

Cognitive reserve to modify the trajectory of dementia: what does it represent for Oaxaca, Mexico?

Gemma M. Martínez-Martínez, Douglas C. Nance, and Elizabeth Muñoz-Ortiz*

Instituto de Investigación sobre la Salud Pública, Universidad de la Sierra Sur, Oaxaca, México

Abstract

The objective of this review article is to highlight variables that the Oaxacan population has that favor cognitive reserve (CR) and which is essential to promote healthy aging. These protective factors that prevent or delay evolution of neurodegenerative disease may enable toleration of age-related changes, maintaining cognitive function despite disease. Research in countries with a high level of development shows that certain lifestyles delay the onset of dementia, but what happens in developing countries like Mexico and its cities, like Oaxaca, where the population has particular characteristics according to health conditions, education, housing, and traditions. What could provide them with CR, despite not having the same quality of life as first world countries? Professional literature from 2014 to 2022 related to CR and dementia internationally and in Mexico was reviewed using Pub-Med, BMC, and Google Scholar. Substantial literature exists in Europe and North America, Oaxaca has various variables which favor CR, most of them have not been properly assessed by research, leading to a disadvantage for people living in Oaxaca compared to older adults in developed countries. Oaxaca, Mexico, has some variables that favor CR, but it does not have all those already documented by research, which leaves older adults living in states like Oaxaca at a disadvantage compared to older adults in developed countries. Although the manifestations of cognitive decline do not appear uniformly, CR may prevent or delay evolution of dementia maintaining quality of life and activities of the elderly. It is essential to carry out research on non-traditional variables that may be enhancing CR and that has not been addressed in developing countries.

Keywords: Older adult. Aging. Dementia. Cognitive reserve. Lifestyle.

Reserva cognitiva para modificar la trayectoria de la demencia: ¿qué representa para Oaxaca, México?

Resumen

El objetivo de este artículo de revisión es resaltar variables que posee la población oaxaqueña que favorecen la reserva cognitiva (CR) y que es fundamental para promover un envejecimiento saludable. Estos factores protectores que previenen o retrasan la evolución de la enfermedad neurodegenerativa pueden permitir la tolerancia de los cambios relacionados con la edad, manteniendo la función cognitiva a pesar de la enfermedad. Investigaciones en países con alto nivel de desarrollo muestran que ciertos estilos de vida retrasan la aparición de la demencia, pero qué pasa en países en vías de desarrollo como México y sus ciudades, como Oaxaca, donde la población tiene características particulares según condiciones de salud, educación, vivienda y tradiciones. ¿Qué podría brindarles la CR, a pesar de no tener la misma calidad de vida que los

*Correspondence:

Elizabeth Muñoz-Ortiz

E-mail: elimo225@gmail.com

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países del primer mundo? Se revisó la literatura profesional de 2014 a 2022 relacionada con CR y demencia a nivel internacional y en México utilizando Pub-Med, BMC y Google Académico. Existe literatura sustancial en Europa y América del Norte, Oaxaca tiene múltiples variables que favorecen la RC, la mayoría de ellas no han sido evaluadas adecuadamente por la investigación, lo que genera una desventaja para las personas que viven en Oaxaca en comparación con los adultos mayores en los países desarrollados. Oaxaca, México, tiene algunas variables que favorecen la CR, pero no cuenta con todas las ya documentadas por la investigación, lo que deja en desventaja a los adultos mayores que viven en estados como Oaxaca frente a los adultos mayores de países desarrollados. Aunque las manifestaciones de deterioro cognitivo no se presentan de manera uniforme, la CR puede prevenir o retrasar la evolución de la demencia manteniendo la calidad de vida y actividades del adulto mayor. Es fundamental realizar investigaciones sobre variables no tradicionales que pueden estar potenciando la CR y que no han sido abordadas en los países en vías de desarrollo.

Palabras clave: Adulto mayor. Envejecimiento. Demencia. Reserva cognitiva. Estilo de vida.

Introduction

Due to increasing life expectancy and declining natality, the population over 60 years of age is increasing faster than any other world-wide age group¹. Old age has generally been perceived as deterioration associated with decreased physical and mental capacities, unlike life stages considered as periods of growth and development. The Pan American Health Organization does conceive old age as a natural process of growth and learning².

The United Nations estimates the population aged 60 or over will have grown by 56% by 2030, from 901 million to 1.4 billion. In 2050, the global population of elderly people will more than double from 2015 to about 2.1 billion. The risk of deficiencies in different cognitive functions will increase. World-wide there are about 47 million persons with dementia, with 9.9 million new cases each year. In most cases, patients are not diagnosed and supported³.

The most common dementia syndrome, Alzheimer's Disease (AD), is of a chronic or progressive nature characterized by deterioration of cognitive function beyond what could be considered consequences of normal aging⁴. Cognitive reserve (CR) has been defined as the brain's ability to optimize or maximize performance through neural networks or use of alternative coping strategies⁵ which may explain individual differences in susceptibility to cognitive or functional decline in the presence of pathological age-related brain changes⁶.

In Mexico, healthy life-years are affected and diminished as a result of inadequate, scarce or non-existent health, and social security systems. Functional systems are essential to provide an autonomous and independent old age. For older people to achieve and enjoy a fully functional life, it is not only necessary to combat pathologies of old age, but also to live in environments that promote healthy aging.

Mexico still lacks awareness of the magnitude of the developing demographic transition. Despite the fact that dementia is considered by the World Health Organization (WHO) as a major public health problem, Mexico's resources allocated to the elderly population are insufficient to cushion the changes of age and entailed morbidity. The government's existing health and welfare programs fail to have a significant impact on, or even to reach, Mexico's diverse social strata to guarantee an adequate quality of life for older adults. It is necessary to reflect on the processes of demographic and epidemiological transition for the creation and establishment of social, economic and health-care policies, especially in impoverished and remote communities, as this would considerably improve the quality of life in the population at large.

Although various investigations have already shown that people with greater CR can avoid symptoms of degenerative brain changes associated with dementia, what does this represent for Mexico? What does it represent for states with massive economic and educational deficiencies like Oaxaca? Mexico does not have enough research on the CR of its population, coupled with that the country through various development, economic, and health problems. Therefore, it faces an enormous challenge in promoting the development of activities that favor CR in the Mexican population. The objective of this review article is to highlight which variables that the Oaxacan population has that is essential to promote.

Then, we would have to ask ourselves, what activities do people carry out that have not been scientifically proven to favor CR? Oaxaca is a state rich in traditions and with a very peculiar gastronomy, from typical dances such as "Flor de Piña" to the daily consumption of insects such as "chapulines" and herbs such as "chepiche", the elaboration of its seven moles or the production traditional ceramic pottery in black clay.

The bibliographic references were consulted in the databases: PubMed and ScienceDirect. Both databases

Table 1. Cognitive and brain reserve

Differences	
Cognitive reserve	Brain reserve
Explains the functionality of the individual in the presence of a brain pathology.	Difference between the degree of brain damage of a person and the pathological clinical manifestation.
Flexibility and adaptability in cognitive networks.	A physical trait: bigger brains, more neurons and synapses.
Influenced by all aspects of life.	Manifests impairment only after the individual's ability is greatly affected by crossing a cerebral threshold.
Individual differences in the anatomy of the brain between one individual and another.	Individual differences in the anatomy of the brain between one individual and another.
Acts at a functional level in the changes of aging.	Brain networks are flexible and adapt for the brain to resist changes from age or disease.
Individual is largely affected by crossing a cerebral threshold.	Brains tolerate more injury before cognitive function is affected.

considered the MeSH terms in English in the search: CR, AND history of CR, brain reserve, cognitive maintenance, cognitive impairment, aging, dementia, neurodegenerative disease, neuropsychiatric symptoms, and cerebral blood flow.

The inclusion criteria consider: scientific articles between the years 2003 and 2020, articles in English and Spanish, original articles, and bibliographic reviews, studies carried out in the adult population over 60 years of age and older with dementia or pathological cognitive impairment. All the selected evidence was thoroughly analyzed resulting in 34 final articles.

CR, brain reserve, and cognitive maintenance

Some people can keep the brain in better condition than others throughout old age, this is known as cognitive maintenance and directly influences two important variables that are often confused, such as CR⁷ and brain reserve⁸ (Table 1). The previous studies suggest that individuals with a low educational level and a small head circumference are 4 times more likely to manifest clinical symptoms typical of a neuronal pathology. Some of the increased prefrontal activity in older adults reflects a greater need or use of executive functions.

Although it is not understood exactly where the CR is located, it is understood that the reserve works and increases through the synapse processes carried out by the neural connections of the brain⁷.

The neural compensation produced by the brain through the use of alternate brain networks is associated with a better performance of the human being in the face of brain pathology. Spatial memory strategies are linked to the structural and functional properties of common mammalian brain parts such as the hippocampus, entorhinal cortex, and striatum. During aging, animals such as rodents present losses in the structures of the neuropil, the neurons modify their anatomy and, therefore, cause poor communication between them. The age-associated decline in memory does not stem from cell death; in older rodents showing fewer neuronal cell synapses compared to the young population, they show greater strength of neuronal signals. Therefore, it is assumed that individuals with a high reserve capacity have greater, stronger, and denser neuronal connections compared to those with a low reserve capacity⁸.

CR concept

This concept arose from the need to explain differences that exist between the cognitive performance of an individual and the development of a cerebral pathology⁹ symbolizes a dividing line between cognitive functions and the integrity of the structures that make up the nervous system. The sum of both factors determines alterations in both the neurological and behavioral abilities of an individual at the beginning of cerebral pathology¹⁰.

CR is understood as the brain's ability to better tolerate the effects of the pathologies associated with dementia. CR can be developed an innate ability or developed as a result of lived experiences, such as education or employment, and may constitute a protective factor against the clinical manifestations of dementia¹¹.

CR tries to compensate for the impact caused by neurocognitive pathology through the use of previously established neural networks, or failing that, through the creation of new networks that would reduce the degree of deterioration¹². Cognitive stimulation in older adults is considered an essential factor to maintain and strengthen neural networks¹¹, because it is believed that the accumulation of experiences throughout life works as a protective mechanism, thus reducing susceptibility to neurocognitive¹². It is considered a resilience mechanism against age-related cognitive decline¹³. CR can change according to the experience and learning that an individual has had throughout life¹².

Some factors that determine the level of CR based on the life experiences of older adults include level of education, occupation, lifestyle, and cognitive needs demanded by the environment, in which they operate, physical activity and diet¹⁴ with all of these functioning as mitigatory factors in cognitive dysfunction¹².

Frequently, people with a higher degree of CR are those who have completed a high degree of studies, who have a greater development of professional skills and a high IQ, and people who have a variety of leisure activities¹⁰. There is evidence that the existence of extensive amounts of CR ensures that the brain will better withstand the cognitive ravages caused by cerebral changes associated with neurocognitive diseases; and all this, before cognitive symptoms appear¹⁴.

Dementia can take a very varied course depending on each individual. Many people preserve their autonomy throughout life regardless of the presence of some brain pathology, as opposed to those who do not preserve their autonomy¹⁴. This is influenced by protective factors that each individual possesses, particularly those that promote CR.

Thus, both physical and functional brain changes differ from person to person, and in some subjects, the use of existing neural networks allows the possibility of efficiently counteracting cognitive deterioration¹².

History of CR

During the 1970s, the inevitable questions about aging were raised. It had been assumed that cognitive decline related to longevity was normal and inevitable. Authors such as Barton and colleagues deduced that the intellectual function of each person is individual, different, and unique, and this depends on the accumulation of life experiences, life history, degree of education, and their family, work and recreational environment, thus proposing that the level of cognitive impairment in the long-lived population is not uniform. Therefore, it is essential to know the elements that promote optimal cognitive function in the aging process¹⁵.

Katzman et al. carried out a study on the elderly population of a nursing home in 1988. The physiological and cognitive state of 137 patients was evaluated, the clinical manifestations presented were assessed and postmortem studies were also applied; 87% of patients presented with dementia. However, in the studies carried out on brains of older adults without signs of dementia, neuropathological features were found analogous to individuals who manifested clinical symptoms typical of AD. The brains of these persons had a greater weight and a higher neuronal density compared to others of the

same age who were also housed in the asylum. Katzman et al. had two postulates: the first was that older adults might have suffered from AD initially; yet, their brains had the ability to prevent the loss of significant numbers of neurons. The second was that the older adults with a larger brain had begun to manifest the pathology with a greater number of neurons compared to the other participants and had a greater CR¹⁶.

At the end of the 1980s, the concept of CR emerged. Persons who did not show symptoms of dementia showed on autopsy that they had brain changes associated with advanced pathology. It was postulated that older adults did not express symptoms of the disease while alive, because their reserve was vast enough to cushion the damage and thus to be able to continue their normal life without the manifestations of symptoms¹⁷.

In 1986 Snowdon¹⁸ carried out "The Nun Study", in which 679 nuns between 75 and 107 years old belonging to the School Sisters of Notre Dame in the United States participated. Relevant events were found, including the non-existence of cognitive decline in many patients. Despite their advanced age, the mental activity and cognitive stimulation that the nuns had on a daily basis was quite high. In postmortem studies, common AD lesions were found, so despite not showing symptoms of the disease, these women were not exempt from presenting brain damage. It should be noted that the lifestyle of the nuns was of the utmost importance in demonstrating that it is possible to develop and maintain a high mental activity throughout life to have a healthy brain resistant to AD.

It was observed that the life experiences of the subject, and how the disease progresses, cause differences between one individual and another. Lifestyle functions as a moderating factor between the disease and its clinical manifestations, affecting, or not, the functional processes of the brain¹⁷.

Research has shown that subjects with high CR can counteract or lessen clinical manifestations caused by cognitive changes related to dementia, and other pathologies that affect the brain, such as multiple sclerosis, stroke, Parkinson's, or Alzheimer's disease. Having a CR in constant growth and stimulation favors the prolongation of an active life, even if exposed to situations that generate stressful impacts on life and require additional effort from the brain¹⁹.

Variables that contribute to CR

There are several variables that contribute to the development of CR, which, therefore, delay the appearance

Table 2. Cognitive and leisure activities

Benefits
Reduce feelings of loneliness in the elderly
Increase creativity and artistic skills
Improve motivation and mood of the person
Promote the proper maintenance of psychomotor functions
Increase and improve the level of self-esteem
Promote interpersonal relationships and integration into society
Maintain productive capacity
Significantly decrease levels of depression and other pathologies
Maintain balance, bodily expression and flexibility
Promote productivity in leisure time and creativity of the individual
Facilitate adaptation to the environment
Increase the perception of the spirit of competition and participation

of symptoms related to dementia, such as education¹², bilingualism¹¹, leisure activities (Table 2)¹², physical activity¹⁷, lifestyle⁹, and diet²⁰.

Educational level to play an important protective role in the cognitive decline that occurs with normal aging, in conditions of a neurocognitive disorder, signs and symptoms are more pronounced in individuals with a poor educational level¹⁰. It has been shown that mastering a language other than the mother tongue could act as a neutralizing element that may reduce the risk factor for dementia, despite not having a formal education¹¹. Oaxaca has multiple indigenous languages; however, the most common are Zapotec, Mixtec, Mazatec, and Mixe²¹. Leisure activities and lifestyle refer to the environment, in which people spend their free time¹⁰. Cognitive and leisure activities are considered as an action to raise the quality of life during the aging process and, thus, obtain different benefits. There is a positive relationship between physical activity and cognitive functioning. Motor function also has a reserve component⁵ only for strenuous activities but also for moderate physical activities. It can also provide CR regardless of the accumulation of various brain pathologies²⁰. A lifestyle characterized by greater involvement in leisure activities of a social nature.

The Mediterranean diet could reduce the risk of dementia through its effects on the cardiovascular system, reducing vascular pathologies, although it is still being studied that vitamins B6 (pyridoxine), B9 (folic

acid), and B12 (cobalamin) have been proposed to have protective effects against cognitive aging. Adequate monitoring and surveillance of body weight is very important in patients with dementia to implement a correct treatment²².

Investing in variables such as diet, exercise, cognitive training, assessment and monitoring of vascular risk, and general health advice could maintain cognitive functioning in older adults and reduce the probability of developing cognitive impairment²³.

In Oaxaca, free time is used to work mainly in rural communities where they carry out primary activities such as agriculture and livestock. Activities that could generate CR are carried out from the reach of the population through the establishment of neural networks through the manual activities of artisans, the preparation of typical regional dishes, etc. Although various investigations⁹ have reported the benefits, not all countries carry out these activities on a daily basis or as part of their normal routine, a clear example is Mexico and especially Oaxaca (Table 3), which has various particularities that could put the elderly of this state at a disadvantage compared to the elderly of the first world countries that do lead to carry out all activities.

Impact of dementia

Social and economic impact

According to the Organization for Economic Cooperation and Development of the total that Mexico allocates to health, the government only finances 24% of medical services, while 41% is paid for by families (2017)²¹. Limited access to health services and heterogeneous quality of medical care cause caregiver families to utilize private health services.

Mexico allocates a total cost per capita of \$6,157 dollars for the care of a person with dementia. This implies a 60% decrease in out-of-pocket spending for families who care for a person affected by dementia²². Caring families need to be supported by relevant health, social, financial, and legal services to withstand the long-term costs of a person with dementia, the frequent hospital visits, lost work days, and the ravages they take on caregiver costs and lost productivity for both patient and caregivers, among other economic difficulties.

There is a great difference in the cost allocated to the management of dementia in older adults in Mexico compared to expenses allocated by high-income countries. For example, in Spain, 31,000 euros a year are allocated for people suffering from neuropathology. Spain has a

Table 3. Variables that contribute to cognitive reserve

Variable	Importance Mexico-Oaxaca
Education	The percentage of illiterate people aged 15 and over decreased from 25.8% (1970) to 4.7% (2020). This 4.7% of the population is equivalent to 4,456,431 people who cannot read or write ²⁶ . In Oaxaca, 46.8% of the older adult population did not have educational opportunities, only 48.3% received basic education (2020) ²⁷ . In Oaxaca, 30.3% of the population between 60 and 74 years of age are illiterate and 50.9% of people aged 75 and over do not know how to read or write (2020) ²⁸ .
Bilingualism	Five out of every 100 people speak an indigenous language ²² while in Oaxaca 31 out of every 100 people are speakers of some indigenous language ²⁹ . The female population has 9.6 years of schooling (2020), while men have 9.8 years of schooling (2020) ¹⁸ . The bilingual use of Indigenous mother tongues and Spanish is elementary, especially in states with low levels of schooling such as Oaxaca ³⁰ .
Cognitive and leisure activities	Mexican men and women over 50 years of age use their free time; to carry out home maintenance, repairs, gardening, read a book, magazine or newspaper, care for children under the age of twelve, sew, embroider, knit or other crafts, do crossword puzzles, number games, care for a sick or disabled adult, play board games like cards, dominoes, or chess, attend a training course, informational talk or class, perform volunteer work and finally, attend a sports or social club ²⁰ . Not all social strata of the older adult population in Mexico carry out the same recreational activities, but even so we cannot rule out that the activities of older adults in rural areas generate cognitive challenges and encourage the creation of solid neural networks, strengthen resilience to neuropathology and maintain cognitive functions. There are no sources that confirm the activities carried out by older adults in Oaxaca, however it is expected that in the future the subject will be investigated to strengthen comprehensive care for this population.
Physical activity	The Mexican population aged 60 and over spends less time on cultural events, sports, games and entertainment compared to family time and the use of mass media ³¹ . In Oaxaca (2015) of the total number of older adults play sports, 62% of the population runs, 27% play basketball and 8% swim ²⁷ .
Lifestyle	Mexico has a low level of quality of life ³² due to various factors, such as the low level of education in rural areas, the lack of time to carry out leisure and rest activities, the quality of housing and the high costs it represents. Oaxaca has first place in Mexico for having the poorest older adult population in the country with approximately 307, 100 older adults in 2018. 91.5% of the Oaxacan population was in a situation of poverty due to the lack of sufficient income to satisfy their basic needs. Other indicators such as educational backwardness, access to health services, access to social security, quality and space in the home, access to basic housing services and access to food, did not improve in terms of results, detrimentally affecting the quality of life of the older adult in Oaxaca ³³ .
Diet	Food intake in older Oaxacans tends to decrease in conjunction with their appetite, therefore the intake of foods with low nutritional and energy value is very frequent, among them are foods such as broths, atole (hot corn masa drink) and highly cooked vegetables ³⁴ .

better quality of life, and therefore, a longer life expectancy, the relationship between work and personal life is well balanced, and the percentage of adults reporting good or very good health is above average²³.

On the other hand, the minimum wage in Mexico is \$172.87²⁴, which signifies an obstacle that limits older adults with dementia to timely and quality care, because caregiving families can seldom afford extra health expenses.

The situation of dementia in Mexico is discouraging, since social inequity prevails as a result of the country's economic conditions. The situation of dementia in Mexico is discouraging, social and economic inequity is prevalent, and there is not enough income to cover basic needs of food, basic health services, education, clothing, and housing. It is clear that the Mexican socio-economic situation shows that, although health is

considered a constitutional right of the population and an obligation on the part of the state, it is not accessible to the majority of citizens and neglected by the State.

As health is considered a human right, it is necessary to carry out an analysis of the inequitable distribution of the socioeconomic conditions that create substantial barriers to access health services for the people, and the relationship with their health and the impact on families and caregivers.

Dementia as a public health problem for Mexico

Dementia is a serious health problem that will have grave consequences on services and the health-care system in Mexico as the population ages. It is predicted

that by 2050, people under 15 years of age will decrease from 30% to 17.4%, and the population over 60 will reach 25%²⁵. The increase in population of older adults, together with the use of health services associated with age-related pathologies, will place greater burdens on the health-care systems and on families.

Improving quality of life, prioritizing dementia as a public health problem, raising awareness in society in general and promoting the inclusion of those who suffer from a disabling brain pathology, and proactive management of modifiable risk factors that can delay or slow the onset or progression of the disease is necessary to improve medical care and health services to provide timely diagnosis, followed by support for caregivers of people with dementia⁴.

Conclusions

In Mexico as a whole, we can conclude that older adults do not have ideal conditions for the development of the traditionally defined CR (high educational level, leisure and cognitively stimulating activities, physical activity, high level of quality of life, and adequate diet) coupled with socioeconomic status and extra health expenses. However, there are peculiarities of the Mexican population, such as in the state of Oaxaca, where although the literature has not reported real data on leisure activities that older adults carry out that favor CR, it is known that they have a culture and tradition where the older adult population has extraordinary skills such as weaving, embroidery, making black clay pottery, and preparing mezcal, among others. Each and every one of these activities can generate CR, so it is essential to carry out research in populations with activities not yet documented that can favor CR. The large percentage of Oaxacan peasants carries out demanding daily physical activities. A man does not consist of memory alone. He has feeling, will, sensibilities, moral being, matters of which neuropsychology cannot speak²⁰. Most indigenous Oaxacans speak at least three languages, are artisans, and physically active as peasants. But what happens in communities where the necessary resources are not available and the elderly live from day to day? What happens to the elderly who work in the fields, or care for livestock, produce pottery, or hunt grasshoppers for food? Because they are a different population from the one normally studied, do they not generate CR?

The increase in the incidence and prevalence of dementia in recent years has largely driven research in neuropathology which has focused mainly on the early

identification of symptoms that prevent or reduce cognitive damage to determine the course of dementia in the elderly. That is why a systematic analysis of "non-traditional" factors that generate CR in developing countries such as Mexico is proposed.

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Conflicts of interest

None.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

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References

1. Alzheimer's Disease International, Pan American Health Organization. Hablemos Sobre Demencia; 2017 Available from: <https://www.paho.org/hablemos-sobre-demencia> [Last accessed on 2020 Oct 30].
2. Soria Z, Montoya BJ, Soria-Romero Z, Montoya-Arce BJ. Envejecimiento y Factores Asociados a la Calidad de Vida de los Adultos Mayores en el Estado de México; 2017. Available from: <https://www.dx.doi.org> [Last accessed on 2020 Dec 20].
3. Instituto Nacional de Geriatría. Aprueba la OMS el Plan de Acción Mundial Para Enfrentar las Demencias; 2017. Available from: https://www.geriatria.salud.gob.mx/contenidos/noticias/plan_mundial_demencias_oms.html [Last accessed on 2020 Oct 29].
4. Demencia; 2021. Available from: <https://www.who.int/es/news-room/facts-in-pictures/detail/dementia> [Last accessed on 2022 Aug 13].
5. Clare L, Wu YT, Teale JC, MacLeod C, Matthews F, Brayne C, et al. Potentially modifiable lifestyle factors, cognitive reserve, and cognitive function in later life: a cross-sectional study. PLoS Med. 2017;14:e1002259.
6. Stern Y, Gazes Y, Razlighi Q, Steffener J, Habbeck C. A task-invariant cognitive reserve network. Neuroimage. 2018;178:36-45.
7. Stern Y. Cognitive reserve: implications for assessment and intervention. Folia Phoniatr Logop. 2013;65:49-54.
8. Stern Y, Barnes CA, Grady C, Jones RN, Raz N. Brain reserve, cognitive reserve, compensation, and maintenance: operationalization, validity, and mechanisms of cognitive resilience. Neurobiol Aging. 2019;83:124-9.
9. Calzada AC, Esteban NB, Cabaco AS, Mateos LM. El papel de la reserva cognitiva en el proceso de envejecimiento. Rev Psicol. 2018;18:160-94.
10. Medaglia JD, Pasquetti F, Hamilton RH, Thompson-Schill SL, Basset DS. Brain and cognitive reserve: translation via network control theory. Neurosci Biobehav Rev. 2017;75:53-64.
11. Wikee G, Martella D. Capacidad física y reserva cognitiva como factores protectores de las funciones atencionales en adultos mayores. Rev Med Chil. 2018;146:570-7.
12. Reynoso-Alcántara V, Silva-Pereyra J, Fernández-Harmony T, Mondragón-Maya A. Principales efectos de la reserva cognitiva sobre diversas enfermedades: una revisión sistemática. Psiquiatr Biol. 2018;25:53-67.
13. Darwish H, Farran N, Assaad S, Chaaya M. Cognitive reserve factors in a developing country: education and occupational attainment lower the risk of dementia in a sample of lebanese older adults. Front Aging Neurosci. 2018;10:277.
14. Grupo Sinapsis. Reserva Cognitiva y Protección Cerebral; 2019. Available from: <https://www.gsinapsis.com/reserva-cognitiva-y-envejecimiento-saludable> [Last accessed on 2020 Nov 01].

15. Reynoso-Alcántara V, Guiot-Vázquez MI, Diaz-Camacho JE. Modelo de reserva cognitiva: orígenes, principales factores de desarrollo y aplicabilidad clínica . *Rev Mex Neuroci.* 2018;19(2):62-73.
16. Katzman R, Terry R, DeTeresa R, Brown T, Davies P, Fuld P, et al. Clinical, pathological, and neurochemical changes in dementia: a subgroup with preserved mental status and numerous neocortical plaques. *Ann Neurol.* 1988;23:138-44.
17. Perneczky R, Kempermann G, Korczyn AD, Matthews FE, Ikram MA, Scarmeas N, et al. Translational research on reserve against neurodegenerative disease: consensus report of the international conference on cognitive reserve in the dementias and the Alzheimer's association reserve, resilience and protective factors professional interest area working groups. *BMC Med.* 2019;17:47.
18. Snowdon DA. Healthy aging and dementia: findings from the nun study. *Ann Intern Med.* 2003;139:450-4.
19. Harvard Health Publishing. What is Cognitive Reserve? Available from: <https://www.health.harvard.edu/mind-and-mood/what-is-cognitive-reserve> [Last accessed on 2020 Nov 02].
20. Maia P, Loureiro L, Silva M, Pata C, Loureiro A, Bartolomé M, et al. Revista Portuguesa de Psicossomática Sociedade Portuguesa de Psicossomática. Available from: <https://www.redalyc.org/articulo.oa?id=28770214> [Last accessed on 2022 May 18].
21. CANIFARMA. Panorama de la Salud 2019 Indicadores de la OCDE; 2019. Available from: <https://www.oecd.org/health/Panorama-de-la-Salud-2019.pdf> [Last accessed on 2021 Jul 27].
22. INEGI. Ciudad de México; 2020. Available from: <https://www.cuentame.inegi.org.mx/monografias/informacion/di/default.aspx?tema=me&e=09>
23. OCDE. Cómo va la vida en España? 2017. Available from: <https://www.oecd.org/statistics/Better-Life-Initiative-country-note-Spain-in-Espagnol.pdf> [Last accessed on 2021 Jul 28].
24. Secretaría de Trabajo y Previsión Social. Entra en Vigor Incremento al Salario Mínimo del 22%. Gobierno Federal Mexicano; 2022. Available from: <https://www.gob.mx/stps/prensa/entra-en-vigor-incremento-al-salario-minimo-del-22?idiom=es> [Last accessed on 2022 Mar 06].
25. Instituto Nacional de Salud Pública. Hablemos de Demencia; 2020. Available from: <https://www.insp.mx/avisos/hablemos-de-demencia> [Last accessed on 2021 Jul 30].
26. INEGI. Analfabetismo. Cuéntame de México; 2020. Available from: <https://www.cuentame.inegi.org.mx/poblacion/analfabeta.aspx?tema=P> [Last accessed on 2020 Nov 05].
27. Publicaciones-Dirección General de Población de Oaxaca. Available from: <https://www.oaxaca.gob.mx/digepo/publicaciones> [Last accessed on 2022 Oct 11].
28. INEGI. Educación. Oaxaca; 2020. Available from: <https://www.cuentame.inegi.org.mx/monografias/informacion/oax/poblacion/educacion.aspx?tema=me&e=20> [Last accessed on 2022 Oct 11].
29. INEGI. Oaxaca; 2020. Available from: <https://www.cuentame.inegi.org.mx/monografias/informacion/oax/default.aspx?tema=me&e=20>
30. Instituto Mexicano del Seguro Social. Diagnóstico y Tratamiento de la Enfermedad de Alzheimer; 2017. Available from: <https://www.imss.gob.mx/profesionales-salud/gpc> [Last accessed on 2021 Jul 27].
31. Procuraduría Federal del Consumidor. Actividades Lúdicas Para Adultos Mayores. La Diversión No Tiene Edad; 2016. Available from: <https://www.gob.mx/profeco/articulos/actividades-ludicas-para-adultos-mayores-la-diversion-no-tiene-edad?state=published> [Last accessed on 2020 Nov 05].
32. Organización para la Cooperación y Desarrollo. Índice Para una Vida Mejor. Vol. 33. France: Organización para la Cooperación y Desarrollo; 2017.
33. CONEVAL. Informe de Pobreza y Evaluación; 2020. Available from: https://www.coneval.org.mx/coordinacion/entidades/documents/informes_de_pobreza_y_evaluacion_2020_documentos/informe_oaxaca_2020.pdf [Last accessed on 2022 Oct 11].
34. DIF Oaxaca. Programa de Atención Integral al Adulto Mayor. Available from: https://www.google.com/url?sa=t&source=web&rct=j&url=https://transparencia.municipioideoaxaca.gob.mx/normatividad/lineamientos_atencion_integral_al_adulto_mayor.pdf&ved=2ahukewjbz_2hstx6ahwdkkqjhzt_dq0qfnoecawqaq&usg=aovvaw1xvgsaz5qvxpjjs2zfai