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# Acoustic Needs of Older People in the Outdoor Environment of Residential Communities: A Case Study in China

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This study examines the acoustic needs of older people in an outdoor environment to design outdoor spaces according to their needs. Using the grounded theory approach, we selected and interviewed 16 older people from four residential communities in China. The acoustic needs of older people in an outdoor environment are established in terms of sound preference, quietness, acoustic variability, acoustic comfort, subjective loudness, sound rhythm, sound clarity, and sound sensitivity. The findings show that older people (a) attach importance to quietness when considering sound preference, (b) prefer taking a walk in an overall quiet environment, although sometimes a lively environment, (c) chose to conduct their activities in an environment with low variation in sound, (d) rate the comfort of their overall acoustic environment highly, (e) show little need for subjective loudness as long as the sounds are not ones they dislike, (f) generally prefer relatively rhythmic sound sources, (g) did not have a significant need for sound clarity, and (h) are tolerant of outdoor acoustic environments and did not pay too much attention to certain sounds. These findings can provide direction for better outdoor space designs in communities, to suit older people, and to create age-friendly cities.

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## NOMENCLATURE

GT – Grounded Theory

## 1. INTRODUCTION

The number of older people in the world is expected to double from 11% in 2006 to 22% by 2050.<sup>1</sup> In comparison with other countries, China has the largest population of older people and most live in their own communities.<sup>2,3</sup> Studying the needs and preferences of older people in the community contributes towards improving their satisfaction and life quality.<sup>4</sup> In terms of outdoor spaces, older people generally prefer shorter walking distances.<sup>5</sup> Hence, closer attention should be paid to the outdoor environments of residential communities.

Research on soundscape can improve the quality of the environment and the life of the residents, thus contributing to urban development.<sup>6</sup> Soundscape focuses on perception rather than physical quantity;<sup>7</sup> it is the acoustic environment of a given scene as perceived by individuals, groups, or communities.<sup>8</sup> Schafer's research paved the way for the interest in soundscape.<sup>9</sup> In addition, studies on the supplementary effect of the soundscape in noise research have helped increase our understanding of its importance.<sup>10</sup>

Yang and Kang studied the acoustic needs of non-elderly individuals in the outdoor environment and concluded that they felt a high sense of acoustic comfort, even in high-pressure sound areas. Music made people comfortable, but not all kinds of music were preferred.<sup>11</sup> Lee et al. concluded that gender

had no significant effect on quietness and acoustic comfort.<sup>12</sup> The phenomenon of noise was one of the most common complaints made by people.<sup>13</sup> Hong et al. conducted *in situ* experiments with 33 young participants and showed that adding bird-songs and water sounds could significantly reduce the loudness of traffic noise in the real environment, and could significantly improve the overall soundscape quality.<sup>14</sup> They also studied the impact of outdoor activities on the acoustic perception of 50 participants and found that outdoor activities (relaxation, outdoor entertainment, and social gathering) had no influence on enhancing satisfaction obtained from natural sounds.<sup>15</sup>

However, most studies on the soundscape of older people focus on the indoor environment. Wang and Kang investigated the soundscape in nursing homes and found that rather than reducing the sound of music or of other activities, such as table tennis, older people preferred reducing the sound of chatter. The type of activity and the quietness of the room were important factors that affected their acoustic needs.<sup>16</sup> Mu et al. discussed the acoustic perception and preferences of older people in nursing homes and found that most people did not appreciate the sounds of chatter but could tolerate mechanical and activity sounds. Their acoustic comfort was affected by their sound preferences and audibility. However, music could entertain older people and encourage them to exercise.<sup>17</sup>

Research on the acoustic environment of urban public spaces shows that older people generally have higher satisfaction with the acoustic environment; they prefer natural or culturally meaningful sounds and also have a higher evaluation of music compared with young people.<sup>11,25</sup> The greatest

difference noticed among older adults and other age groups is on noise annoyance,<sup>28</sup> and one of the reasons for the least sound annoyance in older people could be attributed to hearing and sensitivity loss.<sup>29</sup> According to the research conducted by WHO in 2018, about one-third of people over the age of 65 have moderate hearing loss,<sup>26</sup> such as insensitivity to high-frequency sounds, reduced language recognition ability, etc.<sup>27</sup> The average age of older people without hearing ailments was around 70, and men were 19% more likely to have hearing problems than women.<sup>28</sup> Nevertheless, research on the acoustic needs of older people in the outdoor environment of residential communities is sparse, and this study aims to bridge this gap using the Grounded Theory approach. There are two research questions, namely (1) What aspects do the acoustic needs of older people in outdoor environments of residential communities include? and (2) What are the specific needs relating to each aspect of the acoustic needs of older people? The results can supplement soundscape research on the living environment of older people.

## 2. METHODOLOGY

### 2.1. Participants and Interviews

Four communities in Daqing with good landscapes consisting of large outdoor spaces, high greening rates, and good sanitary conditions were selected randomly, as shown in Fig. 1. Their distance from the main traffic road is about 20 to 130 meters. During the commute period (around 7:00, 11:00, 13:00 and 17:00), the traffic flow on streets outside the residential communities is high. About 300 to 900 vehicles pass by per hour, 12% of which are large vehicles. The average speed of large vehicles is about 20 km/h, and that of small or medium-sized ones is 35 km/h. Large vehicles are mostly driven on streets outside residential communities, while small or medium-sized ones are driven both inside and outside. Besides, birdsongs can be heard in many places usually in the morning, and chatting sounds often appear between 18:00 and 20:00 in a small group of people. The study was approved by the Degree Committee of the School of Architecture, Harbin Institute of Technology (including an ethical review board). Interviews were conducted in the public spaces of these residential communities with the consent of all respondents. Before the beginning of the interview, the respondents were introduced to the content and purpose of the research. They were also assured of the confidentiality of the personal information they would share during the interviews. A total of 16 respondents, 8 male and 8 female, aged between 65 and 73, were selected based on the requirements for respondents' age, and the frequency of outdoor activities. There were no monetary incentives offered for participation. Respondents generally did not show significant hearing loss and could conduct relatively fluent Q&A with the interviewer. Additionally, there was no significant difference in the hearing level among them. All the respondents participate in outdoor activities regularly. Interviews for each respondent took about half an hour.

Six core questions and some detailed ones were prepared in advance, as shown in Table 1. During the interview, there were also additional questions based on the interviewees' replies. After the interview, the results were compiled into a manuscript and analysed through the Nvivo software. As a powerful qualitative analysis software, Nvivo usually organ-

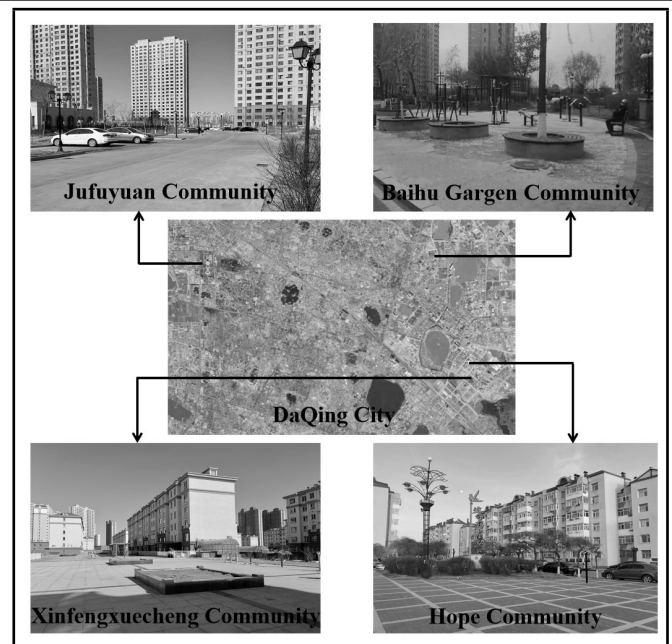


Figure 1. Outdoor spaces in selected communities.

ises and classifies the elements of imported materials (pictures, texts, etc.) based on the grounded theory, constantly compares concepts and establishes connections among them, finally developing theories and answer research questions. Interviews offer great flexibility for meaning interpretation. Using semi-structured interviews, this study aimed to understand the acoustic needs of older people by directly asking for their views and encouraging them to give detailed responses with examples.

### 2.2. Grounded Theory (GT)

GT is used to identify the core concepts that reflect social phenomena based on systematic data collection. It emphasises the close connections among theoretical development, data collection and analysis, and the final theory.<sup>18</sup> In soundscape research, conclusions can be drawn from an in-depth and systematic qualitative analysis of data.<sup>19</sup> This study used GT to explain the acoustic needs of older people in the outdoor environment of residential communities in China. GT has often been used in urban soundscape research,<sup>20,21</sup> and it has significant advantages in the theoretical construction of qualitative soundscape research.<sup>22</sup>

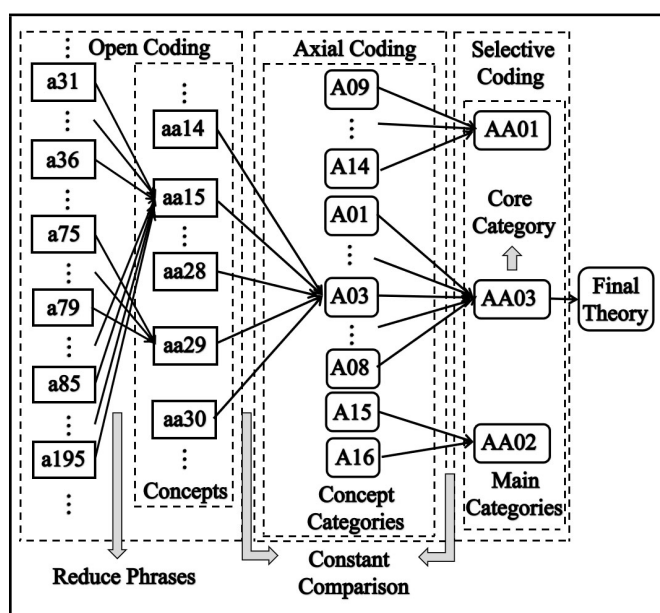
## 3. DATA PROCESSING

GT takes raw data and brings it to a conceptual level through systematic coding; it establishes connections until the data are saturated, to develop an inductive theory.<sup>18</sup> Data include participants' responses, thoughts, and motivations. The coding process consists of three levels: open coding, axial coding, and selective coding.

Open coding was labelled as 'a'. The preliminary concepts that have been drawn were classified and abstracted for categorisation. The concept categories were successively extracted and represented by 'A'. The relationship was generally parallel among A01 sound clarity needs, A02 acoustic variability needs, A03 quietness needs, A04 sound sensitivity needs, A05 sound rhythm needs, A06 subjective loudness needs, A07 acoustic comfort needs, and A08 sound preference needs. In

**Table 1.** Interview questions.

Core questions	Detailed questions
Are you feeling comfortable in the acoustic environment around you? / Are you pleased with the sounds around you when you are outside?	Which are the sounds you like or dislike when you are walking around? (Animal calls, sounds of wind/ cars /construction /music /chatting ...)
Do you think the surrounding environment is too loud? / Are your outdoor surroundings noisy or quiet?	Why do you like or dislike these sounds? /How do you feel about these sounds / How do these sounds affect your outdoor activities?
How do you feel about the overall acoustic environment or individual sounds around you?	Does the noise or the quietness have any effect on you?
Have you heard sounds with a strong sense of rhythm?	Are there any sounds that you rarely hear when you are outdoors?
Whether the surrounding sound is clear or not has any effect on your outdoor activities, if so, please talk about it?	Do you want to hear different kinds of sounds often?
Do you feel that you are sensitive to sounds in the environment?	Are sounds you rarely hear have any effect on you?
	Do you like such rhythmic sounds? How do you feel about them?
	Do you occasionally hear sounds that others can rarely hear?
	How does your sensitivity to sounds affect outdoor activity?



**Figure 2.** Part of the coding process.

analysing the relationship among the concept categories and summarising them, three main categories were derived; core categories were obtained through further comparison and analysis of the data. Some examples of the coding process and the results are as shown in Fig. 2 and Table 2 respectively.

## 4. RESULTS: MAIN CATEGORY ANALYSIS

The three main categories drawn are AA01, current outdoor acoustic environment; AA02, outdoor activity characteristics; and AA03, outdoor acoustic needs. The relationships among the principal categories are progressive and parallel. Finally, ‘outdoor acoustic needs’ is selected as the core category to lead others. The final theory is based on the acoustic needs of older people in the outdoor environment of residential communities.

### 4.1. Current Outdoor Acoustic Environment

Current outdoor acoustic environment refers to different types of sound sources existing in the outdoor environment of residential communities, such as the types of sound sources that are heard often or rarely. When the older people step

out for their activities, they can hear rhythmic sounds, such as square dance music and ringtones. There are also a variety of artificial sounds (firecrackers, etc.), natural sounds (insect calls), and activity sounds (screams, etc.) that are rarely heard. Overall, people considered their outdoor environment as quiet and rarely changing. For example, 14 respondents said that ‘The places where I often hang out are quiet in most cases.’ Certain older people felt that the outdoor space was quieter during the day than at night.

### 4.2. Outdoor Activity Characteristics

Outdoor activity characteristics consist of advantages of outdoor activities and outdoor activity periods of older people. They tend to partake in outdoor activities to enjoy the outdoors or walk and chat with others. Some said they preferred to go out when there were fewer people. For example, one respondent said, ‘The greenery is appealing, and I find that talking to others helps one pass time easily’, and ‘Occasionally, there is so much noise that I don’t go out at that time’.

### 4.3. Outdoor Acoustic Needs

The outdoor acoustic needs of older people include sound preference, quietness, acoustic variability, acoustic comfort, subjective loudness, sound rhythm, sound clarity, and sound sensitivity. Similar to Yang and Kang’s research,<sup>11</sup> older people also think highly of acoustic comfort, and except for some who dislike square dance music, most prefer music being played because it promotes their outdoor activities. Unlike Hong et al.’s research, outdoor activities have a positive influence on older people’s preferences for natural sounds.<sup>15</sup> Similar to the results from Mu et al.’s study,<sup>17</sup> most people also prefer a quiet outdoor environment, and their acoustic comfort is influenced by sound preferences. Additionally, the type of activity also affected older people’s needs in evaluating outdoor soundscapes. However, only a few people in this study said that they disliked the sound of people talking at length during outdoor activities. Most people showed no special like or dislike for the sound of chatter.

#### Sound preferences

Older people disliked artificial sounds caused by construction work or cars because they were unpleasant and noisy; some also stated that they disliked the activity sounds of peo-

**Table 2.** The three-level coding results using grounded theory.

Sorting Memos	Labelling	Conceptualising Data	Categorising Data	Categories	Subcategorisation	
<p>I think the sounds of the outdoor environment of residential communities are quite pleasant during this period, and I am pleased and satisfied.</p> <p>The most disliked sounds are that of construction and the music that is played during the square dance.</p> <p>Construction sounds are jarring.</p> <p>The square dance music is too loud, and the music is unpleasant.</p> <p>I like birdsongs.</p> <p>I usually go out in the morning or afternoon, anyway, not very late.</p> <p>...</p>	<p>a01 Pleased with sounds that I hear when I go out</p> <p>a02 Dislike construction sounds and square dance music</p> <p>a03 Construction sounds are jarring</p> <p>a04 Square dance music is too loud</p> <p>a05 Square dance music sometimes shocks my ears</p> <p>a06 Square dance music is unpleasant</p> <p>a07 Square dance music is not pleasant music</p> <p>a08 Square dance music makes me uncomfortable</p> <p>...</p>	<p>aa01 Artificial sounds that do not affect outdoor activities (a144 and a207)</p> <p>aa02 Activity sounds that do not affect outdoor activities (a143)</p> <p>aa03 Natural sounds that do not affect outdoor activities (a121)</p> <p>aa04 Sound clarity needs depending on quietness (a97, a98 and a99)</p> <p>aa05 Sound clarity needs depending on the type of activity (a177 and a178)</p> <p>aa06 Sound clarity needs depending on sound preference (a51, a52 and a193)</p>	<p>A01 Sound clarity needs (aa04, aa05, aa06, aa07, and aa08)</p> <p>A02 Sound variability needs (aa09, aa10, and aa11)</p> <p>A03 Quietness needs (aa14, aa15, aa28, aa29, and aa30)</p> <p>A04 Sound sensitivity needs (aa31 and aa32)</p> <p>A05 Sound rhythm needs (aa13, aa33, aa34, aa35, aa36, and aa51)</p> <p>A06 subjective loudness needs (aa37)</p> <p>A07 Acoustic comfort needs (aa38, aa39, aa40, and aa41)</p> <p>...</p>	<p>AA01 Current outdoor acoustic environment</p> <p>AA02 Outdoor activity characteristics</p> <p>AA03 Outdoor acoustic needs</p>	<p>AA01 Current outdoor acoustic environment</p> <p>(1) Types of sound sources often heard</p> <p>(2) Types of sound sources rarely heard</p> <p>...</p> <p>AA02 Outdoor activity characteristics</p> <p>(1) Advantages of outdoor activities</p> <p>(2) Outdoor activity period</p> <p>AA03 Outdoor acoustic needs</p> <p>(1) Sound preference needs</p> <p>(2) Quietness needs</p> <p>(3) Acoustic variability needs</p> <p>...</p> <p>Generating the substantive theory</p>	
	Initial data collection	212 items	53 items	16 items	3 items	

ple talking loudly or chatting at length. Sounds that older people favoured were mainly natural sounds (birds chirping, insect calls, etc.) and music. Natural sounds were often pleasant and could make them feel relaxed, and music could promote outdoor activities and let them be more energetic. Besides, quietness had a significant impact on the sound preferences of older people. For example, 8 people said: ‘Birdsongs are interesting and enjoyable’, and 4 people said: ‘I don’t like loud chatting sounds or when people keep chatting beside me’.

*Quietness*

Older people usually preferred outdoor activity in an overall quiet but sometimes lively environment. A relatively quiet environment could put them in a good mood, but boredom or loneliness set in if the place was too quiet. Moreover, noisy environments have negative impacts on outdoor activities, and chronic exposure to noise reduces speech perception and affects memory for processing semantic material.<sup>24</sup> Therefore, there is a need for noise reduction as older people require a certain amount of quiet in the outdoor environment. 12 respondents said, ‘If the surrounding environment is noisy, I become irritable or anxious’.

*Acoustic variability*

Over half of the older people interviewed preferred to engage in outdoor activities in an environment with low variation in sound. This is because they got used to familiar surroundings and developed a sense of comfort. For instance, one respondent said, ‘The acoustic environment that I am used to, with no major changes, makes me feel familiar and comfortable with everything around me’.

*Acoustic comfort*

Almost all respondents rated acoustic comfort highly, and nearly half said they care more about acoustic comfort in the overall environment. Meanwhile, sound preference, quietness and acoustic variability impacted acoustic comfort. A decrease in disliked sounds, noisy environment and acoustic variability could improve acoustic comfort. For instance, one respondent claimed, ‘The lesser I hear the sounds I dislike, the better I feel’.

*Subjective loudness*

Older people’s need for subjective loudness is affected by sound preferences. Sounds they disliked need to be reduced. For instance, one respondent said, ‘If I hear loud and disliked sounds, it will affect my activity outside’. However, older people are more tolerant of the subjective loudness of sounds they like. A 65-year-old male respondent said, ‘Regarding sounds that I like, it doesn’t matter if they are loud’.

*Sound rhythm*

Most people preferred rhythmic sounds, as it was deemed interesting and enjoyable, promoting their outdoor activities. For example, one respondent said, ‘I prefer rhythmic music and I feel more active’. However, some people disliked strong rhythmic sounds while walking; they found it disrupted their outdoor activities, especially when they were resting or chatting outside. A few respondents said that their need for rhythmic sounds was related to subjective loudness, since they preferred rhythmic sounds which were not too loud.

*Sound clarity*

Sound clarity did not appear to be a great need for the re-

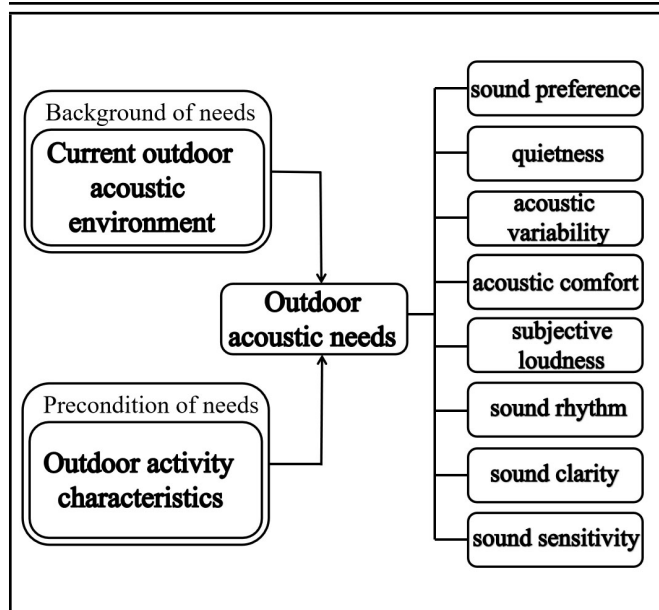


Figure 3. Relationship between the main categories.

spondents. Some believe that the need for sound clarity is affected by quietness, sound preferences, and activity type; others said that the need for sound clarity depends on the type of sound source. For example, 2 respondents claimed, ‘When I am resting outside, I hope the sound is unclear so that it won’t bother me so much’, and ‘I hope that the sounds I dislike are unclear’.

#### Sound sensitivity

Most people were tolerant of outdoor acoustic environments and did not pay too much attention to certain sounds. They believe that their sound sensitivity has little impact on outdoor activities. For example, a 66-year-old female respondent said, ‘I rarely hear sounds that most people did not notice during my outdoor activities’.

### 4.4. The Relationship among the Main Categories

After the analysis, ‘outdoor acoustic needs’ was selected as the core category. The relationship among the three main categories is shown in Fig. 3. To summarise, in the current outdoor acoustic environment, older people usually take part in activities at specific times, and their acoustic needs vary depending on the activity. The ‘current outdoor acoustic environment’ forms the background to ‘outdoor acoustic needs’. Outdoor space is essential to promote social interaction and active ageing among older people.<sup>23</sup> The acoustic environment is also an important part of overall outdoor environment. Respondents discussed their acoustic needs in the outdoor environment of their communities. ‘Outdoor activity characteristics’ refer to the precondition of ‘outdoor acoustic needs’. Older people prefer outdoor activities as they can experience the outdoor environment, experience relaxation and comfort, and walk and chat with their companions. Studies have shown that outdoor spaces are places where people meet with others and enjoy nature.

## 5. CONCLUSIONS

The GT-based study with semi-structured interviews of 16 older people in four residential communities in China resulted

in the identification of three main categories, ‘current outdoor acoustic environment’, ‘outdoor activity characteristics’, and ‘outdoor acoustic needs’, of which, ‘outdoor acoustic needs’ was chosen as the core category to evaluate the ‘current outdoor acoustic environment’, which forms the background for ‘outdoor acoustic needs’, and ‘outdoor activity characteristics’, which is its precondition. Thus, the acoustic needs of older people in the outdoor environment of residential communities were investigated in terms of sound preference, quietness, sound sensitivity, acoustic comfort, subjective loudness, sound clarity, sound rhythm, and acoustic variability.

This study finds that older people: (a) attached importance to quietness when considering sound preference; (b) preferred an overall quiet environment, although at times a lively outdoor environment was enjoyed as well; (c) did not prefer much variation in the sounds of their outdoor environment; and (d) rated the acoustic comfort of their overall outdoor environment highly. They did not show a need for subjective loudness, as long as the sounds were not disliked by them. In general, they preferred sounds with a strong sense of rhythm and had little need for sound clarity, especially when they were resting outdoors. Most were tolerant of outdoor acoustic environments and didn’t pay too much attention to certain sounds. Based on the above results, trees with tall branches and dense foliage can be planted in the residential area, then sounds of birds and wind can be produced naturally. It is also possible to use the characteristics of vegetation in absorbing sound energy, combine them with different forms of terrain and increase vegetation coverage to form multi-level greening to reduce noise.<sup>30</sup> This can make the overall environment quiet but not dull, and help design age-friendly outdoor acoustic environments for residential communities.

Since this study is limited to the Chinese general community, further research could examine and compare the acoustic needs of people living in different community environments (such as different climatic conditions, cultural backgrounds, or blockade conditions). Additionally, the respondents selected in this study were those who participated in outdoor activities regularly, due to the general decrease in people’s outdoor activities during the epidemic. The follow-up research plans to compare these results with older people who have less experience or are older than 73.

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