A cross-sectional study on depression and its associated factors among rural elderly in Chengalpattu District, Tamil Nadu

Ramesh Anshul[1], Ashokkumar Vikram[2], Sankar Karthik[3], Deepak Avinash KR[4], Mani Ezhilvanan[5], Chinnaian Sivagurunathan[6]

[2]Associate Professor, [3]Assistant Professor, [6]Professor and Head, Department of Community Medicine, Annaii Medical College and Hospital, Rajalakshmi Health City, Pennalur, [1]Assistant Professor, Department of Psychiatry, [4]Assistant Professor, Department of Community Medicine, Sri Muthukumaran Medical College Hospital and Research Institute, [5]Associate Professor (Statistics), Department of Community Medicine, Tagore Medical College and Hospital, Chennai, Tamil Nadu, India

ABSTRACT

Background: People around the world are living longer in the modern medicine era, often accompanied by challenges such as loneliness, neglect, and abuse impacting mental health. Depression is a common mental health condition among the elderly, frequently under-recognized and undertreated. **Aims and Objectives:** This study aimed to estimate the prevalence of depression among rural elderly individuals in Chengalpattu district, Tamil Nadu, India, and identify the associated sociodemographic factors. **Materials and Methods:** This community-based cross-sectional study was conducted among 390 eligible individuals aged 60 years and above residing in rural field practice areas of a private medical college. A pre-tested, semi-structured interview schedule was used, including sociodemographic questions and the 30-item geriatric depression scale. Data were analyzed using Statistical Package for Social Sciences v21.0, employing descriptive statistics, Chi-square tests, and binary logistic regression. **Results:** The study revealed that 33.8% of participants had mild/moderate depression, and 10.8% had severe depression. Age group, marital status, working status, presence of chronic diseases, history of abuse/violence/neglect, and role as a decision-maker in the family were found to be significantly associated with depression. Logistic regression showed that currently, working elderly individuals had higher odds of depression. Elderly experiencing abuse/violence/neglect showed a trend toward higher odds of depression, and those whose decision-making role declined showed a trend toward lower odds of depression. **Conclusion:** This study highlights the substantial prevalence of depression among rural elderly individuals and identifies several associated sociodemographic factors. These findings emphasize the need for community-level screening programs, counseling services, and strengthened rural health systems with adequate resources and infrastructure to provide targeted interventions and social support for the elderly, promoting their overall well-being.

Key words: Aged; Older adults; Mental disorder

INTRODUCTION

Elderly (older adults) refers to someone who is over 60 years of age.[1] People around the world are living longer in the current modern medicine era. Every country in the world is experiencing growth in the proportion of elderly in their population. By 2030, 1.4 billion people in the world will be aged 60 years or over, representing one in six people

in the world.[2] India has 104 million older adults (according to Census 2011) constituting 8.6% of the total population of the country.[3]

An increase in longevity, decline of joint family, and breakdown in social fabric pushes the elderly into loneliness and neglect.[4] The elderly are more likely to experience adverse events such as bereavement, a drop in income, or abuse including physical, verbal, psychological, and financial. One in six elderly experience abuse, often by their own caregivers.[5] These factors seriously affect the mental health of the elderly leading to anxiety and depression. The Global Health Data Exchange estimated that 14% of adults aged 60 years and over live with a mental disorder. One of the most common mental health conditions among them is depression. Globally, 5.7% of the elderly experience depression.[6] The Longitudinal Ageing Study in India reported the prevalence of depression among the elderly as 8.3%.[7] These estimates may not reflect the actual numbers in the community as mental health conditions among elderly people are often underrecognized and undertreated. Furthermore, the stigma surrounding these conditions can make people reluctant to seek help acting as a barrier to effective care.

Aims and objectives

The present study was conducted with the objective of estimating the prevalence of depression among rural elderly people and identifying the associated sociodemographic factors.

MATERIALS AND METHODS

After obtaining Institutional Ethics Committee (IEC) approval, the present community-based cross-sectional study was conducted among elderly people living in the rural field practice areas under the Department of Community Medicine of a private medical college in Chengalpattu district of Tamil Nadu from August to October 2024. The field practice areas include three villages, namely Thaiyur, Kelambakkam, and Pudupakkam catering to a total population of 30,947.

Study population
The elderly (60 years and above) belong to both sexes and live in the field practice areas attached to the Rural Health and Training Centre (RHTC), Kelambakkam.

Inclusion criteria
1. The elderly people who were residing in the study area for more than 6 months
2. Those who were willing to participate in the study by giving informed consent.

Exclusion criteria
1. The elderly people having a gross hearing impairment, diagnosed case of dementia or articulation disorders
2. Those who could not be contacted even after two attempts to reach them.

Sample size
Considering the prevalence among the elderly population as 41.7% (Goswami and Deshmukh) and 6% absolute precision, the sample size was calculated using the formula $4PQ/d^2$.[8]

where P- prevalence (41.7%)
Q=100-P i.e., (58.3%)
d=absolute precision, i.e., (5%)

The minimum sample size was calculated as 385, rounded off to 390.

Sampling technique
A simple random sampling technique was used to select the study participants. First, the list of households with elderly people in the three villages was obtained from the RHTC. Then, 130 households from each village were selected using a simple random sampling technique. From each selected household, one eligible individual was selected. In households with more than one eligible elderly, a lottery method was applied to select the study participants. Thus, 390 study participants were selected.

Study tool
A pre-tested, semi-structured interview schedule consisting of two sections was utilized to obtain information from the study participants. Section A consists of questions on sociodemographic characteristics of the study participants such as age, gender, marital status, educational status, annual income, current working status, dependency on family for financial needs, presence of chronic diseases, role as a decision maker in the family and any history of abuse/violence/neglect by any person in the family since 60 years of age. Section B consists of the geriatric depression scale (GDS).

The GDS is a 30-item questionnaire used to screen for depression among elderly people.[9] The cutoff scores and their interpretation are as follows:
    0–9: No depression present
    10–19: Mild depression likely
    20–30: Severe depression likely.

Data collection procedure
The elderly people who fulfilled the inclusion criteria were selected for participation in the study. Informed consent

was obtained from all the study participants after explaining the purpose and nature of the study. Each participant was personally interviewed using the study tool. Adequate privacy was ensured. Anonymity and confidentiality of the obtained information were maintained.

Data analysis

The collected data were entered in the Microsoft Excel spreadsheet and appropriately coded. Statistical Package for Social Sciences v21.0 was used for analyzing the data. Frequency and percentage (%) were used to represent the categorical variables. The prevalence of depression was expressed as a percentage with a confidence interval (CI). Evaluation of differences between groups for categorized variables was done using Pearson's Chi-square test. The independent associations of various factors with the prevalence of depression were evaluated using binary logistic regression. A P<0.05 was considered a significant association.

RESULTS

Table 1 provides insights into various socio-demographic factors of the study participants. The majority of individuals were in the 70–79 age group (46.7%), followed by the 60–69 group (42.1%). About 55.4% were males. The majority of individuals were married (53.1%), with a significant portion being widowed, separated, or divorced (37.2%). Most individuals had completed primary school (35.9%), whereas fewer had completed graduation (13.3%). A large proportion (84.1%) were not currently working with only 15.9% still employed. About half of the participants (52%) were in lower socioeconomic status, and the majority (82.8%) relied on their families for their needs. Around 70% of the participants reported chronic health conditions. Around one-third (37.4%) of study participants have experienced abuse, violence, or neglect within their families.

According to GDS, 33.8% of the elderly had mild/ moderate depression, and 10.8% had severe depression (Figure 1).

Table 2 represents the relationship between depression levels and various sociodemographic factors of the study participants. Age, marital status, current working status, presence of chronic diseases, history of abuse/violence/ neglect within the family, and role as a decision-maker in the family had a statistically significant association with depression levels.

In regression analysis, working status was significantly associated with depression. At present, working elderly people have a higher likelihood of experiencing mild/

| Table 1: Sociodemographic characteristics of study participants (n=390)		
Characteristics	Frequency	Percentage
Age		
60–69	164	42.1
70–79	182	46.6
>80	44	11.3
Gender		
Male	216	55.4
Female	174	44.6
Marital status		
Married	207	53.1
Widowed/separated/divorced	145	37.2
Never married	38	9.7
Social economic class		
Class I (upper class)	40	10.3
Class II (upper middle class)	56	14.4
Class III (middle class)	91	23.3
Class IV (lower middle class)	96	24.6
Class V (lower class)	107	27.4
Education		
Illiterate	108	27.7
Primary school	140	35.9
High school	90	23.1
Graduate	52	13.3
Working status		
Currently working	62	15.9
Not working	328	84.1
Dependency on family for need		
Yes	323	82.8
No	67	17.2
Chronic diseases		
Yes	278	71.3
No	112	28.7
Any abuse/violence/neglect by any person in family		
Yes	146	37.4
No	244	62.6
Role as a decision-maker in the family		
Improved	108	27.7
Remained same	57	14.6
Declined	225	57.7
Geriatric depression scale		
None	216	55.4
Mild/Moderate	132	33.8
Severe	42	10.8
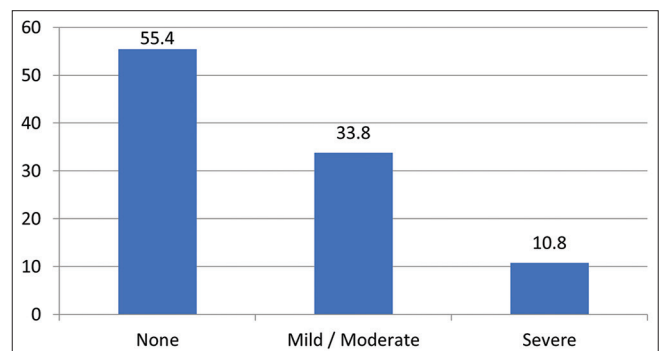
Figure 1: Percentage of depression among study participants

moderate or severe depression (adjusted odds ratio [OR]=2.106, 95% CI: 1.09–4.08, P=0.027). Those elderly

who experienced any abuse/violence/neglect in their family also had higher odds of depression (adjusted OR=1.645, 95% CI: 0.99–2.71, P=0.052). Likewise, those who reported their decision-making role declined were less likely to have depression (adjusted OR=0.517 (0.27–1.01) P=0.053) (Table 3).

DISCUSSION

The present study was done to estimate the prevalence of depression and identify its associated factors among elderly living in rural field practice areas of a tertiary care medical college hospital in Chengalpattu District,

Table 2: Distribution of sociodemographic characteristics of study participants according to the severity of depression

Variable	Depression					
	None (%)	Mild/moderate n (%)	Severe (%)	Total	Chi-square value	P-value
Age						
60–69	106 (64.6)	53 (32.3)	5 (3.0)	164 (100)	82.441	**0.001**
70–79	104 (57.1)	62 (34.1)	16 (8.8)	182 (100)		
>80	6 (13.5)	17 (38.6)	21 (47.7)	44 (100)		
Gender						
Male	121 (56.0)	70 (32.4)	25 (11.6)	216 (100)	0.622	0.733
Female	95 (54.6)	62 (35.6)	17 (9.8)	174 (100)		
Marital status						
Married	122 (58.9)	72 (34.8)	13 (6.3)	207 (100)	15.45	**0.004**
Widowed/Separated/ divorced	75 (51.7)	51 (35.2)	19 (13.1)	145 (100)		
Never married	19 (50.0)	9 (23.7)	10 (26.3)	38 (100)		
Social economic class						
Class I upper class	23 (57.5)	9 (22.5)	8 (20.0)	40 (100)	27.249	**0.001**
Class II upper middle class	38 (67.9)	13 (23.2)	5 (8.9)	56 (100)		
Class III middle class	63 (69.2)	23 (25.3)	5 (5.5)	91 (100)		
Class IV lower middle	49 (51.0)	36 (37.5)	11 (11.5)	96 (100)		
Class V lower class	43 (40.2)	51 (47.7)	13 (12.1)	107 (100)		
Education						
Illiterate	62 (57.4)	34 (31.5)	12 (11.1)	108 (100)	6.320	0.388
Primary school	80 (57.1)	43 (30.7)	17 (12.1)	140 (100)		
High school	42 (46.7)	40 (44.4)	8 (8.9)	90 (100)		
Graduate	32 (61.5)	15 (28.8)	5 (9.6)	52 (100)		
Working status						
Currently working	23 (37.1)	21 (33.9)	18 (29.3)	62 (100)	27.284	**0.001**
Not working	193 (58.8)	111 (33.8)	24 (7.3)	328 (100)		
Dependency on family for need						
Yes	186 (57.6)	105 (32.5)	32 (9.9)	323 (100)	3.936	0.140
No	30 (44.8)	27 (40.3)	10 (14.9)	67 (100)		
Chronic diseases						
Yes	150 (54.0)	97 (34.9)	31 (11.2)	278 (100)	7.442	**0.025**
No	66 (58.9)	35 (31.3)	11 (9.8)	112 (100)		
Any abuse/violence/neglect by any person in family						
Yes	68 (46.6)	51 (34.9)	27 (18.5)	146 (100)	16.279	**0.001**
No	148 (60.7)	81 (33.2)	15 (6.1)	244 (100)		
Role as a decision-maker in the family						
Improved	76 (70.4)	27 (25.0)	5 (4.6)	108 (100)	17.443	**0.002**
Remained same	33 (57.9)	16 (28.1)	8 (14.0)	57 (100)		
Declined	107 (47.6)	89 (39.6)	29 (12.9)	225 (100)		

P value less than 0.05 is considered statistically significant

Table 3: Associated sociodemographic factors of depression

Variables	Categories	Adjusted OR (95% CI)	P-value
Working status	Currently working	1.989 (1.01–3.93)	**0.048**
	Not working	Ref	
Any abuse/violence/neglect by any person in family	Yes	1.645 (0.99–2.71)	0.052
	No	Ref	
Role as a decision-maker in the family	Improved	Ref	
	Remained same	0.306 (0.17–0.55)	**0.001**
	Declined	0.517 (0 0.27–1.01)	0.053

OR: Odds ratio, CI: Confidence interval, P value less than 0.05 is considered statistically significant.

Tamil Nadu. A total of 390 elderly were included as study participants.

In the present study, only 27.7% were illiterate, whereas about 41.9% were illiterate in a study done in Odisha by Antony et al., and Goswami and Deshmukh reported that 45% had not attended school in a study done in Wardha.[8,10] The observed difference in the studies could be due to the different geographic locations of the study area with the present study being done in Tamil Nadu, where the literacy rate is higher.

The majority (53%) of the study participants in the present study were married and living with their spouse. Goswami and Deshmukh, Antony et al., Bincy et al., and Kumar et al. also reported similar findings.[8-12] A large proportion (84.1%) of the present study participants were not currently working which is similar to the finding reported by Antony et al. (52%).[10] About 27% of the study participants belonged to the lower class. Kumar et al. also observed that the majority (21.7%) of their study participants were poor.[12] The majority (82.8%) of the elderly in the present study relied on their families for their needs; Goswami and Deshmukh also reported similar findings with 68% of the elderly dependent on their families.[8]

In the present study, 71.3% of the participants reported chronic health conditions, and around one-third (37.4%) have experienced abuse, violence, or neglect within their families. Goswami and Deshmukh also observed similar findings with 75% of the elderly reporting chronic diseases and 21% reporting abuse/violence/neglect.[8] More than half (57.7%) of the present study participants reported that their role as decision-makers in the family has declined. Similarly, 54% of the participants in a study by Goswami and Deshmukh reported a decline in their decision-making role.[8]

About 44.6% of the study participants in the present study had depression. This finding is in line with the previous community-based research utilizing GDS done by Antony et al. (44.4%), Goswami and Deshmukh (41.7%), and Bincy et al. (67.5%).[8,9,11] Notably, the prevalence of depression was higher among the elderly aged >80 years (38.6% mild/moderate depression and 47.7% severe depression) followed by the 70–79 years age group (34% mild/moderate depression) and 60–69 years age group (32% mild/moderate depression) in the present study. This finding was statistically significant. Similar results were reported by Bincy et al., Goswami, and Deshmukh[8,11] This trend of increasing depression with increasing age among the elderly could be attributed to the increased likelihood of experiencing the loss of loved ones, declining physical health, financial

dependence, and decline in their decision-making role in their family.

Females reported a slightly high (35%) prevalence of mild/moderate depression in the present study in comparison to males (32%). However, this finding was not statistically significant. Bincy et al., in their study done in Tamil Nadu, also reported similar findings, and Goswami and Deshmukh in Wardha observed a much higher prevalence of depression among females (60%).[8,11] Kumar et al. also reported a higher proportion of depression in females.[12] Research evidence suggests that variation in ovarian hormone levels, particularly a decrease in estrogen post-menopause, may contribute to the increased prevalence of depression among elderly women.[13]

In this study, depression was higher among the elderly who were living alone without a spouse, either due to being widowed/separated/divorced (35%) or never married (23%). This finding was statistically significant. Similar results were observed in Antony et al., and Goswami and Deshmukh, Kumar et al.[8,10,12] Compared to the elderly who live with spouses, those without spouses might receive less support, have a narrower social network and experience a stronger sense of loneliness leading to depression.[14]

The prevalence of depression was higher among the elderly belonging to the lower socioeconomic class (47%) compared to those in the upper class (22%) in this study. Goswami and Deshmukh also reported a higher prevalence of depression in those who had annual income <50000 rupees compared to those with income above 2 lakhs.[8] Individuals belonging to low socioeconomic status have a higher likelihood of experiencing depression attributed to the added stress and challenges associated with limited resources. Furthermore, low-income levels increase the dependency of the elderly on their offspring or other family members for sustenance. This, in turn, increases their likelihood of depression.[15]

Currently working elderly in this study were at higher likelihood (adjusted OR=1.989) to experience depression than those not working. Goswami and Deshmukh also observed lesser odds of depression among the elderly who were currently not working (adjusted OR=0.6).[8] This finding could be attributed to the challenges in completing tasks due to declining physical abilities associated with aging, compounded by concerns about ageism and being replaced by younger workers.

Elderly with a history of chronic diseases reported a higher prevalence of depression in this study. Similar findings were observed in the studies done by Antony et al. and Goswami and Deshmukh.[8,10] Patients with chronic diseases

may have physical dysfunction leading to a lower quality of life and lower ability for social and role adaptation than normal. This subsequently leads to denial of self-worth and a sense of powerlessness toward life, ultimately leading to the occurrence of depression.[16] In addition, some medications used to treat chronic diseases can also contribute to depression.

The present study also reports that participants who reported a history of any abuse/violence or neglect by their family members had higher odds of experiencing depression (adjusted OR=1.645) echoing the findings of Goswami and Deshmukh (OR=2.7) and Antony et al., (OR=4.32).[8,10] Furthermore, Saha et al. also observed higher odds of depression among the elderly who perceived discrimination (aOR 1.98) and experienced ill-treatment (aOR 1,39) from family members.[17] In addition, previous research done globally confirms a strong association between elder abuse and depressive symptoms.[18-21] Abuse/violence or neglect by family members causes feelings of fear, isolation, and powerlessness leading to the development of depressive symptoms in the elderly.

This study reported lesser odds of depression among the elderly whose role as decision-makers in the family remained the same or declined in comparison to those whose decision-making role has improved in their family. In traditional Indian society, decisions made by older adults in the family are often considered final. Therefore, those whose decision-making role increases with age may experience a heightened sense of responsibility along with concerns about their decisions being scrutinized by younger family members. This can also lead to feelings of potential conflict within the family, particularly if younger members feel their own input is not valued.[22] All the above-mentioned factors had a significant association with depression in the elderly. Hence, IEC activities focusing on healthy aging, regular physical exercise, healthy habits, and reduction of stress for the elderly and creating awareness by health care professionals among family members in supporting the elderly is recommended.

Limitations of the study
Causality between dependent and independent variables could not be inferred due to the present study being a cross-sectional one.

CONCLUSION

The present study estimated that 33.8% of the elderly living in rural areas have mild/moderate depression, and 10.8% have severe depression. Age, marital status, current working status, presence of chronic diseases, and history of abuse/

violence/neglect by the family were significantly associated with depression. Hence, community-level screening programs to identify depression and to facilitate counseling services for the depressed person need to be provided. In addition, the health system needs to be strengthened, especially in rural areas, with adequate resources and infrastructure. Targeted interventions and social support systems can be established to address the unique challenges faced by the elderly and promote their overall well-being.

REFERENCES

1. Elderly in India 2021. National Statistical Office, Ministry of Statistics and Programme Implementation. New Delhi: Government of India; 2021.

2. World Health Organization. Ageing and Health. Geneva: World Health Organization; 2024. Available from: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health [Last accessed on 2024 Dec 25].

3. Narayan SM. Registrar General and Census Commissioner of India. New Delhi: Census of India, Government of India; 2011.

4. World Health Organization. Ageing and Health. New Delhi: World Health Organization India; 2025. Available from: https://www.who.int/india/health-topics/ageing [Last accessed on 2025 Jan 05].

5. World Health Organization. Mental Health of Older Adults. Geneva: World Health Organization; 2023. Available from: https://www.who.int/news-room/fact-sheets/detail/mental-health-of-older-adults [Last accessed on 2025 Jan 05].

6. Institute for Health Metrics and Evaluation. GBD Results. Washington, DC: Institute for Health Metrics and Evaluation; 2021. Available from: https://vizhub.healthdata.org/gbd-results [Last accessed on 2025 Jan 05].

7. International Institute for Population Sciences (IIPS) and NPHCE, MoHFW. Longitudinal Ageing Study in India (LASI) Wave 1 India Factsheet. Mumbai: International Institute for Population Sciences; 2017.

8. Goswami S and Deshmukh PR. The prevalence of depression among the elderly people living in Rural Wardha. Ind Psychiatry J. 2021;30(1):90-95.
   https://doi.org/10.4103/ipj.ipj_43_17

9. Nathan K. Geriatric Depression Scale (GDS): The Long Form and Short Form. 2023. Available from: https://geriatricacademy.com/geriatric-depression-scale [Last accessed on 2025 Jan 30].

10. Antony A, Parida SP, Behera P and Padhy SK. Geriatric depression: Prevalence and its associated factors in Rural Odisha. Front Public Health. 2023;11:1180446.
    https://doi.org/10.3389/fpubh.2023.1180446

11. Bincy K, Logaraj M and Ramraj B. Depression and its associated factors among the older adults in Rural, Tamilnadu, India. Clin Epidemiol Global Health. 2021;10:100677.
    https://doi.org/10.1016/j.cegh.2020.100677

12. Kumar S, Chauhan S, Patel R, Kumar M and Jean Simon D. Urban-Rural and gender differential in depressive symptoms

among elderly in India. Dialogues Health. 2023;2:100114.

http://doi.org/10.1016/j.dialog.2023.100114

13. Albert PR. Why is depression more prevalent in women? J Psychiatry Neurosci. 2015;40(4):219-221.

https://doi.org/10.1503/jpn.150205

14. Zhang D, Zheng W and Li K. The relationship between marital status and cognitive impairment in Chinese older adults: The multiple mediating effects of social support and depression. BMC Geriatr. 2024;24(1):367.

https://doi.org/10.1186/s12877-024-04975-6

15. Vishwakarma D, Gaidhane A and Bhoi SR. Depression and its associated factors among the elderly population in India: A review. Cureus. 2023;15(6):e41013.

https://doi.org/10.7759/cureus.41013

16. Ma Y, Xiang Q, Yan C, Liao H and Wang J. Relationship between chronic diseases and depression: The mediating effect of pain. BMC Psychiatry. 2021;21(1):436.

https://doi.org/10.1186/s12888-021-03428-3

17. Saha A, Mandal B, Muhammad T and Ali W. Decomposing the Rural-Urban differences in depression among multimorbid older patients in India: Evidence from a cross-sectional study. BMC Psychiatry. 2024;24(1):60.

https://doi.org/10.1186/s12888-023-05480-7

18. Park JI. Relationship between emotional abuse and depression among community-dwelling older adults in Korea. Yonsei Med J. 2018;59(5):693-697.

https://doi.org/10.3349/ymj.2018.59.5.693

19. Pillemer K, Burnes D, Riffin C and Lachs MS. Elder abuse: Global situation, risk factors, and prevention strategies. Gerontologist. 2016;56 Suppl 2(Suppl 2):S194-S205.

https://doi.org/10.1093/geront/gnw004

20. Roepke-Buehler SK, Simon M and Dong X. Association between depressive symptoms, multiple dimensions of depression, and elder abuse: A cross-sectional, population-based analysis of older adults in Urban Chicago. J Aging Health. 2015;27(6):1003-1025.

https://doi.org/10.1177/0898264315571106

21. Santos AJ, Nunes B, Kislaya I, Gil AP and Ribeiro O. Exploring the correlates to depression in elder abuse victims: Abusive experience or individual characteristics. J Interpers Violence. 2017;36(1-2):NP115-NP134.

https://doi.org/10.1177/0886260517732346

22. Srivastava S, Chauhan S, Muhammad T, Simon DJ, Kumar P, Patel R, et al. Older adults' psychological and subjective well-being as a function of household decision making role: Evidence from cross-sectional survey in India. Clin Epidemiol Global Health. 2021;10:100676.

https://doi.org/10.1016/j.cegh.2020.100676

Orcid ID:
Dr. Ramesh Anshul- https://orcid.org/0009-0008-7469-0979
Dr. Ashokkumar Vikram- https://orcid.org/0000-0001-6181-0945
Dr. Sankar Karthik- https://orcid.org/0000-0001-5156-8198
Dr. Deepak Avinash KR- https://orcid.org/0000-0002-7261-6854
Dr. Mani Ezhilvanan- https://orcid.org/0000-0001-6129-5314
Dr. Chinnaian Sivagurunathan- https://orcid.org/0000-0002-4152-8982