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Cognitive Decline: An Analysis of the Elderly Population in Isolated Regions of Mexico

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Abstract: Worldwide studies in the last decade have measured the rate of cognitive decline in the elderly population, mainly in Australia, Europe, United States, and Canada. In Mexico, this information is very limited and the population of Hidalgo State has never been studied. Therefore, we decided to perform a transversal study to determine the rate of cognitive decline in this region. We will present an analysis in order to establish the main differences between rural and urban areas, as well as identifying the particular triggers of cognitive decline on each area.

Keywords: Elderly Population, Aging, Cognitive Decline, Mini-Mental State Examination (MMSE), Educational Level, Living Area

Introduction

The main purpose of this article is to study the elderly population with feasible cognitive decline in isolated areas of Mexico such as the State of Hidalgo, where there are not any previous studies or reports concerning this problem. To achieve this, we used the MMSE test and 3 other variables such as age, educational level and living areas. We hypothesized that people older than 70 years old, with low educational level and living in rural areas have a high risk of developing a cognitive impairment.

According to the World Health Organization (WHO, 2012), persons between 60 and 74 years old are considered of *advanced age*. From *75 to 90* years old, are classified as *old or aged,* and those exceeding 90 years old are named *big old or big long-lived.* However, the United Nations Organization (UNO) considers "*senior"* every person older than 65 years old for the developed countries, and 60 year old for the developing countries (Lee and Mason, 2011). In Mexico is considered to be *an elder* a person who is older than 60 years old.

In 1950, there were about 200 million persons of 60 years old or more in the whole world. By 1975, the number had increased to 350 million (UNO). The population projections for 2025 will be of more than 1,100 million. It means an increase of 224% since 1975. It is foreseen that during the same period the entire world population will increase of 4.100 million to 8.200 million, in other words, 102%. Therefore, in the following 45 years, the persons of advanced age will constitute 13.7 % of the worldwide population (Dávila Lara *et. al*., 2010)

Mexico is not the exception to the global aging phenomenon. In accordance with the National Institute of Statistics and Geography of Mexico (INEGI, 2010), the elderly Mexicans will represent approximately the 24.5% of the whole population by the year 2050. Thus, there will be 1 elder for every 4 non-elder people.

Particularly, in the State of Hidalgo which is located in central Mexico, near Mexico City. Its population data have some interesting features that we will describe in the following lines. At present, for every 100 persons younger than 15 years old, there are 32 persons older than 60 years old, and according to the INEGI, there will be one elder for every three 15 years old habitant. This is very similar to the statistics of the whole country.

One of the consequences of these rapid demographic changes is the appearance of some mental health disorders like Dementia, characteristic of older age which is now a leading cause of disability worldwide (Barnes *et. al.,* 2003; Deary *et. al.*, 2009).

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The Mini Mental State Examination (MMSE) is one of the most commonly used instruments to assess cognitive impairment in both clinical practice and epidemiological research. It is brief, simple, available in several languages, and has been adapted to suit populations from different backgrounds. While the MMSE has limited specificity with respect to individual clinical syndromes, it is a standardized method to grade patient's cognitive mental status. It assesses orientation, attention, immediate and short-term recall, language and the ability to follow simple verbal and written commands. It provides an individual's total score on a scale of cognitive function (Crum, *et. al*., 1993 and Folstein *et. al*., 1975).

Methods

Study Design and Sampling

The investigation was carried out in different regions of the Hidalgo State, located in central Mexico. We determined the living areas according to the INEGI, which classified rural areas as those with a population below 2,500 people and urban as those over that number.

Participants of the study were chosen by their age and living area. The MMSE was applied to a random sample of 158 subjects' aged 60 years or older living in rural or urban areas with no distinction of sex.

According to the Mexican Educational System, the educational level was considered as 'years of education', where 0 was 'no education', 6= 'complete elementary school', 9= 'complete middle school', 12='complete high school', 16-17= "bachelor degree', 18='master's degree and 22= 'PhD degree'.

MMSE Test

We used the Mexican version of the MMSE (Folstein, *et. al., 1975*). It is divided into five different sections that includes items assessing space-time orientation (ten points), registration of information (three points), attention and math calculation (five points), recall (3 points), identifying objects (two points), repetition of a sentence (one point), verbal comprehension (three points), reading comprehension (one point), writing skills (one point) and drawing skills (one point). The total MMSE score can range from 0 to 30. For the present study, we considered MMSE scores equal or below 23 as an indicator of probably cognitive impairment. Those subjects whose answers were 'don't know' or 'no answer' were coded as incorrect (score zero).

Ethical Considerations

All the participants provided written informed consent. The study received full ethics approval from the Bioethics Committee of the Hidalgo State Autonomous University.

Data Analysis

The data analysis was implemented in R studio (http://cran.r-project.org). The data base was migrated from excel to R studio. The boxplots and histograms were done using the R studio packages with the followings commands; "*boxplot* (data_file)" and *"hist (data_file)"*.

Results

Age Related

The 49% (78/158) of the participants presented a probably cognitive decline and 51% (80/158) did not present this impairment. Figure 1A shows the probably cognitive decline of elderly

population by age. It can be noted that the impaired population is older than 70 years old which correspond to 52% (41/78) of the probably cognitive impaired population. In contrast with elderly population without cognitive decline (figure 1B) older than 70 years old represents only 32% (26/80) of non-impaired elderly. Therefore, the probably cognitive impaired participants were older than those without cognitive decline.

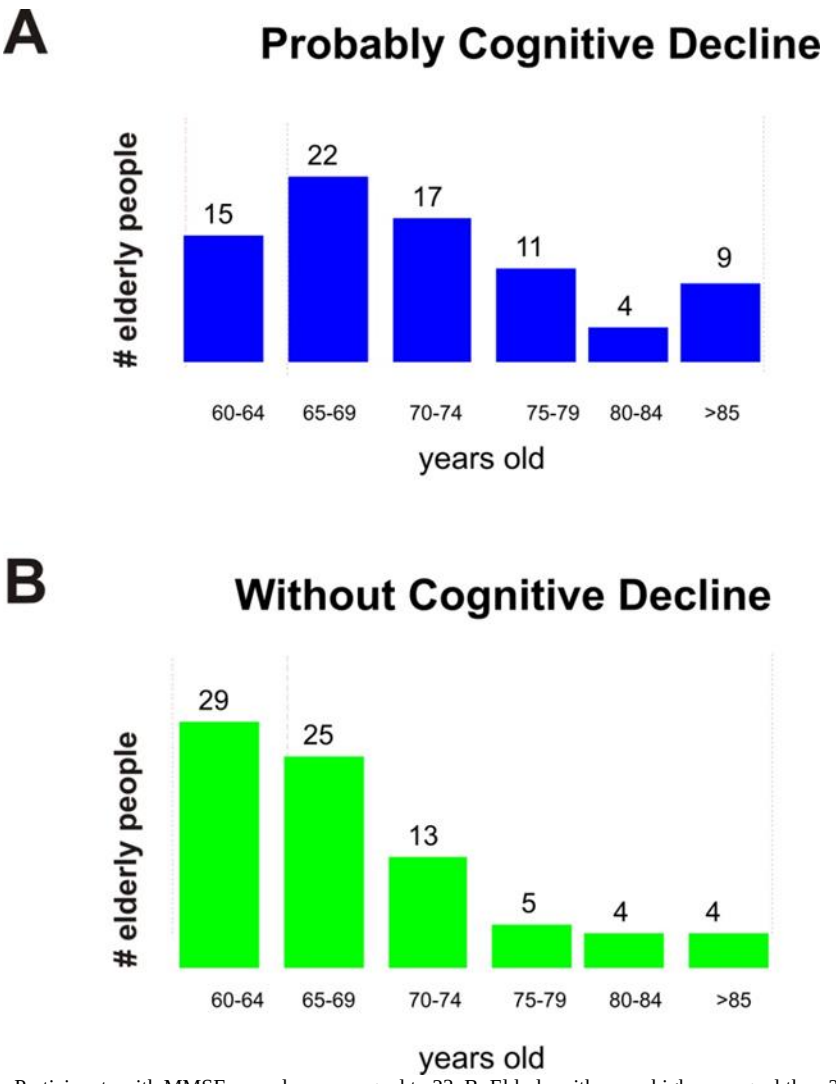


Figure 1 A: Participants with MMSE score lower or equal to 23. B: Elderly with score higher or equal than 24. More details in the text.

Educational Level

The elderly population with presumably cognitive decline has lower educational level compared with the population without this impairment. The 65% (51/78) of cognitive impaired population had educational level between none to elementary school (see figure 2A). In contrast, most of the non-impaired cognitive elderly had up to middle school, 51% (41/80), see figure 2B.

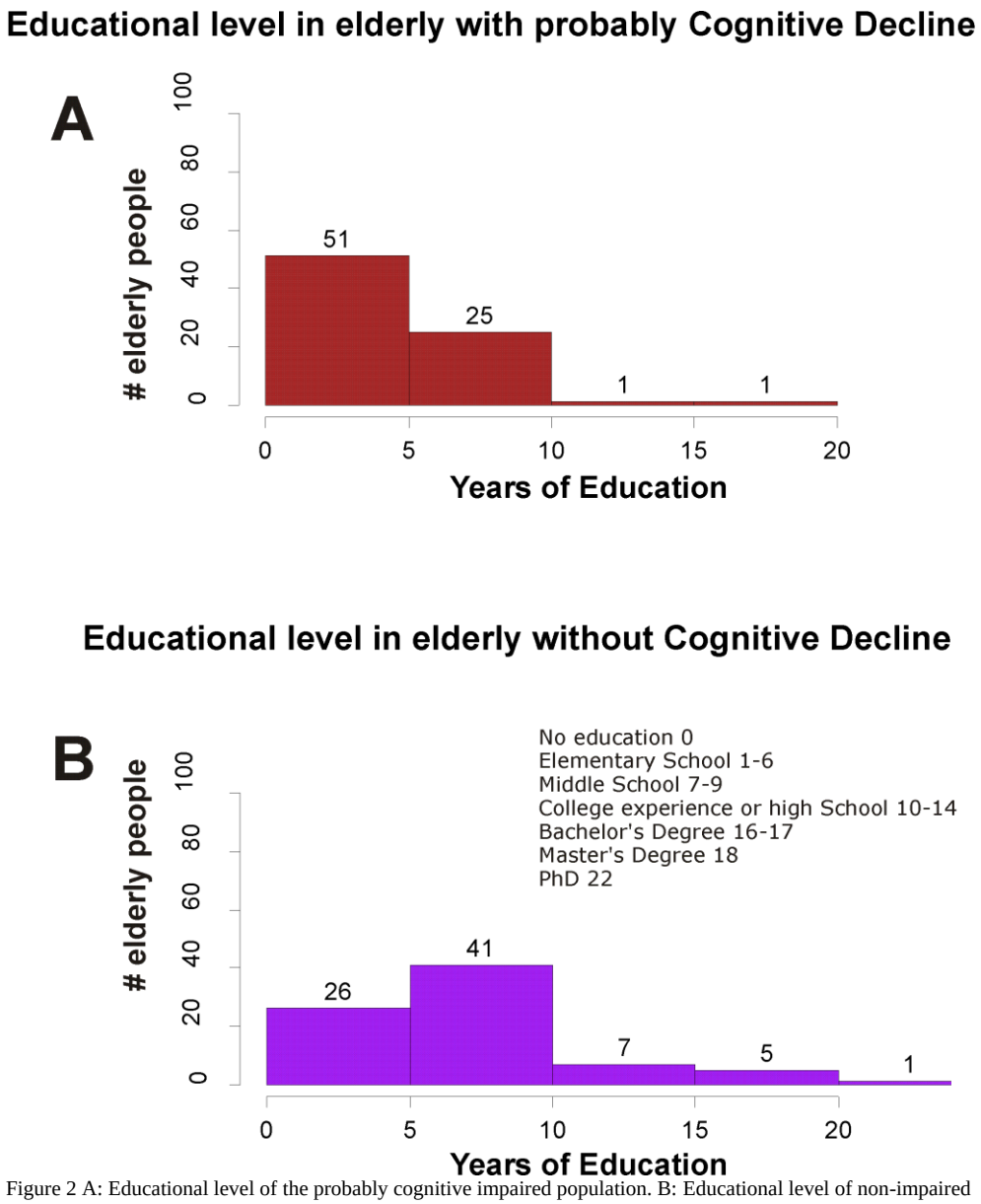


Figure 2 A: Educational level of the probably cognitive impaired population. B: Educational level of non-impaired participants. More details in the text.

Living Area

Elderly people living in rural areas are more likely to present cognitive impairment than those living in urban areas. This first analysis of isolated areas in the State of Hidalgo, demonstrates that 55% (43/78) of the population with cognitive impairment live in rural areas. On the other hand, participants with no cognitive impairment represent the 26% (21/80) and live in rural areas meanwhile the 74% (59/80) live in urban areas, see figure 3. The elderly population in rural areas lives in marginal zones with very limited access to educational settings; hence they have a higher risk to develop a cognitive impairment.

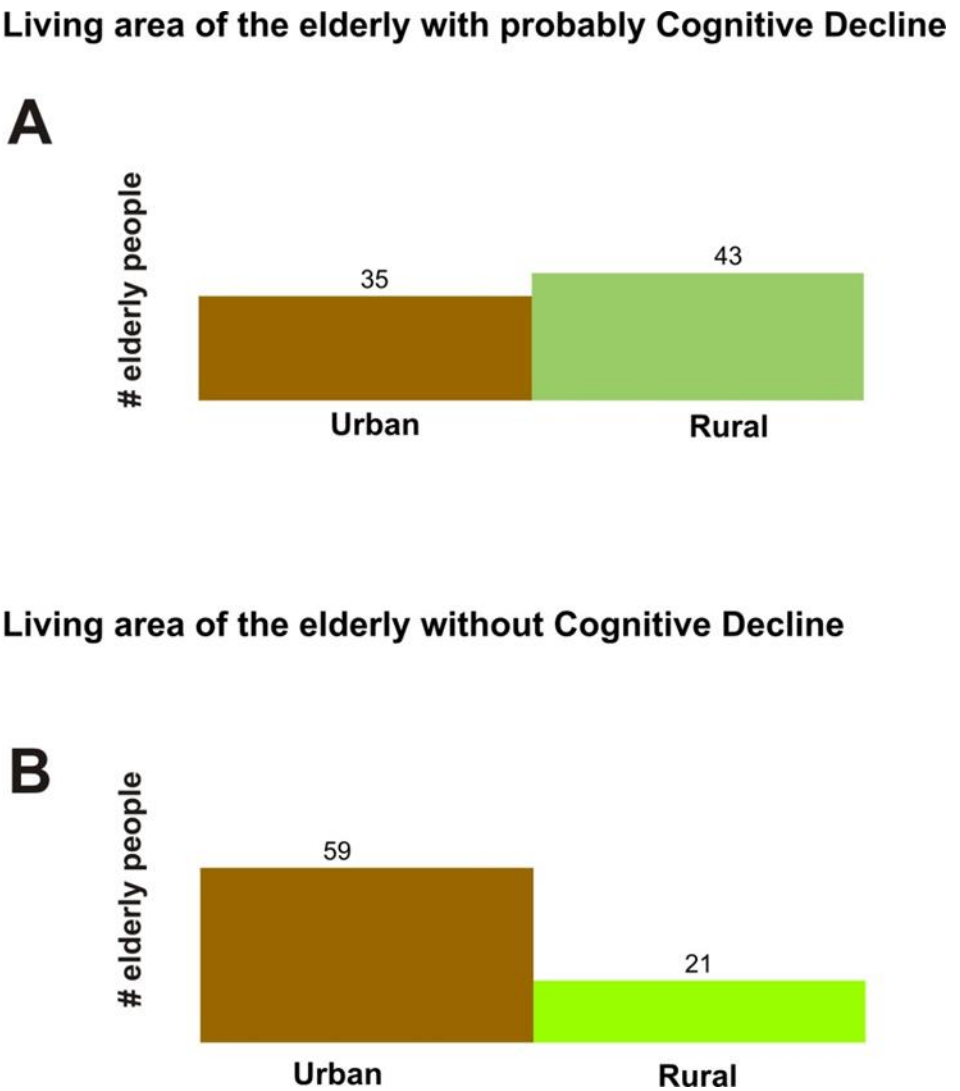


Figure 3: Aging people living in urban and rural areas of Hidalgo State.
A: Population with probably cognitive decline. B: Population without cognitive decline.

MMSE Scores of Elderly Population by Area

To study if there were differences in the scores from the different areas of the MMSE, we analyzed the scores obtained from the participants with and without probably cognitive decline.

Space-time Orientation

The results showed that participants with cognitive impairment have a median of 8 (on a scale of 1-10), while participants without cognitive decline have 10 (Figure 4). We can conclude that subjects without cognitive impairment know exactly where they are, both in space and time. While participants with cognitive decline show a little time-space disorientation.

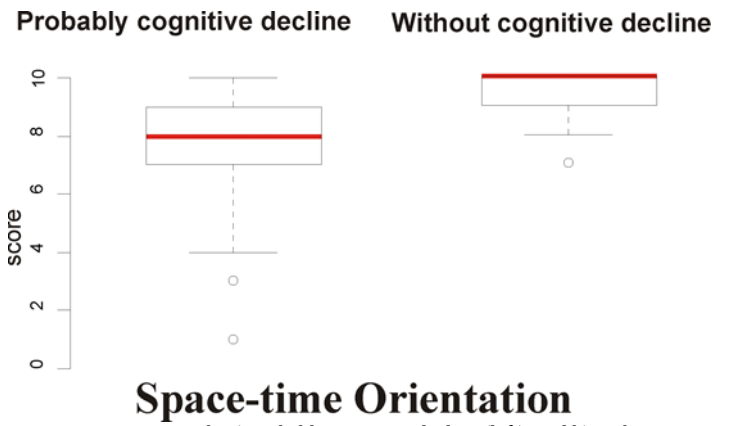


Figure 4: Orientation in patients with: a) probably cognitive decline (left), and b) without cognitive decline.

Memory

In this area, subjects with and without cognitive impairment obtained a median of three points (on a scale ranging from 0 to 3). We noticed that participants with no cognitive impairment were able to perfectly recall the three words. In contrast, participants with feasible cognitive decline could only remember one word, and were unable to recall the other two (Figure 5).

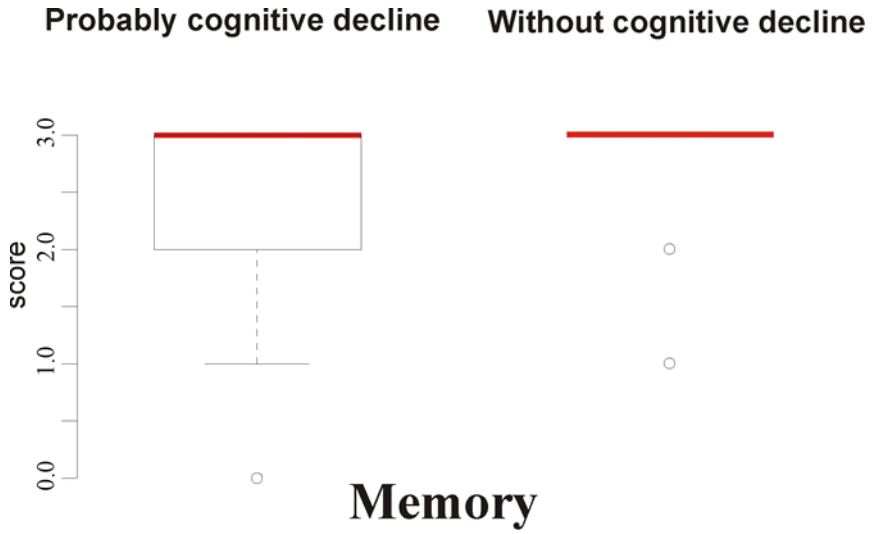


Figure 5: Memory test in patients with: a) cognitive decline (left), and b) without cognitive decline (right). In both cases, the median is 3.

Math Calculation

The maximum possible score obtained by participant in this area is five points. In the graphs shown in Figure 6 we compare the score obtained by participants with probably cognitive decline and those that not have it. On the right side, we can notice that participants with cognitive decline have a score of 0 points. An exception can be noted, an apparently cognitive impaired participant with score of 5 with the highest educational level (Master's degree). Even though, the results of this area look very contrasting, it is important to emphasize that some of the participants with

probably cognitive impairment did not make an effort to answer this part. May be, they were embarrassed and preferred not to answer the question.

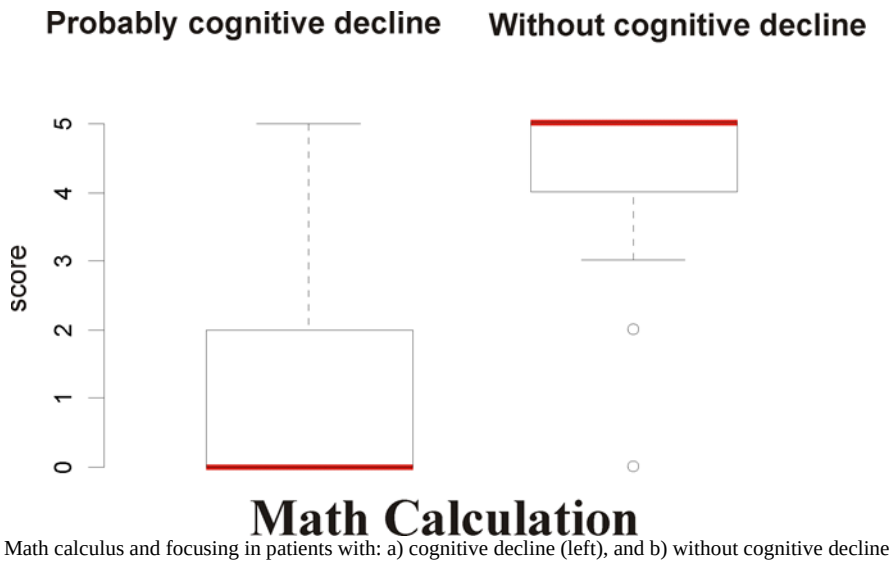


Figure 6: Math calculus and focusing in patients with: a) cognitive decline (left), and b) without cognitive decline (right).

Recall

The recall part of the MMSE test consists in asking the participant to repeat the 3 words named above (paper, bicycle, and spoon). The maximum score is 3. One point in the score is given for each correct answer. As it can be seen from Figure 7, participants who do not present cognitive decline (right side on the figure) are able to recall the 3 words without any problem. On the other hand, participants with probably cognitive decay only could recall an average of 1.5 words.

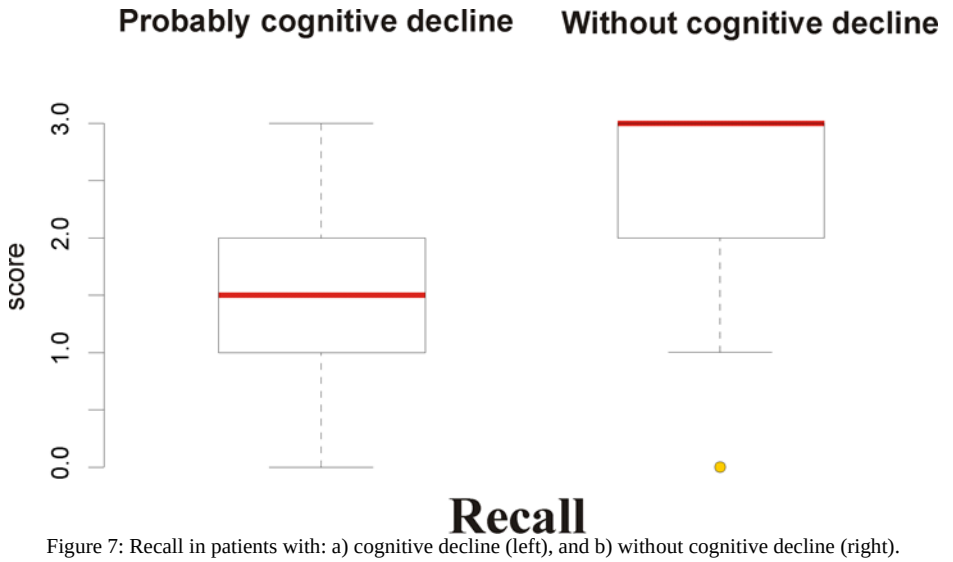


Figure 7: Recall in patients with: a) cognitive decline (left), and b) without cognitive decline (right).

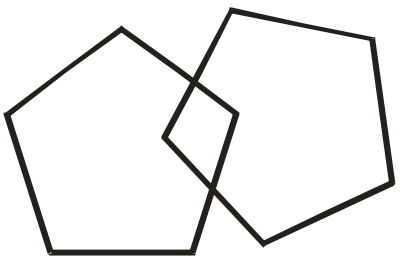
Language

The *language* section of the MMSE test consists on a series of 6 subsections which allow us to assess whether the participant with cognitive decline presents difficulties of language or understanding simple phrases. The total score of this section is on a scale of 0 to 9 points. In the following lines we mention briefly each of the stages.

a) **Identifying objects.** The instructor shows to the participant a pencil and a clock. After that, one asks him/her to name them. 1 point is granted by every correct answer. The quantifying scale is from 0 to 2 points.
b) **Repeating a sentence.** One asked the participant to repeat the following phrase: "Not not, not if, not but". If the phrase is told correctly, 1 point is granted to him/her.
c) **Verbal comprehension.** The instructor gives to the participant a simple order, for example: "Take a paper with your right hand" (1 point is scored if he/she does it correctly). "Fold it in half" (1 point if correct), "and put it on the floor" (1 point if correct). If the participant is unable to carry out those simple activities, there are not points scored.
d) **Reading comprehension.** The instructor shows to the participant a short instruction written in a card, and asks him/her to do whatever it was written and read it aloud. If the participant does it correctly, 1 point is granted to him/her.
e) **Writing skills.** The instructor asks the participant to write a meaningful simple sentence. The phrase must have subject (tacit or implicit) and predicate. If the participant does it appropriately, he/she receives 1 point.
f) **Drawing skills.** The instructor shows to the participant a figure with 2 intersected pentagons (see Figure 8A), and then asks him/her to copy it in blank page of this test. If the figure drawn by the participant has 10 entire angles, two of them intersecting between themselves, the participant receives 1 point.

Figure 8B shows the boxplot with statistical data obtained in the language area. The participants with probably cognitive decline obtained an average of 6.5 hits (left side of the figure). Those without cognitive decline show an average score of 8 (right side on the figure). This means that the participants without cognitive decline have more cognitive skills on writing, reading and understanding texts or simple phrases that allow them to perform routine activities straightforward. On the other hand, subjects with cognitive decline have a lot of difficulties in language and other skills. Also, we can conclude that participants without cognitive decline are capable of performing successfully the entrusted activities, or at least a half of the instructions, or finish them all out correctly (score between 5-8). In contrast, participants with possibly cognitive impairment performed correctly a smaller number of activities (score of 0 -6.5).

A



B

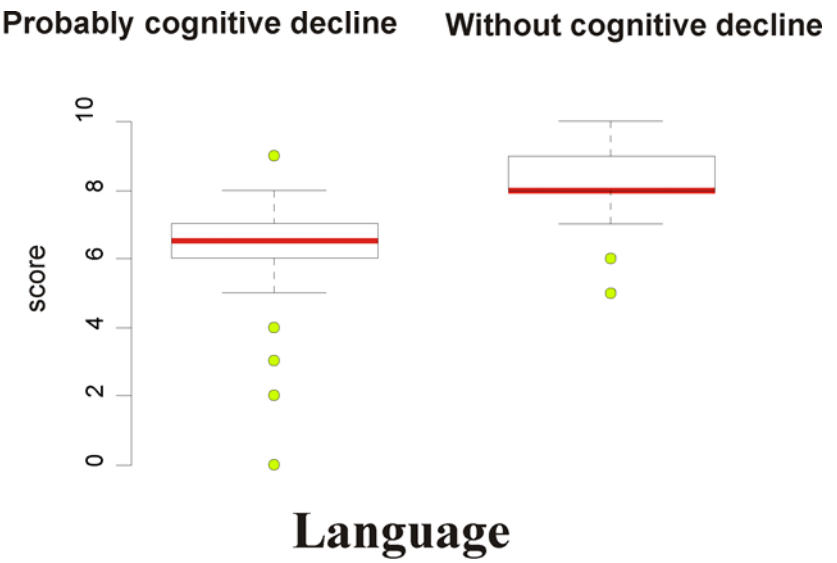


Figure 8: A. Figure with two intersected pentagons B. Language skills evaluated in patients with: a) cognitive decline, (left), and b) without cognitive decline (right). The maximum punctuation allowed for this part of the test was 9.

Discussion

In this study it has been possible to examine both MMSE and other variables like age, educational level and living area. Our results showed that the mean age for participants with probably cognitive impairment were 73 years old, and 69 for those without cognitive decline (see figure 1).This results consist with previous findings that associate age with low scores in the MMSE (Brayne and Calloway, 1990; Crum *et. al.*, 1993; Barnes *et. al.*, 2003; Fei *et al*, 2009). Due to the increase in life expectancy, some of the basic mechanisms of the cognitive information processing such as spatial orientation, numeric ability, verbal ability, verbal memory, working memory, tend to decline across the adult lifespan (Craik, 1994). These functions decline rapidly between the ages of 67 and 74 (Schale, 1996), as seen in our results (see figures 4-8). Besides the fact that some cognitive functions may be affected, due to age-associated structural changes in old age, there are other possible contributors such as education. It is well known that low educational levels influence the performance in the MMSE (Brayne and Calloway, 1990; Crum *et al*, 1993; Zhou *et. al.*, 2006; Fischer *et. al.*, 2009). Lower scores were associated with lower educational achievements, as we confirm in the present study.

Studies in both post-mortem and in vivo (using imaging techniques) have shown a decline in the volume of gray matter as a result of aging (Haug and Eggers, 1991, Hedden and Gabrieli, 2004 and Resnick et. al., 2003). However, multiple experimental studies have demonstrated that a physically and intellectually active life sets in motion cellular and molecular mechanisms that reinforce synaptic connections and prevent cognitive decline associated with the loss of neurons in old age (Mora et. al., 2007). This enriched environment could be adjusted through the gerontology programs in the seniors' centers of Hidalgo State.

The elderly population of Hidalgo State analyzed in this study with probably cognitive impairment has a low educational level as mentioned before and most of them live in rural areas. We observed that this is another risk factor for the development of cognitive decline and dementia, as shown by other authors (Brayne and Calloway; 1990; Zhou, 2006; Fei *et. al.*, 2009). This influence of socioeconomic status (SES) on the scores of the MMSE, could be the result of the isolation of this populated areas and the lack of services such as education and health, in contrast with the urban populations. Moreover, it should be mentioned that people living in rural areas were more likely to be engaged in manual work (data not shown), which may reflect their

SES. We consider that a subject's occupation may influence the development of cognitive decline in a positive or negative manner. Those individuals with the "best" occupation tend to have a better economic status, better diet, healthcare, greater intellectual activity, and spare-time activity that may have a protective effect on cognition (Kalmijn, *et. al.,* 1997; Qiu, *et. al.,* 2003). So, educational level and occupation can interact with each other, where people with higher educational level generally assumed intellectual work, resulting in cerebral function always in active state.

A number of limitations may have impact on the validity of this study. First, we used the MMSE as a screening test to evaluate the mental status of isolated regions of Mexico, particularly in the State of Hidalgo. We are aware that it does not identify specific disorders. Thus, the population studied was composed of a heterogeneous mix of subjects with varying levels of probably cognitive impairment. Second, as the data were collected in a randomized manner from individuals of different isolated regions, there could be some omissions which may have influenced the results. Particularly in the rural communities, where some of the participants where nervous or embarrassed and prefer not to answer some of the questions (like in the math calculations of the MMSE). Third, most of the subjects evaluated were women, because the majority of the men did not want to participate in the study. In spite of these difficulties, we were able collect a significant amount of data from participants.

Concluding Remarks

In conclusion, this is the first study of its kind in the State of Hidalgo highlighting that older adults living in isolated areas (usually rural zones) present some mental health problems. This may be related with their low educational level and SES. Based on the above mentioned data, future studies are still needed as it pertains to other potential contributors to cognitive decline, such as diet and nutrition, cardiovascular diseases, physiological markers, family environment.

Conflict of Interests

None

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