Understanding the activities and areas of concern of elderly population: The case of Singapore

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Abstract. There is a clear demographic trend towards a higher proportion of elderly population in most developed countries and economies. One of the key aspects related to aging is the continuation of high quality of living for elderly population. Such a goal can be achieved when elderly people are autonomous, independent and have lower risks for their health and safety. By means of a field study and personal interviews with four subjects from the identified age group, and a survey with 105 elderly participants, we have recorded their everyday instrumental activities and areas of concern, identifying actions that may pose risks to them and hence, require care and assistance. Based on our findings, we present several possibilities of smart technologies available on the market, which could be used for assisting elderly population to live a pleasant, independent, healthy and safer life in the Singaporean context.

Keywords: Elderly population, areas of concern, everyday activities, information systems, smart technologies, quality of life

1. Introduction

In developed economies, the percentage of elderly population is growing quite rapidly [1,2] primarily due to a general increase in life expectancy. This means there will inevitably be a significant increase in the numbers of aging people to be cared for in the future. According to the Population Division of the Department of Economic and Social Affairs of the United Nations [1], elderly population is considered to include subjects aged 60 years old and above.

This longer lifespan is typically accompanied by an increased desire for elderly people to have an autonomous, fulfilling and high-quality life. In some cases, there is a perception that the “baby boomers” generation, now entering their 60s and 70s consider themselves to be still “middle aged” and not old.

There is an increased tendency to utilize the wealthy resource of experience and skills, which people above 60 tend to provide for the benefit of society at large. As this generation continues to live longer and be more active, it is expected that there will be various societal and financial implications [3,4].

Autonomy and independence are important parameters for the elderly since they represent the foundations for a lower stress and more content lifestyle [5]. In this context, autonomy refers to full control of decision making and of everyday activities while independence is defined as freedom from the support and aid of others during everyday actions. However, as people become older, they also tend to be physically and mentally less competent, and become increasingly less capable of performing their everyday tasks reliably and effectively. This leads them to be more susceptible to accidents, injuries and diseases and their desire for continued autonomy and independence poses risks to their health and safety.

Smart home technologies and information systems [3,6,7] have become quite popular in an elderly
care context, with the aim to maintain or improve the quality of life of older people, while at the same time ensuring a reduced risk for their health and safety. At a high level, these technologies can be defined as computing hardware and software offering sensing/actuating capabilities and advanced intelligence, management and control in domestic environments. Such technologies may imply less care required by third parties, and if true, could mitigate the social and financial impacts of an increasingly aging population [7].

Although such technological solutions for assisting the elderly in their homes are reasonably reliable and effective, and have been around for almost a decade already, their adoption by the general public has been limited. This can be attributed to their high costs, their low level of privacy or because people within the particular age group have difficulties in understanding and trusting those systems, as they may not be user-friendly or require training [8–11].

2. Primary objectives

Our study has been performed in Singapore, which is considered a developed country. Singapore in particular and Asia in general are characterized by limited adoption of smart home technologies, as people tend to be reluctant to include these new technologies in their personal everyday lives. This observation is particularly true for people aged 55 years old and above [13].

The percentage of ageing population in Singapore has increased significantly from 6.0% in 1990 to 7.2% in 2000 and reached 10.5% in 2013 [2]. The forecasted ageing population will reach 900,000 by 2030 which forms approximately 20.5% to 21.4% of the total population. The ratio of Singaporeans over the age of 65 will therefore increase significantly from 1 in every 10 in 2013 to 1 in every 5 by 2030. These facts underscore the importance of elderly people as a large population group in Singapore and the need for an improved and continued high standard of living for them.

Our study focuses on the following aspects:
1. Record the main activities of elderly population in Singapore.
2. Identify actions that pose risks to their health or safety, requiring care and assistance.
3. Review existing smart technologies and information systems that could be used for assisting them to have a better quality of life [5].

Instrumental activities of daily living are the activities that people do once they are up and dressed. These tasks support an independent lifestyle. The main objective is to identify areas of concern during the everyday (mainly instrumental) activities of citizens above 60 in Singapore. Through this work, we aim to understand the reasons why subjects of the selected population perform (or not) particular actions at home, and observe the difficulties they might encounter during their efforts to accomplish everyday tasks. This understanding would then help us to propose smart technology solutions for improving their living standards.

3. Related work

In the past decade, information technologies have become more pervasive in areas such as home automation and healthcare aimed at elderly population. The primary aim of these smart technologies is to improve their quality of life, reduce their day to day impediments and assist them in alleviating health and safety risks. Most of the research related to these technologies till date has been conducted in developed Western economies and the availability of scientific grade information is limited in Asia, especially in Singapore.

3.1. User studies on perceptions and acceptance of smart technologies

Tegart [7] found that smart technologies for personal healthcare are already available on the market, facilitating healthcare assessments, diagnoses, treatments and independent living. He identified five barriers hindering adoption by the public: (a) privacy, (b) autonomy, (c) informed consent, (d) identity, and (e) dignity. According to Morris et al. [4], smart healthcare technologies need to enable consumers to access information with ease, assisting them in managing their personal health.

Two relevant studies by Demiris et al. [8,9] assessed the perceptions of seniors in regard to the installation and operation of smart home technologies relating to quality of life. The analysis revealed that the participants had an overall positive mindset towards smart technologies and highlighted that the installation of these technologies provided significant benefits. Their perception was that the benefits are of greater value when these technologies are reliable, user-friendly, need minimal end-user interaction, cost very little to maintain and are able to detect emergencies. However
when privacy was compromised and there was a need for a third party, the perceived benefits were reduced. A specific example of such a concern was the use of a smart camera for the purpose of fall or accident detection because it was not only intrusive, violating privacy, but also implied the need for someone to be available at all times to render assistance when needed.

Chernbumroong [10] examined the perception of elderly population towards the use of smart home technologies in the form of assistance. The research identified the automatic lighting system as the most accepted technology, while the adoption of cooking hob and oven safety control, sleep-pattern monitoring, emergency alarm and activity monitoring system received a neutral rating. On the other hand, a video monitoring system received the least willingness for adoption, similar to [8, 9].

A questionnaire performed by Giuliani [15], aiming to identify acceptability requirements of domestic technology by elderly people living in Rome, showed that the adoption of a technology depends on the situation and can be very contextual. There is a perception about the need of a higher level of knowledge and education to operate and successfully use new technologies, and the older the user is, the more likely to give up.

In one of the very few studies conducted in Singapore, Eng [11] examined the acceptance of smart home technologies by the elderly Singaporeans. The results showed that more than half of the participants were willing to incorporate smart home features. Their willingness was due to the (expected) enhanced quality of living. Other factors included convenience, savings from electricity bills, ease of care, audio/visual entertainment and security.

3.2. Case studies on applications of smart technologies

Many studies focused on identifying specific existing technologies, products and information systems that could assist people above 60 in their everyday lives. A report by Alwyn [16] presented various health monitoring technologies used for providing ageing services, such as fall detection and hazard prevention (mobility aids, stove use detectors, smoke and temperature detectors, door locks and wander management systems), health and wellness (telemedicine and e-health), medication compliance technologies, cognition assessment, and social connectedness via video and mobile phones, email and the Internet.

A similar study in UK [3] identified possible technologies linked to three key themes of later life, namely: (a) wellbeing (personal healthcare, medication compliance, home safety and security), (b) mobility (personal and public transportation and car driving) and (c) community (networking, engagement in virtual communities and interaction with local community). Similar technological analysis and recommendations were discussed also in a report of the Royal Academy of Engineering [17], stressing mobility, safety and independence in the home and the community as priority areas.

3.3. Identifying daily activities and areas of concern of elderly population

This topic is the most relevant to the work in this paper since our main aim was to capture the daily activities of citizens above 60, identify their everyday risks and areas of concern and find suitable smart technologies, available on the market, to assist them and reduce such risks.

Baltes et al. [18] described the everyday lives of elderly people in Germany in terms of activities, locations and companionship by means of self-recording of the daily actions of 49 individuals aged 65–78 over a period of 6 months. Activities happened predominantly in the mornings, while afternoons and evenings were mostly spent on leisure activities. The paths of their daily lives were marked by two geographic domains: the home followed by public places.

An assessment of the capabilities of older people was performed in [19], with ratings of self-care ability in various activities including toilet functions, feeding, dressing, grooming, locomotion, and bathing. Activities such as telephoning, shopping, food preparation, housekeeping, laundering, use of transportation, use of medicine, and financial behavior were also included.

A different approach was followed in [20], by installing an automatic remote system for monitoring the health of independent elderly people by recording their everyday actions. Data indicated that the total count of output from installed sensors could be an index of indoor activity and several activities could be identified. However, this equipment is quite expensive and more specialized solutions might be more appropriate (see Section 5.5).

Finally, a study in Sweden [21] considered the use of assistive devices and their relation to functional limitations and impairments among people between 70 and 76 years of age in Goteborg. Independence of and de-
pendence on assistance from others was assessed and an index was developed including instrumental activities (e.g. cleaning, shopping, transportation and cooking) combined with personal daily life activities (e.g. bathing, dressing, going to the toilet, transfer, continence and feeding). We compare some of the findings of this study with our demographic analysis in Section 5.3.1.

4. Method

Our methodology is divided in three phases: (a) a field study, (b) personal interviews, and (c) a structured survey. The use of a field study and personal interviews before the survey helped: (a) to prepare the questionnaire in a more informed way, targeted to the case of elderly population in Singapore, (b) to validate our findings from two different views: on the field and through the survey, and (c) to observe details and acquire knowledge difficult to get only with a questionnaire, since some activities and areas of concern would be difficult for some responders of the survey to claim. We describe these phases below.

4.1. Field study

Initially, in order to understand the living environment of elderly population, a field study was conducted. We recruited volunteers from community centers in public housing development. To disseminate our study and recruit volunteers, we added leaflets and informational material about it at the announcement boards of the community centers. Four citizens (2 couples) over the age of 60 (2 males aged 69 and 76 years old, 2 females aged 67 and 80 years old) were agreeable to participate in our study and volunteered to be subjects in their own home. Unfortunately, it was not possible to recruit more participants, because our study involved recording of their everyday activities, which created various privacy concerns to people, although we assured them that we would maintain their anonymity and fully respect their privacy.

All four participants were on regular medication, staying in public housing. One from each couple required the use of a wheelchair to mobilize independently around the home. Not any other functional limitations were self-reported or observed. One couple lived independently and the other lived in a joint family setting with their children. Both couples did not possess smart phones or any other domestic smart technologies. Data collection was achieved by observing their activities during daytime from 10 am until 6 pm for one week, with the help of two volunteers working as researchers in our research laboratory. Volunteers passively recorded the behavior and actions of the participants without interfering with their activities. This recording involved filling a Microsoft Excel file, writing for each observed event the time of occurrence, room of the house, activity description and potential risk (If applied) of the activity. We employed volunteers instead of digital monitoring equipment, because the participants did not want their everyday actions to be completely recorded, feeling under surveillance.

By conducting a field trial, we were able to collate information which the participants could be otherwise unwilling or unable to provide. In this way, we managed to get an initial view of the elderly people’s routine activities and to identify various areas of concern regarding their overall health and safety.

Another important parameter of concern, besides health and safety, is energy savings. Many practices of elderly people result in higher energy use, forcing them to pay high amounts for energy bills [14]. We decided to include this type of activities in our study too, as we believe that the additional financial burden from higher energy bills impacts their quality of living and, in some cases, these actions are directly associated with health and safety risks.

After collecting this information, an analysis was done by mapping the recorded routine activities into different physical locations of the house (i.e. living/dining room, bedroom, kitchen and bathroom). The entire field study was completed within a period of two weeks.

4.2. Personal interviews

Upon completion of the field study analysis, the same four subjects were interviewed in person by the authors. Personal interviews were selected to gain greater insights on the elderly people’s routine activities and behaviors (as recorded by the volunteers at the Excel files), as well as their motivations and reasoning related to these activities. Any ambiguities identified in the first phase of observation were clarified through the interviews, which lasted 60 minutes for each couple and were audio-recorded. In other words, the personal interviews targeted the analysis of the Excel files, to perceive why participants performed particular actions, especially those posing risks to their health/safety. The interviews have been analyzed by means of Microsoft Excel.
4.3. Survey/questionnaire

The findings from the first two phases were then used to formulate a questionnaire in this last part of the study, in order to validate our findings and get further insights on the (possible) use of assistive technologies and their acceptance by elderly population. The questionnaire was divided in three sections: (a) background, (b) technological-friendliness, and (c) routine activities and reasoning. Questions were close-ended for all sections, in a Likert scale from 1.0 (never) to 5.0 (always). All the questions were either multiple-choice or checkbox-style to make it more convenient for the respondents. The questionnaire included 48 questions in total.

Similar to the field study, recruitment of volunteers was performed by adding leaflets and informational material about it at the announcement boards of the community centers. One hundred and five (105) people above 60 who are living in public housing around Singapore were recruited from community centers located in public housing developments. This sample was chosen in a random manner subject to their age demographic. They were asked a list of questions face to face ranging from their background to the frequency of performing various activities, reporting as well the reasoning behind their actions. The survey study was completed over a period of 4 weeks. The responses of the questionnaire were recorded and analyzed in Microsoft Excel and SPSS.

Public housing in Singapore is typically multifamily housing primarily made up of high-rise apartments. The survey was conducted in an anonymous manner, in order to respect the privacy of the participants. No personal particulars such as name, address and contact information were collected, other than more general information such as age, gender, marital status and whether they lived alone or with their children.

5. Results

In this section, we present our overall findings from the study. From the first phase, we record the main activities of elderly population and aspects of concern while performing them, while from the personal interviews we try to explain the reasoning behind the particular actions taken by them. Then, we provide the results from our survey.

Furthermore, we compare the feedback from the participants (especially the responses from the survey) among various groups of them e.g. living conditions, taking medication or not, wheelchair users etc., in order to understand their particular needs. Finally, we study how these activities of elderly population, which are risky for their health or safety, energy-consuming or less convenient might be supported by the use of smart technologies and information systems.

5.1. Activities and areas of concern in the field study

As we mentioned in methodology, the routine activities of the subjects of the selected population were categorized in terms of the physical layout of the home according to its function.

1. **Living and Dining Room**: The main activities undertaken by the participants were the operation of electrical appliances (e.g. television, radio, fan) and lighting, utilizing the home telephone and ensuring the windows and main doors were secure.

2. **Bedroom**: Other than resting and sleeping, the primary activities included the operation of electrical appliances (e.g. fan, alarm) and lighting, and ensuring the windows were secure.

3. **Kitchen**: The key activities covered the operation of electrical appliances (e.g. refrigerator, washing machine, microwave, oven) and lighting, ensuring the windows were secure and utilizing mechanical devices such as water tap and gas stove.

4. **Bathroom**: This primarily revolved around the use of lighting and of mechanical devices such as the water tap.

An important aspect of this study was to identify concerns and risks related to elderly people’s everyday activities. While observing those activities, we also recorded possible actions that would need care. We list these actions and concerns at the second column of Table 1. The third column indicates the reasons for performing (or not) those actions (as derived from the responses at the personal interviews, see Section 5.2). The last column of Table 1 relates activities/concerns with groups of participants most likely to perform these actions (as derived from the responses at the survey, see Section 5.3), where “likely” is defined as an average value larger or equal to 2.7/5.0 on a Likert scale from 1.0 (never) to 5.0 (always). We note that this is only an indication of a relation between user groups and particular actions, and not concrete evidence.
<table>
<thead>
<tr>
<th>Living area</th>
<th>Activity/Area of concern</th>
<th>Reasoning</th>
<th>Most likely group</th>
</tr>
</thead>
</table>
| Living & Dining Room| Electrical appliances left on standby mode most of the time throughout the day. | - Troublesome to switch off the power switch.  
- Might use it later. | Male, aged 60–64, 75–79, 80+                                           |
|                     | Fan and lighting were switched on while no one was in the vicinity for more than 5 minutes. | - Leaving the room only for a short period.  
- Assuming someone else might use it later. | Aged 60–64, 80+, wheelchair users                          |
|                     | Main door left unlocked for at least 10 minutes after entrance of the person before locking it. | - Might need to move in/out of the house again.  
- Assuming the house is safe from intruders. | Aged 70–74                                               |
|                     | Door was not locked properly. | - Multitasking.  
- Due to haste. | Aged 70–74, wheelchair users                                       |
|                     | Leaving the keys at or near the main door. | - Multitasking.  
- Due to haste. | Female, aged 70–74, wheelchair users                                 |
|                     | Telephone was not placed properly after use. | - Assuming telephone was placed properly.  
- Inconvenient to check again. | Female, aged 75–79, wheelchair users                           |
|                     | Dialing the wrong number unintentionally. | - Unable to press the buttons properly. | Aged 60–64, 75–79, wheelchair users, on regular medication |
| Bedroom             | Room fan was switched on when no one in the room. | - Forgetting.  
- Inconvenient to switch off (sometimes).  
- Not considering it important. | Aged 60–64, 80+, wheelchair users |
|                     | Room lighting was switched on during the day. | - A habit to switch on light when entering but not on exit.  
- Difficult to distinguish between on/off during daytime. | Aged 60–64, 80+, wheelchair users |
|                     | Room lighting was switched on when no one in the room. | - Leaving the room for a short period.  
- Forgetting.  
- Not considering it important. | Aged 80+, wheelchair users |
|                     | Room window left open during heavy rain. | - Forgetting.  
- Inconvenient to close window (sometimes). | --                                                      |
|                     | Room window grill key was left at the lock. | - Inconvenient when requiring to open the window again. | Female, aged 70–74, wheelchair users |
|                     | Unwilling to check the room again after moving out. | - Inconvenient to check the room again. | Wheelchair users                                      |
| Kitchen             | Refrigerator door not closed properly. | - Assuming that door was closed. | Aged 70–74                                               |
|                     | Refrigerator door left open for more than 3 minutes. | - Multitasking.  
- Assuming someone else is using it at the same time. | Aged 70–74                                               |
|                     | Gas stove not switched off properly. | - Assuming gas stove is switched off by visual checking. | Aged 75–79                                               |
|                     | Kitchen lighting left switched on during daytime. | - Difficult to distinguish between on/off when daytime. | Aged 80+, wheelchair users |
|                     | Washing machine left on standby mode after operation. | - Inconvenient to switch off immediately after use.  
- Not considering it important. | --                                                      |
|                     | Water tap not turned off properly after use. | - Habit of not checking after use. | Male, aged 60–64, on regular medication                  |
By observing activities and areas of concern, most of them take place in the kitchen, where the majority of domestic electrical appliances are located. Some areas of concern (e.g. water tap not turned off properly after use, gas stove not switched off properly) are considerably more important than others (e.g. room lighting was switched on during the day, refrigerator door not closed properly) and need more attention.

5.2. Understanding the reasoning for elderly people’s actions through the personal interviews

For each of the activities and aspects of concern identified in the field study, we asked the participants involved about the reasons for performing (or not) those actions. Their explanations and excuses are provided at the third column of Table 1.

One can observe that most issues occurred due to forgetting (e.g. leaving the keys at the main door, electrical appliances or lighting not switched off after use, room window left open during rain), inconvenience (e.g. telephone not placed properly after use, washing machine left on standby mode after operation, checking the room for appliances left switched on after moving out), misjudgment (e.g. door not locked properly, refrigerator door not fully closed, gas stove not properly switched off), functional limitations (e.g. dialing the wrong number on the telephone, kitchen lighting left switched on during daytime, gas stove not switched off properly) or due to lack of awareness about the importance of saving energy (e.g. electrical appliances left on standby mode, fan and lighting left switched on while no one was in the room). Some other reasoning involves multitasking and haste, which complicate their efforts making them more prone to mistakes.

5.3. Analysis of the survey

Based on our observations and experience acquired during the first two phases of our methodology, we designed the survey in a way to correlate elderly people’s activities with the assumed risks posed by taking particular actions. The main goals were on one hand to validate and perhaps extend the findings recorded in the first two phases about activities and actions of concern of elderly population, and on the other to assess the comfort levels that the subjects of the selected population have or feel about the use of new technologies, and their overall acceptance in assisting them in their everyday activities.

5.3.1. Demographics

A total of 105 participants agreed to respond to the survey. Their demographics in terms of gender, age, physical condition, living arrangement and whether they regularly take any kind of medication (e.g. for pressure, insomnia, cholesterol lowering) are listed in Table 2. Our aim was to locate a diverse group of elderly people, covering as many different aspects as possible.

The majority of the participants were between 65-69 years old (37%), followed by people between 70–74 years old (21%). One out of four of the participants required the use of wheelchair, mostly the older ones (75 and above) and this occurred more frequently in women (29%) than in men (18%). We note that the wheelchair users from our sample used the wheelchair in different ways (e.g. for longer distances outdoors only, as transport with an attendant, to mobilize independently around the home). Finally, 73% of the participants required to be on regular medication due to health issues. More than half of the participants stayed with their children or relatives while 41% stayed with their spouse.

Interestingly, we discovered that these percentages turned out to be in line with a study of dependence in daily life activities among elderly people in Sweden [21], in which 26% of participants between 73 and 76 years of age had some disability, while one fifth at
Table 2: Demographics of survey participants in terms of gender, age, physical condition, living arrangement and intake of medication

<table>
<thead>
<tr>
<th>Age:</th>
<th>Male (n)</th>
<th>Female (n)</th>
<th>Male (%)</th>
<th>Female (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60–64 years old</td>
<td>8</td>
<td>12</td>
<td>18.18%</td>
<td>19.67%</td>
<td>19.05%</td>
</tr>
<tr>
<td>65–69 years old</td>
<td>17</td>
<td>22</td>
<td>38.64%</td>
<td>36.07%</td>
<td>37.14%</td>
</tr>
<tr>
<td>70–74 years old</td>
<td>5</td>
<td>17</td>
<td>11.36%</td>
<td>27.87%</td>
<td>20.95%</td>
</tr>
<tr>
<td>75–79 years old</td>
<td>7</td>
<td>3</td>
<td>15.91%</td>
<td>4.92%</td>
<td>9.52%</td>
</tr>
<tr>
<td>80 years old &amp; above</td>
<td>7</td>
<td>7</td>
<td>15.91%</td>
<td>11.48%</td>
<td>13.33%</td>
</tr>
<tr>
<td>Physical Condition:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Able-Bodied elderly people</td>
<td>36</td>
<td>43</td>
<td>81.82%</td>
<td>70.49%</td>
<td>75.24%</td>
</tr>
<tr>
<td>Wheelchair users</td>
<td>8</td>
<td>18</td>
<td>18.18%</td>
<td>29.51%</td>
<td>24.76%</td>
</tr>
<tr>
<td>Living Arrangement:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living with children or relatives</td>
<td>22</td>
<td>33</td>
<td>50.00%</td>
<td>54.10%</td>
<td>52.38%</td>
</tr>
<tr>
<td>Living with spouse</td>
<td>20</td>
<td>23</td>
<td>45.45%</td>
<td>37.70%</td>
<td>40.95%</td>
</tr>
<tr>
<td>Living on their own</td>
<td>2</td>
<td>5</td>
<td>4.55%</td>
<td>8.20%</td>
<td>6.67%</td>
</tr>
<tr>
<td>Regular Medication:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>34</td>
<td>43</td>
<td>77.27%</td>
<td>70.49%</td>
<td>73.33%</td>
</tr>
<tr>
<td>No</td>
<td>10</td>
<td>18</td>
<td>22.73%</td>
<td>29.51%</td>
<td>26.67%</td>
</tr>
</tbody>
</table>

Age 70 and almost half of the population at age 76 used assistive devices in daily life activities, and this use was more frequent in women (52%).

5.3.2. Questionnaire: Activities of the elderly population

The questionnaire focused on understanding the needs of elderly population living in Singapore, identifying specific aspects of their activities that may require assistance and care.

Most of the participants found much friendlier the use of the remote control of the television (95%) and of the cable channels (45%) than the one of the air conditioner (18%) and the radio (13%). More than half (65%) claimed being able to make a call from a mobile phone, while 30% could send a text message. Only 10% could use an instant messaging service on their phones such as Whatsapp and even less (8%) could perform a search through an Internet search engine.

Regarding healthcare routine activities, we focused on the behavior of the participants in terms of consumption of medication, checking of medication balance and expiry dates. Skipping or missing medication timing and keeping track of medication balance were considered as “sometimes” by most participants (2.66/5.0 and 2.71/5.0 respectively), while they “rarely” forgot to check expiry dates (2.21/5.0) or to take the medication late e.g. 1–2 days after the one advised (2.09/5.0). Considering that over 73% of the respondents needed regular medication, skipping or missing medication timing and failing to keep track of medication balance constitute quite alarming areas of concern.

Considering safety, misplacing the house keys and forgetting to lock the main door before leaving the house was claimed as “sometimes” by most participants (2.75/5.0 and 2.77/5.0 respectively), while forgetting the keys on the door happened “rarely” (2.12/5.0). Participants claimed as “never” forgetting to leave the windows open when leaving the house (1.25/5.0).

In terms of convenience in performing routine activities, participants tended to “frequently” fall asleep while the electrical appliances were switched on (3.54/5.0). They “sometimes” missed appointments or schedule due to forgetting (2.69/5.0), missed answering incoming calls (3.19/5.0) and misplaced the remote controls of appliances (2.68/5.0).

In terms of communication-related activities, responders “frequently” browsed the address book for contact numbers (3.83/5.0), “sometimes” dialed wrong number (2.67/5.0), “sometimes” placed the telephone improperly after use (2.62/5.0) and “sometimes” forgot the activity they performed before answering a call (2.71/5.0).

Regarding energy-related activities (which are important for older people in aspects of safety and money savings), we asked them about the use of various electrical devices of their house. Participants declared “sometimes” turning off the water tap and gas stove improperly after use (2.68/5.0 and 2.55/5.0 respectively) while they “sometimes” even left them on after use, especially when multitasking (2.40/5.0 and 2.07/5.0 respectively). These habits cause dangers since overflowing of water from sinks could occur or flow of gas could cause an explosion or a fire. Leaving the television (2.73/5.0), the radio (2.65/5.0) and the fans/air conditioner (2.66/5.0) switched on while unattended happened also “sometimes”, while the same happening on the lights (2.28/5.0), the refrigerator’s...
door (2.09/5.0) and the washing machine (2.06/5.0) occurred only “rarely”.

5.3.3. Questionnaire: Reasoning behind activities

In the second part of the questionnaire, the participants were asked to provide the reasoning for their actions relating to some of the previously mentioned activities.

The most common excuse (63.8%) for leaving the main door unlocked was that it was troublesome for them to lock and unlock it, followed by assuming safe from intruders (38.1%). While the respondents aged 60–64 considered multitasking as another important reason (60%), this was not considered by the other age categories (10–21%).

A popular reason (74.3%) for leaving the lights switched on was that it was inconvenient to switch on and off. Forgetfulness and carelessness followed at 31.4%. Interestingly, 60% of people aged 75 and above assumed someone else would use them in a later time.

Moving away for a short period was declared as a common reason (62.9%) for leaving the television switched on, followed by being inconvenient to switch on and off with 47.6%. One out of two participants aged 75–79 indicated that forgetfulness or carelessness and multitasking were also important reasons. Similar findings were observed on the responses about the reasoning for not switching off the fans or the air conditioner.

Finally, leaving the refrigerator’s door open was assumed to happen mainly due to forgetfulness or carelessness (77.1%), and this reason explained also the actions of leaving the water tap and gas stove turned on (80.0%).

5.4. Group demographics of elderly population and their particular needs

The last column of Table 1 correlates activities/concerns (as identified at the field study) with groups of subjects of the selected population most likely to perform these actions (as derived from the responses of the questionnaires).

We noticed two trends regarding the capabilities of people as they age. Firstly, there is an increasing number of them who are wheelchair users, a fact that decreases their mobility, similar to [21]. Next, there is a decline in the number of people who are technologically-friendly as they age (especially 70 and above). This finding is in line with [8,9,15].

Considering gender, all three phases of our study showed similar findings, indicating similar routine activities and behaviors. Hence, gender seems to have no significant role in the types of activities which could be supported by adopting smart technologies.

For wheelchair users, there is a need for assistance as their mobility decreases in carrying out their everyday activities. Certain actions such as switching on and off electrical devices or lights constitute difficult tasks for most of them.

Only a minority of participants (mainly those aged 60–69 years old) live on their own. We found that these “independent” participants were more responsible and careful while performing everyday activities when compared to those staying with other, younger family members. Finally, consumption of regular medication is observed at both genders and all age groups, and it increases proportionally with age. The main concern for elderly people concerning regular medication involve proper timing and correct dosage.

5.5. Use of smart technologies for assisting elderly population

Based on the identified areas of concern of the participants that may require care and assistance (as listed at the second column of Table 1 and discussed in Section 5.3.2), we have performed a small research to discover smart technologies that could be used to support these actions, in order to avoid any risks to the health, safety or inconvenience of elderly population. This research for smart technologies was performed by contacting the most well-known manufacturers of assistive technology products and checking whether their products matched the need of elderly in the context of Singapore, as identified through this study. Also, we performed a keywords-based search on the web using as keywords the areas/issues of concern as recorded during our work.

Table 3 lists these smart products, explaining their functionality and describing the associated activities at which they could be adopted or areas of concern at which they could be applied. Our research focused on smart technologies available on the market which constitute familiar, easy to use solutions for elderly people, even for those with disabilities or functional limitations.

At the third column of Table 3, a distinction is made between active and passive technologies i.e. those that require active use by the older person and those that passively function in the background without the need for active engagement. Ease of use (self-assessed) is provided at the last column of the table.
Table 3

<table>
<thead>
<tr>
<th>Activity/ Area of concern</th>
<th>Smart technologies available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart power outlet:</td>
<td>Automatically switches off the electrical appliance when it finishes execution or when a timer elapses.</td>
</tr>
<tr>
<td>Voice Command System:</td>
<td>User gives instruction to retrieve or relay information via voice activation command.</td>
</tr>
<tr>
<td>Motion sensor:</td>
<td>Detect the movement of the user in order to de-activate the fan or switch off the lights (combined with a smart power outlet).</td>
</tr>
<tr>
<td>Keyless door system:</td>
<td>Automatically locks/unlocks door via a smartcard, a Bluetooth-enabled device, a smart phone or a key fob. Auto-lock function can be activated when door closed.</td>
</tr>
<tr>
<td>Item locating system:</td>
<td>Alerts the user when the keys are closer than the preset distance via a smart phone.</td>
</tr>
<tr>
<td>RFID tagging system:</td>
<td>Alerts the user when the phone is misplaced after use.</td>
</tr>
<tr>
<td>Picture Dialing System:</td>
<td>Shows the picture of contacting person onto the home telephone. By selecting the picture of the intended person, user can proceed with the call.</td>
</tr>
<tr>
<td>Voice Command System:</td>
<td>User gives voice instruction to dial or retrieve contact number of the intended person automatically.</td>
</tr>
<tr>
<td>Emergency Call System:</td>
<td>Caregiver can preset several emergency contact numbers into the home telephone system for quick access.</td>
</tr>
<tr>
<td>Motion sensor (combined with a smart power outlet).</td>
<td>Both Average</td>
</tr>
<tr>
<td>Humidity sensor:</td>
<td>Senses rain and alerts the user.</td>
</tr>
<tr>
<td>Item locating system:</td>
<td>Alerts the user when the keys are closer than the preset distance via a smart phone.</td>
</tr>
<tr>
<td>RFID tagging system:</td>
<td>Alerts the user when the phone is misplaced after use.</td>
</tr>
<tr>
<td>Cooking hob &amp; oven safety control system:</td>
<td>Automatically cuts off the gas supply and switches off the appliance when the preset temperature is exceeded.</td>
</tr>
<tr>
<td>Timer switch valve:</td>
<td>Cuts off the supply of gas or water after specified time duration.</td>
</tr>
<tr>
<td>Gas/Smoke Sensor:</td>
<td>Detects the present of gas and sets an alarm.</td>
</tr>
<tr>
<td>Room fan or lighting switched on when no one in the room or during the day.</td>
<td>Motion sensor (combined with a smart power outlet). Both Average</td>
</tr>
<tr>
<td>Window left open during heavy rain.</td>
<td>Humidity sensor: Senses rain and alerts the user. Active Average</td>
</tr>
<tr>
<td>Room window grill key was left at the lock.</td>
<td>Item locating system: Alerts the user when the keys are closer than the preset distance via a smart phone. Active Average</td>
</tr>
<tr>
<td>Refrigerator door not closed properly.</td>
<td>RFID tagging system: Alerts the user when the phone is misplaced after use. Active Average</td>
</tr>
<tr>
<td>Gas stove not switched off properly.</td>
<td>Cooking hob &amp; oven safety control system: Automatically cuts off the gas supply and switches off the appliance when the preset temperature is exceeded. Passive Easy</td>
</tr>
<tr>
<td>Washing machine left on standby mode after operation.</td>
<td>Smart power outlet: Automatically switches off the electrical appliance when it finishes execution or when a timer elapses. Both Average</td>
</tr>
<tr>
<td>Water tap not turned off after use.</td>
<td>Cooking hob &amp; oven safety control system or Timer switch valve Passive Easy</td>
</tr>
<tr>
<td>Water tap turned on when unattended.</td>
<td>Motion sensor (combined with Cooking hob &amp; oven safety control system or Timer switch valve). Both Average</td>
</tr>
<tr>
<td>Forgot to take medication and keeping track of medication balance</td>
<td>Automated pill dispenser: Dispenses correct types and quantities of medication according to the preset timings automatically. Both Average</td>
</tr>
<tr>
<td></td>
<td>Medication reminder system: Informs elderly people about the time for their medication via alarm on the device and/or a flashing light indicator. Calls alert for late consumption. Both Average</td>
</tr>
<tr>
<td></td>
<td>Inventory management system: Updates the caregiver and the person automatically about the records of medication consumption and balance. Both Average</td>
</tr>
</tbody>
</table>

6. Discussion

While relevant initiatives focused mainly on the application of smart technologies for assisting elderly people in their everyday lives [3,7,16,17] or the acceptance of these technologies by older people [4,7,9–11], there is a limited understanding of the areas of concern in the context of their everyday activities and tasks, especially focusing in Singapore and Asia more generally. While some related efforts targeted the understanding and recording of daily actions of elderly people [18–21], they did not identify areas of potential
risks in which assistive smart technologies could be applied, nor they tried to perceive the rationale and reasoning of the people performing some particular actions.

The contribution of this paper is the use of a new methodology for identifying the needs of elderly population in Singapore by observing and recording their (mainly instrumental) everyday activities. Through the understanding of their everyday actions, we have identified various areas of concern, where smart technologies could be applied for support. Our study targets potential risks (health, safety and increased energy consumption) that subjects of the selected age group face during their everyday actions and our research suggests various smart products available on the market, for assisting them while performing those actions.

From the large list of smart technologies and information systems provided in Table 3, users may select only the ones that fit to their particular needs and everyday actions [15]. As Eng [11] pointed out, more than 50% of older Singaporeans are willing to include some of these features in their homes to enhance their quality of living. However, these smart products need to be user-friendly for people to use, as the interaction capabilities of citizens above 60 with new technologies tend to weaken by age [9].

In an effort to select the most important of these products, we identify the automated pill dispenser and medication management system where healthcare is concerned. In relation to personal safety, a detection system of smoke and gas, a keyless door system and motion/humidity sensor for remembering to lock windows or doors are among the most needed. Regarding convenience and comfort, a universal remote control for switching off electrical devices would help elderly people to accomplish this task more easily. Then, communications would be facilitated by a picture or a voice dialing system.

Energy management may include the adoption of motion sensors and smart power outlets for automatically switching off unused devices and for understanding their consumption patterns and actual cost of use.

Moreover, utilizing the Internet for communication and healthcare purposes is a challenging task with much potential, especially since related surveys showed that elderly population can learn to use computers and are looking for methods to stay connected and be informed [22]. Besides, various Web-based platforms such as the Co-living project [23], target to create virtual collaborative living communities for older people, helping them to be socially-active and connected as they age.

Smart phones may also be harnessed for alerts/notifications in case of emergency (e.g. smoke or gas detection, windows or doors left open) or in scenarios relating to fitness and lifestyle, education and management, ambient assisted living and health surveillance, by using various mobile applications [24].

We need to note the research performed on body-area wireless sensor networks and wearable sensor technology for healthcare [25], being able to monitor the health status of elderly people continuously, aiming to minimize the need for caregivers and to help chronically ill people to live an independent life, by providing rich contextual information and alerting in case of abnormal observations. However, these systems have still major challenges including intrusiveness (compromising privacy) and discomfort, high sensitivity and need for calibration, reduced battery lifetimes, and issues of user-friendliness, security and ease of deployment [25].

Finally, a major criticism for assisted living technologies in general is that the components of sensing and home monitoring, wearable technologies and electronic social interaction have not yet succeeded to become ubiquitous in the everyday lives of elderly population. Nonetheless, technology in this area is evolving fast, with considerable business opportunities.

Our user study has some limitations that affected our findings and observations. At first, we did not prioritize activities according to their overall risk to the participants. For example, the activity of leaving the main door unlocked when unattended might have a higher risk rather than misplacing the house keys. This priority of concerns would be important for focusing on particular assistive technologies, especially when cost is not affordable for all or many users.

Secondly, the distribution of the survey sample was skewed towards people below 70 years old. People aged above 75 constituted only 23% of our survey’s responders (24 participants). Thus, the responses may not be the best representations of some actual needs of citizens as they become older and weaker. Third, we did not consider some cutting edge technologies such as robotics, telemedicine, virtual reality and gaming, as discussed in [4,7,25].

Moreover, our study focused on the routine activities of elderly population within their home. Their involvement in outdoor activities was not taken into consideration. For example, personal mobility and public transportation are important topics discussed in [17]. Also, some outdoor activities are mentioned in [18]. This aspect is left for future work.
Finally, aspects such as the small sample size, the manual, self-reporting approach to collect data, as well as the possible cultural bias in the Singaporean context might have affected the validity and strength of this study.

7. Conclusion and future work

In this paper, we have performed a three-phase user study for understanding the needs and areas of concern of elderly population in their everyday lives. By means of an interview, personal interviews and a survey, we have identified the main activities of the participants and the risks posed to them when performing these actions. We have discussed with the participants to understand the reasoning behind their actions and, based on the feedback received, we have proposed various smart technologies available on the market, which can be used to assist citizens above 60 in their everyday needs ensuring their health, safety, convenience, low energy footprint and a high, dignified quality of life with increased autonomy and independence.

As the concept of smart home is relatively unknown to older Singaporeans, there need to be active awareness and progressive change in elderly people’s perception towards smart technologies. The campaign of ageing-in-place for elderly Singaporeans, promoted by the government, should be revamped to incorporate smart home technologies especially with the new third-generation housing concept being introduced [26].

As future work, we plan to perform more thorough field studies and personal interviews involving a larger number of elderly population, in order to better understand their needs and activities.

Our study did not explicitly map the different smart technologies to the willingness of the participants to use them regularly. Such an extension would be helpful and meaningful as Singapore makes its journey into smart ageing.

We will continue to assess new, promising technologies targeting the support of subjects of the selected population during their everyday lives. We also plan to explore various ways to make these technologies friendlier and more acceptable and, finally, to deploy some of these smart products in houses around Singapore, to examine their effectiveness in assisting people.

We believe that the adoption of smart technologies has the potential to enhance the living environment for the ageing population. Although some of these technologies are still quite expensive, not fully reliable, easy to use and accurate, they are capable of supporting the everyday activities of the elderly people satisfactorily. By means of home technology, elderly population would be able to experience a more autonomous and independent living and a high quality of life during their golden years.

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