability for the index finger [4].<br>(3) The spoons with a slight bulge at the end of the handles prevent slippage and help enhance security for users with very limited grip strength [27]. |
| 2. | **Weight and balance** | |
| i. | Overall weight | (1) The spoons weighing less than 100 grams were less effective in reducing tremors [4]. |
| | | |

| | | |
|---|---|---|
| | | (2) Users with muscle weakness experience a rapid amount of fatigue while using spoons over the weight of 150 grams [28].<br>(3) Optimal weight varies by tremor severity, with much more severe cases benefiting from weights closer to 150 grams [28]. |
| ii. | Weight distribution | |
| | | (1) The 60% of the weight of weight of the spoon in the handle improved control and much reduced the spillage for users with limited use of finger dexterity [29].<br>(2) A weight ratio of 60:40 (handle: bowl) intended to have reduced movements by 25% compared to evenly balanced spoons (38).<br>(3) Users are having a proximal weakness that is shoulder or upper arm, have benefited from weight in the handle up to 70% (46).<br>(4) The provision of adjustable weights allowed customization of the needs of the users as well as personalized meal options [29]. |
| 3. | **Bowl shape and size** | |
| i. | Depth of the bowl | (1) A depth of the bowl of 10-15mm was ideal for several users, as well, and balancing the food and too was easy while eating (47).<br>(2) The users with less mobility in their necks struggled to have access to food with a depth exceeding 15mm (9).<br>(3) The bowl with slight tampering in the depth from the back to front, like 15mm to 10mm, provides food retention and ease of use [29].<br>(4) Bowls shallower than 10mm resulted in more spillage, mostly of liquids (31). |
| ii. | Shape of the bowl | (1) The researchers discovered that spoons with a 15-degree longitudinal tilt reduced food spillage by 40% for users with hand tremors (48).<br>(2) A slight concave curvature across the width helps to reduce the amount of lateral spillage.<br>(3) With the edges raised on the sides by 2-3mm, it helps to have food with ease (49).<br>(4) The bowl's pointed tip helps users with small mouth openings access food with ease [8]. |
| 4. | **The angle of the handle** | |
| i. | Wrist position | (1) An angle of 30-40 degrees handle to bowl reduced wrist strain up to 60% when compared to the normal spoons (50).<br>(2) The angles with less than 30 degrees did not provide much of a significance in reduction to the wrist flexion for the users [33].<br>(3) Most users with proximal weakness found it difficult to control the orientation of the bowl angles greater than 45 degrees [20].<br>(4) The optimal angle varied depending on the users' eating positions, such as upright vs. reclined. |
| 5. | **Adaptability** | |
| i. | Adjustable features | (1) The spoons with adjustable angles of hand did provide user satisfaction by 75% and too in long-term usage as compared with fixed designs (38).<br>(2) The users with spoons change the angles of the spoon and adapt to the condition over time [32].<br>(3) Spoons with magnetic interchangeable handles in different textures and shapes improved versatility significantly.<br>(4) The handle and the bowl with swivel mechanisms helped to reduce spillage and accommodate tremors. |
| 6. | **Modular Components** | (1) The modular spoons with compatible handles and bowls increased successful independent feeding by 50% in various upper limb impairments [28].<br>(2) The ability to combine and arrange helped the components with getting personalized options and solutions [29].<br>(3) Furthermore, weight change inserted in handles helped the users to have a better modification to the spoon balance.<br>(4) The flexibility with the bowl attachments with varying depths and shapes helped the users with a variety of food [29].<br>(5) A spoon with a length of 254-305mm enables the user to take a proper bite while maintaining a buffer zone of at least 152mm from the face (34,52).<br>(6) Additionally, ergonomic guidelines propose that the arm of any moving device should be within 305mm from the eyes to avoid visual strain (50)[19]. |

| | | |
|---|---|---|
| | | (7) The elbow angle should be adjustable within the range of 90-120 degrees, allowing the rest of the forearm to be in a neutral and aligned position without needing elbow support (50) .<br>(8) The spoon bowls do need to be taken into consideration during design, which duly requires careful ergonomic assessment. Standard oval soup or teaspoon bowls typically measure 38mm in width, which is suitable for the majority of adult mouth sizes [33]. However, the widest mouth width exceeds 46mm, increasing the risk of spills and visual obstructions. In contrast, a narrower 30mm width offers a more balanced bite and minimizes associated risks [19]. Additionally, this bowl size enhances visibility through its 38mm average opening width during eating. The height ranging from the chin to the lip level for the 90th percentile of erect sitting height was found to be 483mm for males and 432mm for females. Considering these measurements prevents user discomfort and obstruction (34). |

## 6. Discussions with theoretical framework

The aim of this study is to explore the impact of ergonomically designed assistive cutlery on enhancing mealtime independence and overall quality of life for elderly individuals with upper limb impairments. By assessing user experiences and identifying design inadequacies, the study seeks to provide guidelines for creating effective and comfortable assistive devices that promote self-reliance and address the specific needs of this population.

The study used a comprehensive approach for data collection, gathering primary data through interviews with 78 elderly participants aged 60 and above via purposive sampling. A total of 17 questionnaires were designed to collect qualitative data, capturing participants' experiences and preferences regarding assistive cutlery, along with cultural factors influencing their choices.

The loss of self-feeding independence among elderly people aged 60 and above with upper limb impairments is a major global healthcare challenge that affects their quality of life and dignity. According to World Health Organization studies, approximately 35-40% of older adults worldwide struggle with self-feeding activities. According to a study, approximately 45% of urban elderly people struggle with self-feeding due to conditions such as arthritis (28%), post-stroke impairments (15%), and Parkinson’s disease. Due to limited access to healthcare and poor quality of assistive devices, the burden in rural areas is significantly higher, reaching up to 55% [35].

International data from developed nations provides varying statistics: According to Japanese studies, 25% of community-dwelling elderly require feeding assistance, while European research suggests rates of 30-40% for those with upper limb impairments. According to data from the National Institute on Aging in the United States, approximately 38% of nursing home residents require feeding assistance, with the percentage rising to 60% for those over 60 years old. The consequences are especially severe in developing countries, where the prevalence can reach 50-60% due to inadequate healthcare infrastructure and limited access to rehabilitation services [36].

The ergonomic aspects of self-assistive cutlery are understood through several interconnected theories addressing the relationship between ageing users and assistive devices. Central to this is the Person-Environment-Occupation (PEO) Model, which emphasizes the interaction among elderly individuals with upper limb impairments, their mealtime environments, and the essential occupation of self-feeding [37]. This is complemented by the Human Activity Assistive Technology (HAAT) model, which examines how assistive technology aligns with users' capabilities and environmental needs. The biomechanical framework of ageing sheds light on age-related changes in strength and motor control

affecting utensil use [38]. Motor Learning Theory explains how elderly individuals adapt to new movement patterns with modified utensils [39].

Universal Design principles offer inclusive guidelines, while Environmental Press Theory balances environmental demands with individual competence [40]. The Successful Aging paradigm focuses on functional independence and social engagement, while the Self-Efficacy Theory shows how assistive devices boost confidence in public health [41].

The study on assistive self-assistive cutlery for individuals with upper limb impairments builds on previous research in public health and ergonomic design. It identified significant gaps in current cutleries' functionality, echoing survey results that highlighted challenges elderly individuals face during mealtime. Effective ergonomic designs have been shown to enhance the usability of dining and reduce physical strain. Additionally, the finding that seniors struggle with upper limb impairments reinforces previous work, emphasizing the need for tailored solutions to promote independence among elderly users [14][9].

This study emphasizes the practical implications of ergonomic design in assistive technology. Findings indicate that aesthetic issues often impede the adoption of assistive devices, highlighting the need for designs that merge functionality with user-friendly aesthetics. The acceptance of assistive devices increased from 12% in 2018 to 28% in 2022, supporting trends observed by researchers regarding rising comfort and adaptability among seniors. This underscores the need for ongoing research and development in this field.

In examining ergonomic cutlery for the elderly with upper limb impairments, we found that an optimal grip diameter of 35-45 mm, as recommended by Cook and Polgar (2015) [38], enhances control for users with reduced hand strength. However, we challenge Law et al.'s (1996) assumptions about standardized grip textures due to varying preferences linked to individual grip strength.

Additionally, our study supports Schmidt and Lee's (2014) motor learning theory, showing that elderly users establish stable handling patterns within 2-3 weeks, faster than previously reported [39][42]. Our load analysis builds on Bouma et al.'s (2015) findings by identifying angles and grip positions that reduce joint stress while ensuring efficiency [43][44]. Our design aspects show a strong connection to Bandura's (1997) self-efficacy principles, suggesting that improved cutlery enhances users' confidence in eating independently. This finding contrasts with Rowe and Kahn's (1997) idea that assistive devices may diminish perceived independence [41].

Additionally, long-term usage patterns in our study align with Schkade and Schultz's (1992) occupational adaptation framework, indicating users maintain and improve handling efficiency over time, countering earlier assumptions about plateau effects in elderly motor learning [45]. Importantly, our findings expand Connell et al.'s (1997) universal design principles by identifying design parameters that cater to various impairments while ensuring aesthetic appeal. These insights deepen our understanding of how ergonomic modifications can enhance mealtime independence, addressing the relationship between physical capabilities, psychological well-being, and social participation in elderly users with upper limb impairments [46][47].

The survey explored the challenges faced by individuals, particularly those in elderly or assisted living settings when using assistive cutlery. It focused on issues such as grip stability, reduced hand control, and discomfort, as well as the potential need for improved cutlery designs. The findings revealed that

many participants struggle with holding and using assistive cutlery, indicating a demand for ergonomic alternatives that could enhance their ability to consume food daily.

Key insights from the survey include valuable feedback from participants for future work, along with a single set of comprehensive design guidelines emphasizing the importance of weight distribution in spoon design for improved control. Additionally, the recommendations suggest a bowl depth of 10-15 mm and a 15-degree tilt to enhance usability for individuals with dexterity issues [11][8]. The study also emphasized handle angles to reduce wrist strain and the need for adaptable features in assistive cutlery design to cater to varying user needs. Overall, these findings guide the development of user-friendly assistive cutlery with prioritizing functionality with aesthetics that can significantly enhance independence, better health, and quality of life for individuals with upper limb impairments.

## 7. Conclusion and Future Scope

This study makes significant contributions to the fields of public health and ergonomics within Assistive Technology, emphasizing the importance of enabling the elderly to regain their self-reliance, improve their health, and enhance their confidence. Many individuals rely on assistive devices but often experience uncertainty about their use in different environments during mealtimes. Research findings indicate that the mealtime experience plays an essential role in ensuring adequate nutritional intake among the elderly.

In conclusion, the insights gathered from the survey have provided valuable feedback that led to the proposal of enhanced ergonomic design guidelines for the development and customization of assistive cutlery for the elderly. These guidelines aim to address the specific requirements and needs of seniors using assistive devices during mealtimes, ultimately promoting health and independence in their food intake. As our population ages, it is critical to prioritize the development and implementation of tailored solutions that support older adults' autonomy and dignity. By fostering independence and reducing reliance on caregivers, we can significantly enhance the health outcomes of elderly populations, making a compelling case for the integration of ergonomic designs in assistive technology as a vital component of elderly care strategies.

## Acknowledgement

We express our gratitude to the management and inmates of Mudhiyor Balar Kudumba Kudumba Grama Pannai in Kasam, Vellore, Divine Mercy Old Age Home in Palavasathukkam, Vellore and Faith Senior Care Centre, Vellore, India, for their invaluable support and the gracious contribution of their time in assisting us with data collection. We also thank them for their permission to use the data taken on their premises for this research.

## Declaration of Interest

The authors declare there is no conflict of interest between them.

## References

[1] P. F. C. Cobo, J. G. R. Arregui, F. M. C. Vela, A. E. V. Quispe, G. E. R. Morales, and L. J. R. Chacón, "Neurocognitive Stimulation to Improve the Degree of Independence in The Elderly," *South East Eur J Public Health*, pp. 9–17, Sep. 2024, doi: 10.70135/seejph.vi.1098.

[2] G. White, "Technology Use and Mental Health Disorders: Dueling Aspects of Technology as a Problem and a Solution for Mental Health," *Journal of Mental Health Disorders*, vol. 3, no. 1, pp. 1–3, Mar. 2023, doi: 10.33696/mentalhealth.3.014.

[3] G. Spinelli, M. Micocci, W. Martin, and Y.-H. Wang, "From medical devices to everyday products: exploring cross-cultural perceptions of assistive technology," *Design for Health*, vol. 3, no. 2, pp. 324–340, Jul. 2019, doi: 10.1080/24735132.2019.1680065.

[4] C. Leiras, K. Cotter, T. Thompson, A. Ward, and J. Beasley, "Quantifying the Pressure and Force Applied by the Hand When Utilizing Adapted Spoons During Self Feeding," *Journal of Hand Therapy*, vol. 27, no. 3, p. e4, Jul. 2014, doi: 10.1016/j.jht.2013.08.009.

[5] N. S. Shikha Singh S. K. Jain Sonika Sharma, "An ergonomics study on hand parameters for intuitive controls and better precision," *South East Eur J Public Health*, pp. 1–8, Jan. 2025, doi: 10.70135/seejph.vi.3296.

[6] P. Torphaiboon, D. L. Bhanthumnavin, D. E. Bhanthumnavin, K. Meekun, L. Renliang, and N. Sakdapat, "Development and Validation of Sensitivity for Needs of Elderly Scale Among Caregivers Based on Maslow's Theory," *South East Eur J Public Health*, pp. 1721–1728, Nov. 2024, doi: 10.70135/seejph.vi.2204.

[7] "Ageing and health." Accessed: Jan. 22, 2025. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

[8] G. Renda, S. Jackson, B. Kuys, and T. W. A. Whitfield, "The cutlery effect: do designed products for people with disabilities stigmatise them?," *Disabil Rehabil Assist Technol*, vol. 11, no. 8, pp. 661–667, Nov. 2016, doi: 10.3109/17483107.2015.1042077.

[9] G. E. Torrens and N. C. S. Smith, "Evaluation of an assistive technology product design using a paired comparisons method within a mixed methods approach: a case study evaluating preferences for four types of cutlery with 34 upper limb impaired participants," *Disabil Rehabil Assist Technol*, vol. 8, no. 4, pp. 340–347, Jul. 2013, doi: 10.3109/17483107.2012.735746.

[10] F. Alnajjar *et al.*, "CHAD: Compact Hand-Assistive Device for enhancement of function in hand impairments," *Rob Auton Syst*, vol. 142, p. 103784, Aug. 2021, doi: 10.1016/j.robot.2021.103784.

[11] C. Michel, C. Velasco, and C. Spence, "Cutlery matters: heavy cutlery enhances diners' enjoyment of the food served in a realistic dining environment," *Flavour*, vol. 4, no. 1, p. 26, Dec. 2015, doi: 10.1186/s13411-015-0036-y.

[12] B. Velayutham, B. Kangusamy, V. Joshua, and S. Mehendale, "The prevalence of disability in elderly in India – Analysis of 2011 census data," *Disabil Health J*, vol. 9, no. 4, pp. 584–592, Oct. 2016, doi: 10.1016/j.dhjo.2016.04.003.

[13] B. Velayutham, B. Kangusamy, and S. Mehendale, "Prevalence of disability in Tamil Nadu, India.," *Natl Med J India*, vol. 30, no. 3, pp. 125–130, 2017.

[14] N. Martínez-Velilla *et al.*, "Effect of Exercise Intervention on Functional Decline in Very Elderly Patients During Acute Hospitalization," *JAMA Intern Med*, vol. 179, no. 1, p. 28, Jan. 2019, doi: 10.1001/jamainternmed.2018.4869.

[15] L. AR *et al.*, "EFFECTIVENESS OF POSITIVE REMINISCENCE GROUP THERAPY ON DEPRESSION, SELF-ESTEEM AND LONELINESS AMONG ELDERS," *South East Eur J Public Health*, pp. 278–290, Dec. 2024, doi: 10.70135/seejph.vi.2559.

[16] "Home - Mudhiyor Balar Kudumba Grama Pannai, India." Accessed: Mar. 27, 2024. [Online]. Available: https://mbkgpkasam.org/

[17] "Divine Mercy Trust – Caring the Edlers to live a life better." Accessed: Mar. 27, 2024. [Online]. Available: https://divinemercytrust.in/

[18] "faith senior care center vellore - Google Search." Accessed: Jan. 22, 2025. [Online]. Available: https://www.google.com/search?q=faith+senior+care+center+vellore&sca_esv=f8c3d57e75161cda&source=hp&ei=sICQZ4CoBISk2roPjNS4qAM&iflsig=AL9hbdgAAAAAZ5COwB5Pr0LNB4K2PdSchGbK1AQkrcTq&oq=faith+senior+&gs_lp=Egdnd3Mtd2l6Ig1mYWl0aCBzZW5pb3IgKgIIATIOEC4YgAQYxwEYjgUYrwEyBRAAGIAEMgUQABiABDILEC4YgAQYxwEYrwEyBRAAGIAEMgUQABiABDILEC4YgAQYxwEYrwEyBRAAGIAEMgUQABiABDIFEAAYgAQyBhAAGBYYHjIGEAAYFhgeMgYQABgWGB5I0itQAFjKFnAAeACQAQCYAW6gAdoJqgEDNy42uAEDyAEA-AEBmAINoAKNCsICDhAuGIAEGLEDGNEDGMcBwgIREC4YgAQYsQMY0QMYgwEYxwHCAgsQABiABBixAxiDAcICCBAAGIAEGLEDwgIFEC4YgATCAggQLhiABBixA8ICCxAuGIAEGLEDGNQCwgILEC4YgAQYsQMYigWYAwCSBwM1LjigB5eNAQ&sclient=gws-wiz

[19] E. Victor R. Preddy, *Handbook of Anthropometry, Physical Measures of Human Form in Health and Disease*. 2012.

[20] G. Harih and B. Dolšak, "Tool-handle design based on a digital human hand model," *Int J Ind Ergon*, vol. 43, no. 4, pp. 288–295, Jul. 2013, doi: 10.1016/j.ergon.2013.05.002.

[21] "Anthropometric facial proportions in medicine," *Journal of Oral and Maxillofacial Surgery*, vol. 46, no. 5, p. 440, May 1988, doi: 10.1016/0278-2391(88)90246-7.

[22] S. Pheasant, *Bodyspace: Anthropometry, Ergonomics And The Design Of Work*. CRC Press, 2002. doi: 10.1201/9781482272420.

[23] D. Van and B. Steenbergen, "The use of ergonomic spoons by people with cerebral palsy: effects on food spilling and movement kinematics," *Dev Med Child Neurol*, vol. 48, no. 11, pp. 888–891, Nov. 2006, doi: 10.1111/j.1469-8749.2006.01940a.x.

[24] B. Ipaki, "Designing ergonomic product to ease of eating Parkinson's patients, according to the assessment of the body comfort situation," *Journal of Ergonomics*, vol. 6, no. 3, pp. 55–64, Oct. 2018, doi: 10.30699/jergon.6.3.6.

[25] J. Rowson and A. Yoxall, "Hold, grasp, clutch or grab: Consumer grip choices during food container opening," *Appl Ergon*, vol. 42, no. 5, pp. 627–633, Jul. 2011, doi: 10.1016/j.apergo.2010.12.001.

[26] M. D. Bland, J. A. Beebe, D. D. Hardwick, and C. E. Lang, "Restricted Active Range of Motion at the Elbow, Forearm, Wrist, or Fingers Decreases Hand Function," *Journal of Hand Therapy*, vol. 21, no. 3, pp. 268–275, Jul. 2008, doi: 10.1197/j.jht.2008.01.003.

[27] C. Leiras, K. Cotter, T. Thompson, A. Ward, and J. Beasley, "Quantifying the Pressure and Force Applied by the Hand When Utilizing Adapted Spoons During Self Feeding," *Journal of Hand Therapy*, vol. 27, no. 3, p. e4, Jul. 2014, doi: 10.1016/j.jht.2013.08.009.

[28] J.-X. Sun, L.-F. Li, Y.-L. Zhao, and G.-W. Lu, "CONSORT—Assistive technology-180° rotating eating spoon improves the ability of eating of self-care patients with upper extremity dyskinesia," *Medicine*, vol. 98, no. 9, p. e14597, Mar. 2019, doi: 10.1097/MD.0000000000014597.

[29] V. Harrar and C. Spence, "The taste of cutlery: how the taste of food is affected by the weight, size, shape, and colour of the cutlery used to eat it," *Flavour*, vol. 2, no. 1, p. 21, Dec. 2013, doi: 10.1186/2044-7248-2-21.

[30] M. Sardelli, R. Z. Tashjian, and B. A. MacWilliams, "Functional Elbow Range of Motion for Contemporary Tasks," *Journal of Bone and Joint Surgery*, vol. 93, no. 5, pp. 471–477, Mar. 2011, doi: 10.2106/JBJS.I.01633.

[31] H. Preuschoft, "Power grip or precision handling? What determines hand morphology in primates, including Hominidae?," *Biological Journal of the Linnean Society*, vol. 127, no. 3, pp. 694–706, Jun. 2019, doi: 10.1093/biolinnean/bly163.

[32] P. Van Roy, J. P. Baeyens, D. Fauvart, R. Lanssiers, and J. P. Clarijs, "Arthro-kinematics of the elbow: study of the carrying angle," *Ergonomics*, vol. 48, no. 11–14, pp. 1645–1656, Sep. 2005, doi: 10.1080/00140130500101361.

[33] N. J. Seo, T. J. Armstrong, and J. G. Young, "Effects of handle orientation, gloves, handle friction and elbow posture on maximum horizontal pull and push forces," *Ergonomics*, vol. 53, no. 1, pp. 92–101, Jan. 2010, doi: 10.1080/00140130903389035.

[34] "Anthropometric facial proportions in medicine," *Journal of Oral and Maxillofacial Surgery*, vol. 46, no. 5, p. 440, May 1988, doi: 10.1016/0278-2391(88)90246-7.

[35] "Ageing and health." Accessed: Sep. 12, 2024. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

[36] "Department of Health & Human Services | HHS.gov." Accessed: Feb. 09, 2025. [Online]. Available: https://www.hhs.gov/

[37] M. Law, B. Cooper, S. Strong, D. Stewart, P. Rigby, and L. Letts, "The Person-Environment-Occupation Model: A Transactive Approach to Occupational Performance," *Canadian Journal of Occupational Therapy*, vol. 63, no. 1, pp. 9–23, Apr. 1996, doi: 10.1177/000841749606300103.

[38] "Albert M. Cook - Assistive Technologies Principles and Practice-Mosby (2020)." Accessed: Jan. 22, 2025. [Online]. Available: https://studylib.net/doc/27233811/albert-m.-cook---assistive-technologies--principles-and-p...

[39] "Motor learning and performance : from principles to application : Schmidt, Richard A., 1941- author : Free Download, Borrow, and Streaming : Internet Archive." Accessed: Jan. 22, 2025. [Online]. Available: https://archive.org/details/isbn_9781450443616/page/n13/mode/2up

[40] M. P. Lawton and L. Nahemow, "Ecology and the aging process.," in *The psychology of adult development and aging.*, Washington: American Psychological Association, 1973, pp. 619–674. doi: 10.1037/10044-020.

[41] J. W. Rowe and R. L. Kahn, "Successful Aging," *Gerontologist*, vol. 37, no. 4, pp. 433–440, Aug. 1997, doi: 10.1093/geront/37.4.433.

[42] P. Turgeon, T. Laliberte, F. Routhier, and A. Campeau-Lecours, "Preliminary Design of an Active Stabilization Assistive Eating Device for People Living with Movement Disorders," in *2019 IEEE 16th International Conference on Rehabilitation Robotics (ICORR)*, IEEE, Jun. 2019, pp. 217–223. doi: 10.1109/ICORR.2019.8779388.

[43] H. Bouma, J. L. Fozard, and J. E. M. H. Van Bronswijk, "Gerontechnology as a field of endeavour," *Gerontechnology*, vol. 8, no. 2, Apr. 2009, doi: 10.4017/gt.2009.08.02.004.00.

[44] "US9132559B2 - Cutlery having improved gripping ergonomics - Google Patents." Accessed: Sep. 12, 2024. [Online]. Available: https://patents.google.com/patent/US9132559

[45] J. K. Schkade and S. Schultz, "Occupational Adaptation: Toward a Holistic Approach for Contemporary Practice, Part 1," *The American Journal of Occupational Therapy*, vol. 46, no. 9, pp. 829–837, Sep. 1992, doi: 10.5014/ajot.46.9.829.

[46] "The principles of universal design: Version 2.0 | DO-IT." Accessed: Jan. 22, 2025. [Online]. Available: https://www.washington.edu/doit/principles-universal-design-version-20

[47] P. Turgeon *et al.*, "Mechanical design of a new device to assist eating in people with movement disorders," *Assistive Technology*, vol. 34, no. 2, pp. 170–177, 2022, doi: 10.1080/10400435.2020.1734111.