ORIGINAL ARTICLE

The relationship between tooth loss and cognitive function among elderly: a cross-sectional study

Winda Fauzul Mustofa[1]
Tecky Indriana[2]
Rudy Joelijanto[3]

[1]Undergraduate student, Faculty of Dentistry, Universitas Jember, Jember, Indonesia
[2]Department Biomedical Science, Pathology of Oral and Maxillofacial,Jember,Indonesia
[3]Department Orthodontic, Jember, Indonesia

* Correspondence:
tecky@unej.ac.id

Received: 21 October 2024
Revised: 24 December 2024
Accepted: 20 March 2025
Published: 31 March 2025
DOI: 10.24198/pjd.vol37no1.58538

p-ISSN 1979-0201
e-ISSN 2549-6212

Citation:
Mustofa, W.F.,Indriana, T; Joelijanto, R; The relationship between tooth loss and cognitive function among elderly: a cross-sectional study. Padj J Dent, March 2025; 37(1): 69-77

ABSTRACT

Introduction: Tooth loss refers to the condition in which teeth are dislodged from their sockets. In elderly individuals, tooth loss can lead to reduced chewing ability, which may contribute to a higher likelihood of cognitive function. The purpose of this study was to analyze the relationship between tooth loss and cognitive function among the elderly. **Methods**: The study employed an analytical observational method with a cross-sectional design. Participants were recruited using a purposive total sampling technique. Subjects were selected based on specific inclusion and exclusion criteria, resulting in a final sample size of 48 participants. All participants provided informed consent, and data were collected using the Mini-Mental State Examination (MMSE) questionnaire. The data were tabulated and analyzed descriptively, followed by a Spearman correlation test with a significance threshold set at 0.000 (p-value <0.05). **Results**: The correlation coefficient was found to be 0.487, indicating a moderate positive relationship between tooth loss and cognitive function among elderly. **Conclusion**: There is a moderate positive relationship between tooth loss and cognitive function among elderly.

KEYWORDS

Elderly, tooth loss, cognitive function

INTRODUCTION

The elderly population is predicted to continue increasing globally. According to the World Health Organization (WHO), the elderly population is classified into four age groups: middle age (45-59 years), elderly (60-74 years), old (75-90 years), and very old (over 90 years old).[1] It is estimated that the global population aged 60 years and older will rise from 1.4 billion in 2020 to 2.1 billion in 2050.[2] In Indonesia, regions with elderly old population structure are defined as those where individuals aged 60 years or older constitute 10% or more of the total population. East Java province, with an elderly population of 13.86%, falls into this category. Jember Regency, a region within East Java, has 365,400 elderly residents, accounting for about 14.28% of its total population.[3]

The elderly population is closely associated with oral health problems, one of which is tooth loss. Tooth loss experienced by the elderly causes teeth to lose contact with opposite teeth so that tooth occlusion is unbalanced and results in decreased chewing function.[4-5] The more teeth are lost, the occlusal area of the tooth decreases, causing a decrease in the effectiveness of chewing.[6-8] A person is expected to have at least 20 teeth that can function inside the oral cavity An elderly person is also related to memory function.[9-13] In the elderly who have tooth loss, it is more difficult to chew hard food so that food is often swallowed immediately even though it is not smooth.[14-17] Additionally, aging is also related

to memory function, and the prevalence of this cognitive function prevalence will increases with age. According to the World Health Association (WHO), cognitive decline affects than 3% of individuals aged 60-70 years, but this figure rises to 25% among those aged f 85 years and older.[18]

Cognitive function, derived from the word "cognition", refers to the process involving structuring, acquiring and using knowledge. It encompasses an individual's ability to assess, relate to, and interpret events. Cognition refers to the process in which individuals extract, process, and store information. Age-related changes also lead to alterations in cognitive functions, such as processing speed, attention, memory, language skills, visuospatial abilities, and executive functioning.[19,42,43] Through cognitive function, individuals process incoming sensory information, which includes attention (focusing), memory (recalling), language (communicating), motor skills (moving) and executive function (decision-making). This primary purpose of the cognitive function is to capture sensory input (tactile, visual, and auditory), transform it, process it, and store it before being used for interneuron connections.[20]

Decreased cognitive function can have an impact on physical dysfunction and certain chronic diseases or can even be linked to death in severe cognitive abilities.[21] Therefore, the risk of cognitive decline becomes greater when tooth loss occurs as it reduces mastication effeciency.[22] Previous research suggests that individuals with better mastication function tend to have better cognitive function. For instance, Halim et al. found that most individuals with strong masticatory abilities also demonstrated better cognitive performance. Many factors influence cognitive function, one of which is the type of food consumed. Chewing can facilitate the entry of nutrients into the body, especially vitamin B, which supports brain function.[23] Additionally, decreased cognitive function in the elderly can negatively impact social interaction due to the declines in movement, the existence of social interaction can improve the understanding, judgment, memory and expression of an elderly person.[21]

Cognitive decline significantly impacts daily life. Chewing activities can also be considered a form of a light physical exercise that occurs throughout one's lifetime.[24] Elderly individuals who experience tooth loss often avoid foods that are difficult to chew, increasing the risk of nutritional deficiencies.[25] Additionally, those who lose teeth may swallow inadequately chewed, which can lead to digestive issues, further contributing to nutritional deficiencies and negatively affecting general health.[26]

Elderly individuals often have less motivation to maintain dental health through regular visit to a dentist. The elderly in this study, there are several elderly people who are far from their families and the study was conducted on all elderly people aged 60-74 years who entered the research criteria in the orphanage focused on the elderly who have lost >20 teeth and <20 teeth living in orphanages. Elderly individuals living in orphanages often lack family support, unlike those living with their families, who receive enough support and tend to have better quality of life.[27]

This is in different to previous studies that put more emphasis on the elderly who suffer from aphasia and dementia that affect the interaction of the test.[28] Although numerous studies have reported associations between oral health and systemic conditions in elderly populations, research specifically examining the relationship between tooth loss and cognitive function among elderly individuals in institutional care settings in Indonesia remains limited. Most previous studies have focused on general or community-dwelling elderly, often overlooking how environmental and psychosocial factors in orphanage or nursing home populations may influence both oral and cognitive health outcomes.

The novelty of this study lies in its evaluation of the relationship between tooth loss and cognitive function among elderly individuals living in an institutional

setting, using the Mini-Mental State Examination (MMSE) to provide objective cognitive assessment data within the Indonesian context. This research offers new insight into how tooth loss, as a marker of masticatory and nutritional function, may contribute to cognitive decline among institutionalized elderly populations. This study aims to analyze the relationship between tooth loss and cognitive function among the elderly.

METHODS

The study was conducted in October 2023. This research is an observational analytic study with a cross-sectional analytical survey design. It was carried out at the Tresna Werdha Social Services Technical Service (UPT PSTW) in Jember. The sampling method used in this study was purposive total sampling, with a total of 48 respondents.

The inclusion criteria were as follows: elderly individuals aged 60-74 years, those with tooth loss, those who were mobile (able to move independently), those capable of communication, and those who were literate or able to perform simple calculations. The exclusion criteria included elderly individuals with uncontrolled comorbidities and those unwilling to participate in the study. Validity and reliability tests in this study were not performed. Each research subject in this study has completed and signed an informed consent form.

The calculation of the number of teeth left in the oral cavity in this study was carried out by intraoral examination. The examination was carried out by paying attention to the elderly who had <20 and >20 tooth loss. All remaining teeth are counted except for the root of the tooth and the root of the tooth is considered tooth loss because it cannot function in the oral cavity.

Measurement of cognitive function of the elderly using the MMSE test. The instrument used in this study was the Mini-Mental State Examination (MMSE) questionnaire. This test assesses various cognitive functions, including memory, attention and language.[28] The tools and materials required included stationery, mouth glass, stopwatch, mask, gloves, dental examination sheet and MMSE questionnaire sheet, alcohol, and Informed Consent.

In the assessment of dementia, MMSE is only one part of the examination which also includes other tests, a physical examination and the patient's history and symptoms. Descriptive analysis was performed using Microsoft Excel 2021 to determine the characteristics of the research subjects. Additionally, the Spearman correlation test was conducted using IBM SPSS version 26 software with a 95% confidence interval to analyze the relationship between the two variables.

RESULTS

The results of this study are presented in Tables 1, 2, 3, 4, 5, while data analysis is summarized in Table 6 and 7.

Table 1. Characteristics of respondents by gender and education

Characteristics	Category	Frequency	Percentage (%)
Gender	Male	24	50%
	Female	24	50%
Education	Not in school	11	23%
	Elementary school	21	44%
	Junior High School	8	17%
	Senior High School	6	12%
	Bachelor	2	4%

Table 1 presents the characteristics of respondents based on gender and education at the Tresna Werdha Jember Social Services Unit in October 2023. According to the research criteria, the gender distribution was equal, with 24 men (50%) and 24 women (50%). The highest level of education among respondents was elementary school, with 21 individuals (44%) completed this level.

Table 2. Characteristics of respondents based on tooth loss

Number of tooth losses	Frequency	Percentage (%)
≤20 teeth	15	31%
>20 teeth	33	69%

Table 2 presents the characteristics of respondents based on tooth loss at the Tresna Werdha Jember Social Services Unit in October 2023. The data indicate that more than half of the respondents experienced a loss of >20 teeth, accounting for 33 individuals (69%).

Table 3. Category of test

Category	Maximum score
Orientation	10
Registration	3
Attention and calculation	5
Memory	3
Language	9
Total	30

Table 3 shows the maximum score of each category questionnaire. Scores for the MMSE range from 0-30. Assessment of cognitive function in Table 4 uses the levels of cognitive function disorders consisting of none, mild, and severe. Interpretation of MMSE scores, cut offs commonly used to define cognitive impairment are: a.None: 27-30 (indicates normal cognitive function), b.Mild: 23-26 (indicative of mild cognitive impairment), c.Severe: 0-22 (indication of dementia)[28]

Table 4. Characteristics of respondents based on cognitive function

Cognitive function	Frequency	Percentage (%)
None	8	17
Mild	19	39
Severe	21	44
Total	48	100

Table 4 presents the characteristics of respondents based on cognitive function at the Tresna Werdha Jember Social Service Unit in October 2023. The data indicate that the majority of respondents met the research criteria for severe cognitive function, accounting for 21 individuals (44%).

Table 5. Cross-tabulation of tooth loss with cognitive function

Tooth loss	Cognitive function						Total	
	None		Mild		Severe			
	f	%	f	%	f	%	f	%
≤20 teeth	6	13	7	14	2	4	15	31
>20 teeth	2	4	12	25	19	40	33	69
Total	8	17	19	39	21	44	48	100

Table 5 presents the cross-tabulation of tooth loss with cognitive function among elderly individuals at the Tresna Werdha Jember Social Service Unit in October 2023. The data reveal that most respondents with >20 tooth loss experienced severe cognitive function, accounting for 19 individuals (40%).

Table 6. Tests of Normality

		Shapiro-Wilk		
	Cognitive function	**Statistic**	**df**	**Sig**
Tooth Loss	None	.566	8	.000
	Mild	.616	19	.000
	Severe	.341	21	.000

Table 6 present the results of the normality test using SPSS (version 26). The results showed a significance of the normality test of 0.000 <0.05 (p<0.05) which means that the data is considered not normally distributed.

Table 7. Spearman test correlation between tooth loss and cognitive function

			Tooth loss	**Cognitive function**
Spearman's rho	Tooth Loss	*Correlation Coefficient*	1000	.487**
		Sig. (2-tailed)	.	.000
		N	48	48
	Cognitive Function	*Correlation Coefficient*	.487**	1000
		Sig. (2-tailed)	.000	.
		N	48	48

The results of SPSS data analysis (version 26) involved non-parametric testing using the Spearman test (α: 0.05) to determine the relationship between variables. Based on the Spearman test results, the probability value (p: 0.000) was smaller than the significance threshold (α: 0.05) (Table 7). This indicates a statistically significant relationship between tooth loss and cognitive function among elderly individuals at UPT PSTW Jember. The correlation coefficient between tooth loss and cognitive function was 0.487, suggesting a moderate positive correlation. This means that as tooth loss increases (fewer teeth remaining, particularly in the >20 teeth loss category), cognitive function tends to decline among the elderly at UPT PSTW Jember.

DISCUSSION

Based on the results above, the most elderly education level is elementary school (Table 1). In this study that most respondents are elementary school educated (Table 1). The results of cognitive function with heavy categories in this study also tend to respondents who have elementary school education (44%) and do not in school (23%). This is because education as a process of life experience in the process there is also a process of intellectual stimulation which will affect cognitive function. A person who has a low level of education also has less environmental and mental experience so that it can have less impact on his intellectual stimulation. This can have an impact on a person's cognitive function to be poor.[29]

Based on table 2 shows the elderly who have a loss of ≤20 teeth as much as 15 (31%) and a loss of >20 teeth as much as 33 (69%). Tooth loss will increase with age. Losing a person's teeth can occur due to an aging process that causes changes in periodontal tissue and an increase in degenerative diseases such as osteoporosis. This disease can cause a decrease in the quality of the alveolar bone so that the teeth are easily detached from the socket. Based on previous research on animals undergoing tooth extraction, it can be proven that the osteoporosis phenotype has the potential to interfere with alveolar socket repair after tooth extraction.[30]

Based on table 4 conducted on 48 respondents using the MMSE questionnaire at the UPT PSTW Jember, it shows that the elderly who do not have cognitive function impairment as much as 8 (17%), have moderate cognitive function impairment as much as 19 (39%) and have the most severe cognitive function impairment at 21 (44%). In this study, the assessment of the cognitive function of the elderly who had the most difficulty answering so that they scored the most 0 (zero), namely remembering the date, on what floor, copying designs, and writing sentences. Based on these results related to cognitive functions used in the process of thinking, remembering, learning, considering things and solving problems.[31] Based on the tests that have been carried out through questionnaires, it can be seen from the old age's thinking process in answering questions, especially questionnaires about remembering dates, being on what floor, copying designs and writing sentences. The difficulty of the elderly in answering these questions can reach 3-4 minutes.

Based on table 5, a cross-tabulation of tooth loss with cognitive function (none, mild, severe) was performed. The data reveal that most respondents with >20 tooth loss experienced severe cognitive function, accounting for 19 individuals (40%). It is undeniable that tooth loss has been associated with the development of memory and cognitive impairment as well as dementia. Evidence suggests that having fewer than 20 teeth increases the likelihood of cognitive impairment and dementia in the elderly.[32] The results of the normality test that has been carried out (table 6) present that the data is not normally distributed. This was shown in the significance results of the normality test of 0.000 <0.005 ($p<0.05$). From these results, a non-parametric test was carried out using the spearman test.[33]

Based on the results of the Spearman test (table 7), the probability value (p: 0.000) was smaller than the significance threshold (α: 0.05). This indicates a statistically significant relationship between tooth loss and cognitive function among elderly individuals residing at the Tresna Werdha Social Services Technical Service (UPT PSTW) in Jember. Tooth loss can lead to poor occlusion and reduced mastication, which may contribute to a decline in cognitive function. Chewing activities increase blood supply to the brain, providing physiological benefits that support cognition in the central nervous system.[34]

Elderly individuals experiencing tooth loss may experience reduced blood flow to the brain. Tooth loss causes a functional impairment of the masticatory motor system, leading to a decrease in cerebral blood flow.[35] Previous research found that blood flow in cognitive-related areas of the brain decreased 12 weeks after tooth extraction in mice.[36] Reduced blood supply to the brain negatively affects the hippocampus, a region critical for memory. Adequate blood supply to the hippocampus is essential for its function, as it supports memory processes.[37] This phenomenon is linked to the proliferation of astrocytes in the hippocampus due to insufficient blood supply, which induces harmful factors, such as IL-6, IL-1β, and IL-17. These factors can inhibit the expression of BDNF (Brain-Derifed Neurotrophic Factor). When BDNF expression is suppressed, the survival of nerve cells is compromised, leading to a decline in hippocampal function. Consequently, this reduction in hippocampal ability contributes to impaired cognitive function.[38]

The correlation coefficient of tooth loss and cognitive function among elderly individuals at UPT PSTW Jember, based on SPSS 26, was 0.487. This value indicates a moderate positive correlation. In this study, the correlation is classified as a moderate because cognitive function can be influenced by other factors, such as irregular eating patterns or a lack of appetite, which may hinder the intake of nutrients and electrolytes essential for cognitive function. Additionally, cognitive function can be affected by mood and emotion, which may reduce an individual's attention and focus on tasks. Emotions plays a significant role in cognitive processes, including perception, attention, learning, memory, reasoning and problem-solving.[39] Beyond mood and emotion, sleep is another critical factor influencing a person's cognition. Adequate sleep is important for cognitive

function, and sleep deprivation can affect neural processing in the brain.[40] Sleep serves as a restorative process for the body, and insufficient sleep can lead to fatigue, reduced concentration and mood disturbances.[41]

This study is in line with previous research indicating a relationship between tooth loss and cognitive function in the elderly. This association may be attributed to a lack knowledge and awareness among the elderly regarding dental health maintenance, as well as the perception that cognitive decline is a normal part of aging.[22] Therefore, a significant relationship exists between tooth loss and cognitive function among elderly individuals living at UPT PSTW Jember.

The limitation of this study was conducted with a cross-sectional design, which limits its ability to establish causal relationship between the number of missing teeth and cognitive function. Longitudinal studies are recommended to explore causality further. Additionally, this research focuses exclusively on elderly individuals aged 60-74 years living at UPT PSTW Jember and, so the findings may not be generalizable to elderly population outside this location or age range.

CONCLUSION

Elderly with tooth loss more than 20 had a moderate correlation with a positive correlation with cognitive function. The decrease in the number of teeth, there is also a decrease in the cognitive function of an elderly person. The implications of this findings can provide input for quality improvement dental services for the elderly to emphasize the importance of maintaining dental health to maintain cognitive function. One thing that is hoped is that cognitive function disorders in the elderly can be prevented by exercise and enough sleep. Future research should explore this relationship further, focusing more on looking at what aspects are decreasing based on the questionnaires conducted.

Acknowledgement: The authors would like to thank the research subjects in UPT Social PSTW Jember, the research team, and the Faculty of Dentistry, Universitas Jember.
Author Contributions: Conceptualization, T.I., R.J. and W.F.; methodology, T.I., R.J. and W.F.; software, T.I., R.J. and W.F.; validation, T.I., R.J. and W.F.; formal analysis, T.I., R.J. and W.F.; investigation, T.I., R.J. and W.F.; resources, T.I., R.J. and W.F .; data curation, T.I., R.J. and W.F.; writing original draft preparation, T.I., R.J. and W.F .; writing review and editing, T.I., R.J. and W.F.; visualization, T.I., R.J. and W.F.; supervision, T.I., R.J. and W.F.; project administration, T.I., R.J. and W.F.
Funding: This research received no external funding
Institutional Review Board Statement: All research procedures were approved by the Ethical Committee of Medical Research Faculty of Dentistry University of Jember with the number 2260/UN25.8/KEPK/DL/2023.
Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.
Data Availability Statement: Data is unavailable due to privacy or ethical restrictions.
Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

1. Friska B, Usraleli U, Idayanti I, Magdalena M, Sakhnan R. The relationship of family support with the quality of elderly living in sidomulyo health center work area in Pekanbaru road. JPK: J Proteksi Kesehatan. 2020 May 31;9(1):1-8. https://doi.org/10.36929/jpk.v9i1.194
2. Statistik IB. Statistik penduduk lanjut usia. 2022.
3. Jember BP. Kabupaten Jember dalam angka 2023. Badan Pusat Statistik Kabupaten Jember. 2023.
4. Kochi, I., Takei, E., Maeda, R., Ito, K., Magara, J., Tsujimura, T., et al. Changes of bolus properties and the triggering of swallowing in healthy humans. J Oral Rehabil. 2021; 48(2): 592–600. https://doi.org/10.1111/joor.13151
5. Aktar, T., Karci, B., Yucel, H. C., & Ergin, F. Determining the relationship between food texture and dental condition: First bite and chewing aspects. Arch Oral Biol. 2022. https://doi.org/10.1016/j.archoralbio.2022.105483
6. Zelig, R., Goldstein, S., Touger-Decker, R., Firestone, E., Golden, A., Johnson, Z., et al. Tooth Loss and Nutritional Status in Older Adults: A Systematic Review and Meta-analysis. JDR Clin Transl Res. 2022; 7(1): 4–15. https://doi.org/ 10.1177/2380084420981016
7. Kugimiya, Y., Watanabe, Y., Igarashi, K., Hoshino, D., Motokawa, K., Edahiro, A. & Hirano, H. Factors associated with masticatory performance in community-dwelling older adults: A cross-sectional study. The Journal of the American Dental Association. 2020; 151(2): 118-126. https://doi.org/10.1016/j.adaj.2019.10.003.
8. Kim, H. E., & Lee H. Factors affecting subjective and objective masticatory function in older adults: Importance of an integrated approach. J Dent. 2021. https://doi.org/10.1016/j.jdent.2021.103787

9. Zelig, R., Byham-Gray, L., Singer, S. R., Hoskin, E. R., Fleisch Marcus, A., Verdino, G., et al. Dentition and malnutrition risk in community dwelling older adults. J Aging Res Clin Pr. 2018; 107–14. https://doi.org/ 10.14283/jarcp.2018.19
10. Kossioni, A., Maggi, S. Gerodontology Essentials for Health Care Professionals. 2020; 21–23, 52–53
11. Nguyen, M. S., Jagomägi, T., Voog-Oras, Ü., Nguyen, T., & Saag, M. Oral health behaviour and oral health status of Elderly Vietnamese. Oral Heal Prev Dent. 2018; 16(2): 153-161 https://doi.org/10.3290/j.ohpd.a40318
12. Karawekpanyawong, R., Nohno, K., Kubota, Y., & Ogawa, H.. Oral Health and Nutritional Intake in Community Dwelling 90-Year-Old Japanese People: A Cross-Sectional Study. Gerodontology. 2023; 40(1): 100–111. https://doi.org/10.1111/ger.12627
13. Rabiei, M., Masoudi Rad, H., Homaie Rad, E., & Ashourizadeh, S. Dental status of the Iranian elderly: A systematic review and meta-analysis. J Investig Clin Dent. 2019; 10(4): e12459. https://doi.org/10.1111/jicd.12459
14. Saccomanno, S., Saran, S., Coceani Paskay, L., De Luca, M., Tricerri, A., Mafucci Orlandini, S., et al. Risk factors and prevention of choking. Eur J Transl Myol. 2023; 33(4): 11471. https://doi.org/10.4081/ejtm.2023.11471
15. Muñoz-Núñez, M., Laguna, L., Tárrega, A. What is the food like that people choke on? A study on food bolus physical properties under different in vitro oral capacities. Food Res Int. 2023; 165: 112474. https://doi.org/10.1016/j.foodres.2023.112474
16. Cichero, J.A.Y. Age-related changes to eating and swallowing impact frailty: Aspiration, choking risk, modified food texture and autonomy of choice. Geriatr. 2018; 3(4); 69. https://doi.org/10.3390/geriatrics3040069
17. Zelig, R., Jones, V.M., Touger-Decker, R., Hoskin, E.R., Singer, S.R., Byham-Gray, L., et al. The Eating Experience: Adaptive and Maladaptive Strategies of Older Adults with Tooth Loss. JDR Clin Transl Res. 2019; 4(3): 217–228. https://doi.org/10.1177/2380084419827532
18. Irawani AT, Nuryawati LS. Pengaruh Brain Gym Lanjut Usia Terhadap Fungsi Kognitif Pada Lanjut Usia di UPTD Puskesmas Majalengka Kecamatan Majalengka Wetan Kabupaten Majalengka Tahun 2019. Syntax Literate; J Ilmiah Indonesia. 2019 Oct 20;4(10):1-1.https://doi.org/10.36418/syntax-literate.v4i10.746
19. Rohaeni ES, Gunadi A. Peningkatan pengenalan konsep bilangan melalui media fauna pantai pada anak usia 4-5 tahuN. Yaa Bunayya: J Pendidikan Anak Usia Dini. 2018 Jun 12;2(1):19-26. DOI: https://doi.org/10.24853/yby.2.1.19-26
20. Astuti DA, Ivana T, Jamini T. Pengaruh senam otak terhadap fungsi kogntif pada lansia. J Keperawatan Suaka Insan (JKSI). 2018 Dec 16;3(2):1-9.https://doi.org/10.51143/jksi.v3i2.118
21. Zhu CE, Zhou L, Zhang X. Effects of leisure activities on the cognitive ability of older adults: a latent variable growth model analysis. Frontiers in psychology. 2022 Apr 13;13:838878. DOI: https://doi.org/10.3389/fpsyg.2022.838878
22. Yuana, M. I., & Basuki, H. O. (2022). Hubungan Kehilangan Gigi Dengan Fungsi Kognitif Pada Lansia. J Keperawatan Medika, 1(1).
23. Nazrien, N., Prabowo, T. and Arisanti, F., 2024. The Role of Cognition in Balance Control. OBM Neurobiology, 8(1), pp.1-12.http://dx.doi.org/10.21926/obm.neurobiol.2401211
24. Müller F, Shimazaki Y, Kahabuka F, Schimmel M. Oral health for an ageing population: the importance of a natural dentition in older adults. International dental J. 2017 Oct;67:7-13. https://doi.org/10.1111/idj.12329
25. Chan AK, Tsang YC, Jiang CM, Leung KC, Lo EC, Chu CH. Diet, Nutrition, and oral health in older adults: a review of the literature. Dentistry J. 2023 Sep 19;11(9):222. https://doi.org/10.3390%2Fdj11090222
26. Kaurani P, Kakodkar P, Bhowmick A, Samra RK, Bansal V. Association of tooth loss and nutritional status in adults: an overview of systematic reviews. BMC Oral Health. 2024 Jul 24;24(1):838. https://doi.org/10.1186/s12903-024-04602-1
27. Baris AB, Bidjuni H, Rompas S. Perbedaan Makna Hidup Lansia Yang Tinggal Di Panti Werdha Senja Cerah Dan Yang Tinggal Bersama Keluarga Di Desa. J Keperawatan. 2019 Oct 24;7(2). https://doi.org/10.35790/jkp.v7i2.27472
28. Myrberg K, Hydén LC, Samuelsson C. The mini-mental state examination (MMSE) from a language perspective: an analysis of test interaction. Clinical linguistics & phonetics. 2020 Jul 2;34(7):652-70.. https://doi.org/10.1080/02699206.2019.1687757
29. Riskiana NE, Mandagi AM. Tingkat pendidikan dengan fungsi kognitif pada lansia dalam periode aging population. Preventif: J Kesehatan Masyarakat. 2021 Dec 31;12(2):256. https://doi.org/10.22487/preventif.v12i2.194
30. Só BB, Silveira FM, Llantada GS, Jardim LC, Calcagnotto T, Martins MA, Martins MD. Effects of osteoporosis on alveolar bone repair after tooth extraction: A systematic review of preclinical studies. Archives of Oral Biology. 2021 May 1;125:105054. https://doi.org/10.1016/j.archoralbio.2021.105054
31. Tavares VD, Rossell SL, Schuch FB, Herring M, de Sousa GM, Galvão-Coelho NL, Hallgren M. Effects of exercise on cognitive functioning in adults with serious mental illness: A meta analytic review. Psychiatry Research. 2023 Mar 1;321:115081.https://doi.org/10.1016/j.psychres.2023.115081
32. Budală DG, Balcoș C, Armencia A, Virvescu DI, Lupu CI, Baciu ER, Vasluianu RI, Tatarciuc M, Luchian I. Does the Loss of Teeth Have an Impact on Geriatric Patients' Cognitive Status?. J of Clinical Medicine. 2023 Mar 16;12(6):2328.https://doi.org/10.3390/jcm12062328
33. Zakaria MN. The limitation of widely used data normality tests in clinical research. Auditory and Vestibular Research. 2022 Jan 1;31(1):1-3. https://doi.org/10.18502/avr.v31i1.8127
34. Krishnamoorthy G, Narayana AI, Balkrishanan D. Mastication as a tool to prevent cognitive dysfunctions. Japanese Dental Science Review. 2018 Nov 1;54(4):169-73. https://doi.org/10.1016/j.jdsr.2018.06.001
35. Wang X, Hu J, Jiang Q. Tooth loss-associated mechanisms that negatively affect cognitive function: A systematic review of animal experiments based on occlusal support loss and cognitive impairment. Frontiers in Neuroscience. 2022 Feb 10;16:811335.https://doi.org/10.3389/fnins.2022.811335

36. Luo B, Pang Q, Jiang Q. Tooth loss causes spatial cognitive impairment in rats through decreased cerebral blood flow and increased glutamate. Archives of Oral Biology. 2019 Jun 1;102:225-30. https://doi.org/10.1016/j.archoralbio.2019.05.004
37. Chen H, Iinuma M, Onozuka M, Kubo KY. Chewing maintains hippocampus-dependent cognitive function. International J of Medical Sciences. 2015;12(6):502. https://doi.org/10.7150/ijms.11911
38. Hu J, Wang X, Kong W, Jiang Q. Tooth Loss Suppresses Hippocampal Neurogenesis and Leads to Cognitive Dysfunction in Juvenile Sprague–Dawley Rats. Frontiers in Neuroscience. 2022 Apr 28;16:839622. https://doi.org/10.3389/fnins.2022.839622
39. Tyng CM, Amin HU, Saad MN, Malik AS. The influences of emotion on learning and memory. Frontiers in psychology. 2017:1454.https://doi.org/10.3389/fpsyg.2017.01454
40. Mehta KJ. Effect of sleep and mood on academic performance—at interface of physiology, psychology, and education. Humanities and Social Sciences Communications. 2022 Jan 11;9(1):1-3. https://doi.org/10.1057/s41599-021-01031-1
41. Maria MT, Hasegawa Y, Khaing AM, Salazar S, Ono T. The relationships between mastication and cognitive function: A systematic review and meta-analysis. Japanese Dental Science Review. 2023 Dec 1;59:375-88.https://doi.org/10.1016/j.jdsr.2023.10.001
42. Shi P, Feng X. Motor skills and cognitive benefits in children and adolescents: Relationship, mechanism and perspectives. Frontiers in Psychology. 2022 Nov 21;13:1017825. https://doi.org/10.3389/fpsyg.2022.1017825
43. Hong S, Baek SH, Lai MK, Arumugam TV, Jo DG. Aging-associated sensory decline and Alzheimer's disease. Molecular Neurodegeneration. 2024 Dec;19(1):1-28.https://doi.org/10.1186/s13024-024-00776-y