

# Developing Products for the Elderly: PUIA Design Taxonomy



Neha Yaragatti and Ravi Kumar Gupta

**Abstract** Increase in the elderly population over the years presents both challenges associated with their wellbeing and opportunities for growth and fulfilment. Due to a reduced functional capacity, elderly users do not achieve the required task efficiently with products currently used. Hence, there is a need to develop products which are designed considering requirements, and conditions of the elderly to aid their Activities of Daily Living (ADL). This paper reviews the works in the field of product design for the elderly with an aim of identifying the taxonomies used in the design process. The need for a general design taxonomy while designing products for the elderly is identified. A taxonomy is developed with Product, User, Interaction, and Activity as main categories and its usage is demonstrated by applying it to redesign of handwash dispenser.

**Keywords** Product design · Senior citizen · Elderly · Aged people · Taxonomy · Customization · ADL · ICF

## 1 Introduction

With the dawn of a new decade, the year 2020 marks the beginning of the Decade of Healthy Ageing (2020–2030), which is an opportunity to bring together people and societies from every corner of the world for a collaborative and synergistic action to improve the lives of the elderly population [1]. According to the World Health Organization (WHO), by the year 2050, the world population aged 60 years and above is expected to hit the 2 billion mark by increasing the world proportion to nearly 22% from 12% in 2015 [2]. As a person ages, his/her functional capacity decreases which

---

N. Yaragatti · R. K. Gupta (✉)

CAD Lab, Department of Mechanical Engineering, SAMM, Manipal University Jaipur, Jaipur 303007, India

e-mail: [ravikumar.gupta@jaipur.manipal.edu](mailto:ravikumar.gupta@jaipur.manipal.edu); [ravikumar.gupta@manipal.edu](mailto:ravikumar.gupta@manipal.edu)

R. K. Gupta

Department of Mechanical and Manufacturing Engineering, Manipal Institute of Technology Bengaluru, Manipal Academy of Higher Education, Manipal 576104, India

poses various challenges to the elderly and reduces their adaptation to ever changing environment [3, 4]. But the longer life can mean increasing opportunities, growth, joy, and vitality which can provide a chance to pursue long neglected interests and contribute to the overall development of society. Hence population ageing can be an opportunity to improve the products and services for aged people which can enable good health and better quality of life for their complete lifetime [5].

Younger users are functionally well defined and adapt to any products they use. When designing for the general population, designers they may not give a thought about how satisfactory the results of the design are when used by the elderly. Aged population are often sidelined and used only in the design of assistive and niche products like disability aids. So, most of the products used by common population do not explicitly consider the needs and desires of the elderly [6, 7].

Despite the consistent effort of researchers to provide comfort and independence for the elderly, their requirements are not completely understood and met. The requirements differ based on the type of product, but it is important to understand certain conditions of the elderly to establish better design goals. Hence there is a need for a generic product development method for designing products for elderly.

To contribute to this ongoing research, this paper reviews the works related to product design for the elderly and presents a Product-User-Interaction-Activity (PUIA) taxonomy based on product functions and features. The taxonomy usage is demonstrated by applying it to redesign of handwash dispenser for the elderly. PUIA taxonomy helps in establishing design goals and improvements required in the existing product based on the needs of elderly and can be applied to a product which is to be designed to for the elderly.

## **2 Review on Products Designed for Elderly and Taxonomies Used**

Aging can cause elderly inconvenience in using everyday objects that are not specifically designed for them. This section will review some design projects that have contributed to the ongoing research and identify taxonomies used in the design process.

### ***2.1 Products Used in Daily Activities***

Lilja et al. demonstrated that elderly people's performance of some activities of daily living (ADL) like mobility, hobbies, shopping, and social contacts could be related to problems of support in the environment. In every activity, there were people who, wanted to perform some activities but were rated as not having the ability to do so,

needed more functional training of the products and services, or assistance [8]. With better products, elderly can carry out their daily activities more efficiently.

Studies conducted by Raviselvam et al. [9, 10] focused on using elderly as lead users in the design of everyday objects. The International Classification of Functioning, Disability and Health (ICF) codes were used to study body part functions. The elderly ignored some of the tasks due to design complexity of everyday objects. Based on the needs and suggestions shared by elderly participants, water bottle cap, soda can, mattress and sewing needle were redesigned and on an average, 89% of the general population participants preferred redesigned products over existing ones [9, 10].

Based on the ergonomic simulation of typical nail clipping postures, Wu et al. [4] redesigned nail clipper with a power grasp handle of knife angle 114 degree between the handle and normal line to cutter edge (to maintain neutral wrist angle), and a pedal plate (to reduce lumbar angle and ease the toenail clipping process). They stated that with age, hand pinch strength decreases, and finger and toenails become dry, hard, and thick making it difficult for elderly to clip their nails. Taxonomy developed includes nail clipping postures—two-point pinch, lateral pinch, and grasping hold; toenail clipping postures—leg crossed posture, sole supinated posture, and sole pronated posture. The new clipper was rated better in terms of comfort and satisfaction by elderly participants [4]. Neutral posture is important in product design for elderly.

Dekker et al. [11] explored the types and usage of supports by the Dutch elderly in toilet environment. A test frame consisted adjustable supports (vertical, front, and side supports) and a height-adjustable toilet bowl. Taxonomy developed for user tests includes type of support preferred while sitting down, standing up, and during the task, heights preferred to hold the support, and the way force is applied with each support. Vertical supports are preferred for sitting down and standing up, during toilet use side supports are also valued [11]. Providing supports lets the body muscles assist each other during movement, which can improve the elderly's task efficiency.

Demirbilek et al. [12] proposed Usability, Safety, Attractiveness Participatory (USAP) design model to capture the voice of the users and applied it for designing door handles for elderly. The USAP model categorizes relationship between elderly's requirements, design limitations, and technical requirements. User needs include: accidents related to doors, physical aspects, key and keyhole, other than key, opening door to a visitor, door operations—elbow operated levers if hands are full/dirty, foot operated door, and if no door situations [12]. Factors leading to accidents and injuries and alternate body part usage are interesting aspects to consider in the design.

Koppa et al. [13] demonstrated a set of refrigerator design guidelines for elderly women who live alone. Their study consisted of two parts: (1) a simulation to analyze postures during the refrigerator use with five types of pre-designed shelves (2) build-it-yourself session where the users arranged the interior configuration of the refrigerator according to their needs. Taxonomy developed includes comfort rating for each type of shelf, number of shelves used, preferred heights of shelf and container locations based on which, three design configurations for refrigerator interior were proposed. As the elderly participants preferred varying number of shelves, types,

and locations for items, flexibility of product usage must be an important design goal [13].

Guan [14] demonstrated leisure chair design recommendations for the elderly. Safety, comfortableness, adjustability, portability, appearance, and auxiliary function were identified as the product attention factors (product aspects, the user pays attention to during the activity) for leisure chair and mapped to the leisure activities. The disadvantages, material features, and types of existing leisure chairs used by the elderly were also listed. Based on this research and study, Guan recommended some design considerations [14].

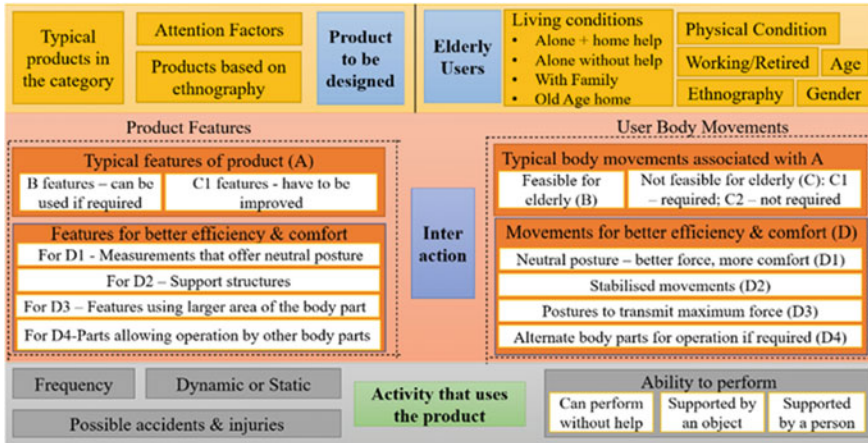
## ***2.2 Taxonomy for Elderly Product Design***

The literature review provided a good insight into the design approaches followed by various researchers and designers. Due to content limitations, only few products were discussed which cover most of the important aspects of daily living—personal care, toilet environment, living space, kitchen environment, essential and leisure activities. Taxonomies like Activities of Daily Living (ADL), ICF codes, and taxonomies based on surveys and questionnaires have been used to guide the designers throughout the design process. ADL and ICF are widely used in the medical research as the terms rely solely on the user's performance and capacity. They help narrow down the activities performed by elderly and body functions related to the activity but do not relate the products with the user. Some products were designed based on surveys and questionnaire and relied on taxonomies that were specific to the product.

The previous sections provided a brief review of the products designed for elderly which included design approach followed, and taxonomy used. The next section demonstrates the newly developed taxonomy for elderly product design.

## **3 PUIA Taxonomy for Designing Products for Elderly**

In design, taxonomy helps in understanding subject specific concepts and creates a vocabulary for the same. Vocabulary helps in organizing the components of concepts, making it easier to find or come back to them throughout the design process. Considering voice of the elderly, analyzing their current situation and environment related to the activity, and observing their interaction with the existing products are important for the design process. Due to the elderly's contrasting experiences and lifestyles, demographic, and cultural changes, they differ greatly from one another and do not have similar requirements and interests [15]. Hence, there is a need to develop a generic taxonomy to facilitate the research related to the product and elderly conditions.



**Fig. 1** Product—user—interaction—activity (PUIA) taxonomy

Based on the literature review, design considerations for the elderly are identified, and existing products are analyzed for the use of the elderly against application, ease of usability, fulfilment of functionality. PUIA (Product-User-Interaction-Activity) taxonomy is developed to guide designers in the product design process for elderly. PUIA taxonomy helps in considering special requirements of elderly, their living conditions, and relate factors associated with user body movements to product features. The PUIA taxonomy has four major categories as depicted in Fig. 1: Product to be designed, Elderly Users, Interaction, and Activity with their further classifications.

### 3.1 Product to Be Designed

Once the product which is to be designed (A) (see Fig. 1) is identified, designer must identify the typical products available in the market. In certain cases, products differ based on the ethnography. Ethnography is the study of people in their own environment based on their cultures, habits, differences, etc. Analysis of such products will help in the preparation of survey questionnaire and interviews and help in understanding user interaction with the product. Product attention factors are the aspects of product that the user pays attention to during activity. These factors can be used to measure the features of the product which need to be addressed from the end user’s point of view [14].

### ***3.2 Elderly Users***

Details of target users are crucial aspects of the design process. For the elderly users, details such as age, gender, physical condition are usually collected and analyzed. Apart from these, living conditions of elderly can reflect on their socio-cultural aspects, emotional wellbeing, special needs, and in some cases the extent of product requirement. Whether elderly users are working, non-working or retired can help designers understand their skillset and ability to perform the target activities. Ethnographic details of elderly users can help understand their ways of life and products they currently use.

### ***3.3 Interaction***

Product-user interaction is subdivided into product features and user body movements. The typical body movements associated with the product are to be identified and categorized as feasible for the elderly (B) and not feasible (C) as presented in middle panels of Fig. 1. The not feasible movement (C) are further divided into required (C1) for the new design and not required (C2). The corresponding product features associated with these body movements are categorized as B features and C1 features. Since, B features are associated with movements feasible for the elderly, they can be considered only if required. C1 features are associated with the not feasible but required movements, so these must be improved to provide better design solutions. Interaction category also houses a set of suggested body movements for better task efficiency and comfort (D), and the corresponding product features as depicted in middle panels of Fig. 1. Neutral postures (D1) during the product usage and task performance transmit better force, provide better surface contact and comfort to the elderly [4]. For D1, the corresponding product features include product dimensions which support the neutral posture of the body parts and joints involved. Stabilized body movements (D2) are bound to enhance user safety and improve task efficiency. Providing support structure whether as a part of the product or where the product is to be used or placed can be a way to achieve this. Not every product is designed to support postures that provide better grip and transmit maximum force from user (D3). For elderly, such postures must include a large area of the body part (for example, using the whole palm instead of a couple of fingers, both hands instead of one hand, etc.). Lastly, using alternate body parts (D4) are considered if required [12].

### ***3.4 Activity that Uses the Product***

Analyzing the activity is as important as analyzing target users and product. Frequency of the activity can provide information about product specific details

(e.g. a spoon is used daily, multiple times, irrespective of the user background) and user specific details (e.g. shopping—how many times a user does shopping, amount of items bought each time). If any activity is performed frequently, the problems associated with it must be minimal to avoid the adverse effects in the long run [16]. Nature of the activity—dynamic like walking, lifting or static like sitting, reading, watching or a combination of both [14], provides a good picture of the product-user interaction. Accidents and injuries related to the activity must be analyzed to establish design goals which reduce or eradicate their possibility. Since they do not happen frequently, we tend to neglect the effects. But for elderly users, even a single and small injury can cause great discomfort and can be fatal in the long run [12]. Target users’ ability to perform the activity helps identify their special needs.

### 3.5 Advantages of PUIA Taxonomy

Comparative study of PUIA taxonomy with ADL, ICF, and other design approaches used in designing products for the elderly is explained in Table 1. As shown in the table, ADL and ICF taxonomies are more relevant for medical professionals rather than the product designers. Most of the other taxonomies used by the designers are usually developed based on interviews and discussion with the elderly, and study about the product to be developed. In contrast to these taxonomies, PUIA taxonomy incorporates all the major aspects of the product design process for the elderly and is not product specific.

**Table 1** Comparison of PUIA Taxonomy and other taxonomies/methods for elderly products

Taxonomy/Method	Features	Observations
ADL [3]	Activities performed in daily life	Only activities
ICF [9, 10]	Body functions, body structures, activities and participation, environmental factors, personal factors	Product is not considered, not very relevant to design field
Taxonomy from study/interview [4, 11, 13]	Depends on the product to be designed	Very product specific
PUIA taxonomy	Typical products, details of activity that uses the product, details of elderly users, their ability to perform the activity, design considerations based on body movements involved	Generic taxonomy for elderly users, body movements, elderly users, activities, and suggests design improvements

## 4 PUIA Taxonomy Applied to Redesign of Handwash Dispenser

A typical handwash dispenser is considered for elderly usage as shown in Fig. 2a. User presses top of the dispenser to pump out handwash liquid. When pressure is applied, air is pushed out of the tube of the dispenser bottle. The pressure difference creates a suction effect and draws the liquid soap back up the tube. This liquid is then released into the user's hand. The PUIA taxonomy usage is demonstrated by applying it to the design of portable press down handwash dispenser for the elderly as shown in Fig. 3. The steps followed to redesign existing typical handwash dispenser as follows.

- i. Product category research as illustrated in the taxonomy.

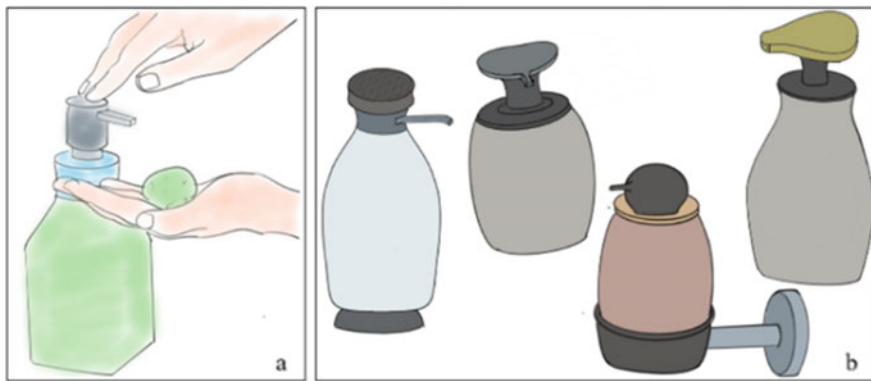


Fig. 2 a Typical handwash dispenser, b ideation sketches for new design

Press Down Handwash Dispenser	<b>Attention Factors</b> <ul style="list-style-type: none"> <li>portability</li> <li>appearance</li> <li>easy operation</li> <li>stability</li> <li>easy refill</li> </ul>	<b>Typical products in the category</b> <ul style="list-style-type: none"> <li>wall mounted</li> <li>automatic</li> <li>press down dispensers</li> </ul>	<b>Products based on ethnography (India)</b> <ul style="list-style-type: none"> <li>Handwash liquid makers offer their own press down dispensers and refill packs.</li> <li>Press down dispensers that come with bathroom accessory set.</li> </ul>	<b>Elderly Users-100</b>	<b>Living conditions</b> <ul style="list-style-type: none"> <li>Alone + home help - 20</li> <li>With Family - 53</li> <li>Alone without help - 25</li> <li>Old age home - 2</li> </ul>	<b>Physical Condition</b> <ul style="list-style-type: none"> <li>30 - normal</li> <li>15 - walking aid</li> <li>5 - wheelchair</li> </ul>
				<b>Gender</b> <ul style="list-style-type: none"> <li>70 - female</li> <li>30 - male</li> </ul>	<b>Working/Retired</b> <ul style="list-style-type: none"> <li>20 - working</li> <li>45 - retired</li> <li>35 - modern family background</li> </ul>	<b>Ethnography</b> <ul style="list-style-type: none"> <li>30 - traditional Rajasthani family</li> <li>40 - semi traditional background</li> <li>30 - modern family background</li> </ul>

<b>Product Features</b> <b>Typical features of product (A)</b>	<b>User Body Movements</b> <b>Typical body movements associated with A</b>	<b>Activity that uses the product</b> Washing the hands
<b>B features - can be used if required</b> Has to be refilled	<b>Feasible for elderly (B)</b> Movements associated with refilling the dispenser	<b>Frequency</b> Very frequent (4-8 times/ day)
<b>C1 features - have to be improved</b> Press down feature must be made easier as the elderly may not be able to transmit required force easily	<b>Not feasible for elderly (C)</b> C1 - required - press down with fingers/palm C2 - not required - NA	<b>Dynamic or Static</b> Both - Static body posture with hand movements
<b>Features for better efficiency &amp; comfort</b> For D1 - Measurements that offer neutral posture - NA	<b>Movements - better efficiency &amp; comfort (D)</b> Neutral posture - better force, more comfort (D1) - NA (press down feature does not disturb the neutral feature of the wrist joint)	<b>Possible accidents &amp; injuries</b> <ul style="list-style-type: none"> <li>dispenser may topple and displace the palm suddenly</li> <li>Leaking of handwash liquid which makes the surface slippery</li> </ul>
<b>For D2 - Support structures</b> <ul style="list-style-type: none"> <li>Dispenser holder which is mounted on the wall</li> <li>Suction rubber attached at the bottom</li> </ul>	<b>Stabilised movements (D2)</b> - While pressing the dispenser, due to shaky hands of the elderly, the dispenser may topple and displace the palm suddenly which can cause an injury	<b>Ability to perform</b> <ul style="list-style-type: none"> <li>Can perform without help of other person</li> <li>Object support- walking stick</li> </ul>
<b>For D3 - Features using larger area of the body part</b> Handle for power grasp and then press down instead of small surface for pressing down by the fingers	<b>Postures to transmit maximum force (D3)</b> - A power grasp posture of the palm instead of finger/palm press down	
<b>For D4 - Parts allowing operation by other body parts</b> Optical foot operated dispensing mechanism	<b>Alternate body parts for operation if required (D4)</b> - Foot	

Fig. 3 PUIA taxonomy applied to redesign of handwash dispenser



- ii. Analysis of the details of elderly users (described based on assumptions).
- iii. The interaction category presents the problems associated with press down action of the typical handwash dispensers available in the Indian market which offer a very small surface area for pressing. Since elderly lack the required strength for the movement, product features are suggested to improve efficiency of the activity.
- iv. Activity presents frequency of washing hands, its nature, and accidents and injuries associated with it. Users' ability to perform the activity is assumed in the taxonomy.
- v. Based on the taxonomy, some design concepts are sketched as shown in Fig. 2b.

The PUIA taxonomy can assist in the product design process by providing insights on the problems of elderly which need to be addressed and the corresponding product features to solve these problems. This is a general taxonomy which can be applied to any product used in the activities of daily living of the elderly. The newly developed product features must be designed such that the body movements of the elderly happen efficiently and smoothly. For this, more comprehensive design guidelines based on all the body movements and actions which happen while carrying out daily activities must be developed. Hence there is a need for a more detailed design taxonomy to closely link the needs of elderly users and their physical conditions to the product features, applications, and functionalities.

## 5 Conclusion

Ageing is a very complex phenomenon. The plight of ageing is just one side of the coin. By implementation of adequate strategies and development products and services that promote user safety, wellbeing, and social inclusion, the elderly can spend their extra years of life in vigor and comfort. This not only benefits the elderly individual but also helps in the healthy development of the society. With more and more product design projects being implemented for the elderly, there is a need for a good design taxonomy to guide the designers. After reviewing certain products designed for the elderly, this paper presented a generic product design taxonomy, the **Product-User-Interaction-Activity (PUIA)** taxonomy. The taxonomy usage was demonstrated by applying it to the case of redesign of handwash dispenser. Future work includes development of a more meticulous design taxonomy comprising of product design recommendations for all the body movements associated with the activities of daily living of the elderly, and design of products for the elderly based on the newly developed taxonomy.

## References

1. WHO Homepage. <https://www.who.int/ageing/decade-of-healthy-ageing>. Last accessed 2020/10/28
2. WHO Homepage. <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>. Last accessed 2020/10/28
3. Laukkanen P, Era P, Heikkinen RL, Suutama T, Kauppinen M, Heikkinen E (1994) Factors related to carrying out everyday activities among elderly people aged 80. *Aging Clin Exp Res* 6(6):433–443
4. Wu HC, Chiu MC, Hou CH (2015) Nail clipper ergonomic evaluation and redesign for the elderly. *Int J Ind Ergon* 45:64–70
5. WHO Homepage. <https://www.who.int/westernpacific/news/feature-stories/detail/addressing-the-needs-of-ageing-populations>. Last accessed 2020/10/28
6. Hannukainen P, Hölttä-Otto K (2006) Identifying customer needs: disabled persons as lead users. In: *International design engineering technical conferences and computers and information in engineering conference*, pp 243–251. ASME, Philadelphia
7. Demirkan H, Olguntürk N (2014) A priority-based ‘design for all’ approach to guide home designers for independent living. *Archit Sci Rev* 57(2):90–104
8. Lilja M, Borell L (1997) Elderly people’s daily activities and need for mobility support. *Scand J Caring Sci* 11(2):73–80
9. Raviselvam S, Wood KL, Hölttä-Otto K, Tam V, Nagarajan K (2016) A lead user approach to universal design—involving older adults in the design process. *Stud Health Technol Inform* 229:131–140
10. Raviselvam S, Noonan M, Hölttä-Otto K (2014) Using elderly as lead users for universal engineering design. In: *Universal design*, pp 366–375
11. Dekker D, Buzink SN, Molenbroek JF, de Bruin R (2007) Hand supports to assist toilet use among the elderly. *Appl Ergon* 38(1):109–118
12. Demirbilek O, Demirkan H (2004) Universal product design involving elderly users: a participatory design model. *Appl Ergon* 35(4):361–370
13. Koppa RJ, Jurmain MM, Congleton JJ (1989) An ergonomics approach to refrigerator design for the elderly person. *Appl Ergon* 20(2):123–130
14. Guan S (2011) Study on the leisure chair design of elderly people. *Adv Mater Res* 215:131–135
15. Pericu S (2017) Designing for an ageing society: products and services. *Des J* 20(sup1):S2178–S2189
16. de Wit M, Demirbilek O (2003) Shopping and the elderly: a universal design case study. In: *2nd inclusive design conference*, pp 25–28. UNSWorks, Sydney