

# Knowledge of the public about the role of lumbar puncture in the diagnosis of Alzheimer's disease in China

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## Research Article

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## Abstract

**Background:** Lumbar puncture for cerebrospinal fluid (CSF) detection has not been widely used in clinical practice in China. The aim of this study was to investigate the knowledge of the public about the role of lumbar puncture in the diagnosis of Alzheimer's disease (AD).

**Methods:** A questionnaire survey was conducted using the "Sojump" application. The participants followed the instruction to answer the questionnaire on mobile phone. The survey included the demographic data of the participants, the knowledge about the role of lumbar puncture in the diagnosis of AD, the reasons to decide to undergo lumbar puncture examination. Univariate analysis and multivariate logistic regression analysis were used to investigate the factors associated with the decision.

**Results:** A total of 1050 valid questionnaires were collected, including 403 (38.4%) non-medical staff and 647 (61.6%) medical staff. A total of 862 participants (82.1%) were willing to undergo lumbar puncture, of whom 508 (58.9%) considered that it was helpful to confirm the diagnosis. Multivariate analysis showed that the factors associated with willingness in non-medical staff included: age ( $OR=0.963, P=0.003, 95\% CI: 0.939-0.987$ ), education level ( $OR=2.073, P=0.037, 95\% CI: 1.044-4.114$ ), monthly income ( $OR=1.340, P=0.031, 95\% CI: 1.028-1.748$ ), and occupation type ( $OR=1.569, P=0.038, 95\% CI: 1.026-2.400$ ). The factors associated with willingness in medical staff included: residence ( $OR=9.182, P=0.036, 95\% CI: 1.151-73.238$ ), monthly income ( $OR=4.008, P=0.002, 95\% CI: 1.689-9.511$ ), and hospital Level ( $OR=38.311, P<0.001, 95\% CI: 14.323-102.478$ ).

**Conclusions:** In the general population, more than 80% of people were willing to undergo lumbar puncture for AD diagnosis. However, the desire for the lumbar puncture depends on age, education level, economic status and occupation type.

## Background

Following the increasing population of elderly individuals, the prevalence and incidence of Alzheimer's disease (AD) are increasing, posing great challenges to families and society [1–5]. As previously reported, approximately 70–80% of AD patients in China have not received treatment mainly due to economic difficulties and low awareness of the disease[6], therefore, cost-effective early diagnosis might be the key to delaying disease progression and reducing the burden of care[7–9]. As amyloid  $\beta$  (A $\beta$ ) and tau in the brain are the pathologic markers for AD, detecting A $\beta$  and phosphorylated tau are widely recommended biomarkers for the diagnosis of AD. Positron emission tomography (PET) examination could accurately detect A $\beta$  and tau deposition in the brain, but it is expensive and require special tracers, thus limiting its application in routine clinical practice[10–13]. In contrast, determination of A $\beta_{1-42}$  and phosphorylated tau levels in cerebrospinal fluid (CSF) is much simpler and relatively inexpensive, but it has not yet been widely used in clinical settings in China.

In the present study, we conducted a questionnaire survey aiming to investigate the knowledge of the public people about the role of lumbar puncture in the diagnosis of AD, hoping to provide more evidence

for proper management of AD.

## Methods

### Survey and data collection

A survey was conducted using the “Sojump” application through the WeChat platform, which was the most widely used social tools in China. We designed a questionnaire and shared it in WeChat Moments. Anyone who received the message through the WeChat platform could participate in the survey. The participants entered the “Sojump” interface through their mobile phones and answered the questions following the instructions. The questionnaire included: the demographic data of the participants, the knowledge about the role of lumbar puncture in the diagnosis of AD, the reasons to decide to undergo lumbar puncture examination, etc.

The survey started on July 17, 2021 and ended on July 31, 2021, covering a 2-week period. Then the data of the questionnaires were collected by the management portal of the “Sojump” application.

### Definition Of Variates

In the present study, we divided the participants into two groups, which were medical staff and non-medical staff. The medical staff was defined as working in a hospital. The education levels were classed as middle school and below (school education less than 9 years), high school (school education 9–12 years), college and above (school education more than 12 years). Monthly income refers to the average monthly income of family members. Mental workers refer to those who complete their work mainly with the brain nervous system, and manual workers refer to those who complete their work mainly with the body motor system.

### Statistical analysis

The data were imported into an Excel spreadsheet for analysis. The continuous variables which were approximately normally distributed were reported as means  $\pm$  standard deviations, while categorical variables were presented as frequencies and percentages. Unpaired Student’s t-tests for continuous variables and chi-squared tests for categorical variables were applied. Univariate analysis and multivariate logistic regression analysis were used to investigate the factors associated with willingness to undergo lumbar puncture.

All statistical analyses were performed with SPSS Statistics version 24.0 (IBM, New York, USA). A two-sided  $p$ -value  $< 0.05$  was considered significant.

## Results

# **Demographic characteristics of the total participants**

A total of 1065 people participated in the survey, 15 were excluded due to incomplete or inconsistent answers, thus 1050 (98.6%) were included in the analysis.

As shown in Table 1, the participants were divided into two groups. 403 (38.4%) were non-medical staff, among which, 111 (27.5%) were caregivers of AD patients, 292 (72.5%) were the general public. 647 (61.6%) were medical staff, which was made up of 492 (76.0%) working in tertiary hospitals, 140 (21.6%) working in secondary hospitals, and 15 (2.3%) working in primary hospitals. There were statistically significant differences in gender, age, residence, education level, marital status, occupation type, working status, monthly income and type of medical insurance between non-medical staff and medical staff. (Table 1)

Table 1  
Demographic characteristics of the participants

	<b>Non-Medical staff(n = 403)</b>	<b>Medical staff (n = 647)</b>	<b>P</b>
Gender			
Male (n, %)	144(35.7)	128(19.8)	< 0.001
Female (n, %)	259(64.3)	519(80.2)	
Age(years)	56.5 ± 13.5	37.6 ± 15.1	< 0.001
Residence			
Rural (n, %)	46(11.4)	48(7.4)	0.027
Urban (n, %)	357(88.6)	599(92.6)	
Education level			
Middle school or below (n, %)	49(12.2)	0(0.0)	< 0.001
High school (n, %)	79(19.6)	10(1.5)	
College or above (n, %)	275(68.2)	637(98.5)	
Marital status			
Single (n, %)	66(16.4)	118(18.2)	< 0.001
Married (n, %)	316(78.4)	525(81.1)	
Widowed (n, %)	21(5.2)	4(0.6)	
Occupation type			
Manual worker (n, %)	90(22.3)	180(27.8)	0.047
Mental worker (n, %)	313(77.7)	467(72.2)	
Working state			
Working (n, %)	275(68.2)	628(97.1)	< 0.001
Retired (n, %)	128(31.8)	19(2.9)	
Monthly income			
< ¥ 3000 (n, %)	68(16.9)	42(6.5)	< 0.001
¥ 3000- ¥ 4999 (n, %)	129(32.0)	177(27.4)	
¥ 5000- ¥ 99999 (n, %)	144(35.7)	305(47.1)	
≥ ¥ 10000 (n, %)	62(15.4)	123(19.0)	

	Non-Medical staff(n = 403)	Medical staff (n = 647)	P
Type of medical insurance			
Employee (n, %)	293(72.7)	611(94.4)	< 0.001
Others (n, %)	110(27.3)	36(5.6)	

## Characteristics Of The Participants Willing And Unwilling To Undergo Lumbar Puncture

There were 862 (82.1%) participants willing to undergo lumbar puncture, and 188 (17.9%) declared unwillingness. Gender, age, education level, marital status, occupation type, working status, monthly income, and type of medical insurance had significantly different between willingness to undergo the lumbar puncture group and the unwillingness to undergo the lumbar puncture group. Also, the desire about willing to undergo lumbar puncture had significant differences between medical staff and non-medical staff (Table 2)

Table 2  
Factors influencing participants' recognition of lumbar puncture

	willing to undergo (n = 862)	unwilling to undergo (n = 188)	P
Gender			
Male (n, %)	209(24.2)	63(33.5)	0.009
Female (n, %)	653(75.8)	125(66.5)	
Age(years)	40.0 ± 15.6	47.5 ± 15.1	0.011
Residence			
Rural (n, %)	73(8.5)	21(11.2)	0.240
Urban (n, %)	789(91.5)	167(88.8)	
Education level			
Middle school or below (n, %)	26(3.0)	23(12.2)	< 0.001
High school (n, %)	50(5.8)	39(20.7)	
College or above (n, %)e	786(91.2)	126(67.0)	
Marital status			
Single (n, %)	154(17.9)	30(16.0)	0.013
Married (n, %)	693(80.4)	148(78.7)	
Widowed (n, %)	15(1.7)	10(5.3)	
Occupation type			
Manual worker (n, %)	212(24.6)	58(30.9)	0.005
Mental worker (n, %)	650(75.4)	130(69.1)	
Working state			
Working (n, %)	768(89.1)	135(71.8)	< 0.001
Retired (n, %)	94(10.9)	53(28.2)	
Monthly income			
< ¥ 3000 (n, %)	73(8.5)	37(19.7)	< 0.001
¥ 3000- ¥ 4999 (n, %)	248(28.8)	58(30.9)	
¥ 5000- ¥ 99999 (n, %)	384(44.5)	65(34.6)	
≥ ¥ 10000 (n, %)	157(18.2)	28(14.9)	

	willing to undergo (n = 862)	unwilling to undergo (n = 188)	P
Type of medical insurance			
Employee (n, %)	763(88.5)	141(75.0)	< 0.001
Others (n, %)	99(11.5)	47(25.0)	
Participant identity			
Non-Medical staff (n, %)	256(62.9.7)	147(78.2)	< 0.001
Medical staff (n, %)	606(70.3)	41(21.8)	

## Factors Associated With Willingness To Undergo Lumbar Puncture

Because the demographic characteristics had significant difference between medical staff and non-medical staff, these two groups were analyzed separately when multivariate analysis. Willingness to undergo lumbar puncture were defined as dependent variable (unwillingness = 0, willingness = 1), gender, age, residence, education level, marital status, occupation type, working status, monthly income and type of medical insurance were defined as independent variables for non-medical staff, hospital level, and department were added to the independent variables for medical staff, and multivariate logistic regression analysis was used to investigate the factors associated with the decision.

As shown in Table 3, the factors associated with willingness in non-medical staff included: age (OR = 0.963,  $P$  = 0.003, 95% CI: 0.939–0.987), education level (OR = 2.073,  $P$  = 0.037, 95% CI: 1.044–4.114), monthly income (OR = 1.340,  $P$  = 0.031, 95% CI: 1.028–1.748), and occupation type (OR = 1.569,  $P$  = 0.038, 95% CI: 1.026–2.400).

Table 3  
Multivariate analysis of willingness to undergo lumbar puncture in non-medical staff

Variable	<i>b</i>	SE	Wald	<i>P</i>	OR	95% CI	
						Lower	Upper
Age	-0.038	0.013	8.910	0.003	0.963	0.939	0.987
Education level	0.729	0.350	4.343	0.037	2.073	1.044	4.114
Monthly income	0.293	0.135	4.679	0.031	1.340	1.028	1.748
Occupation type	0.450	0.217	4.318	0.038	1.569	1.026	2.400

As shown in Table 4, the factors associated with willingness in medical staff included: residence (OR = 9.182,  $P$  = 0.036, 95% CI: 1.151–73.238), monthly income (OR = 4.008,  $P$  = 0.002, 95% CI: 1.689–9.511), hospital Level (OR = 38.311,  $P$  < 0.001, 95% CI: 14.323–102.478).

Table 4  
Multivariate analysis of willingness to undergo lumbar puncture in medical staff

Variable	<i>b</i>	SE	Wald	<i>P</i>	OR	95% CI	
						Lower	Upper
Residence	2.217	1.059	4.380	0.036	9.182	1.151	73.238
Monthly income	1.388	0.441	9.913	0.002	4.008	1.689	9.511
Hospital Level	3.646	0.502	52.743	< 0.001	38.311	14.323	102.478

## Reasons For Willingness To Undergo Lumbar Puncture

Among 862 participants who were willing to undergo lumbar puncture, the majority (508, 58.9%) considered that the lumbar puncture examination could help the diagnosis of AD, 215 (24.9%) considered that this examination could enable patients to receive early treatment, and other reasons are shown in Fig. 1.

## Reasons For Unwillingness To Undergo Lumbar Puncture

Of the 188 participants who were unwilling to undergo lumbar puncture, 80 (42.6%) participants considered that AD is currently incurable and the diagnosis would be of little significance, 54 (28.7%) participants have feared the harm due to the invasive operation, and other reasons are shown in Fig. 2.

## Discussion

Determination of A $\beta$ <sub>1-42</sub> and phosphorylated tau levels in CSF has been recommended by numerous guidelines and consensus[14–15], but it has not been widely used in clinical practice in China[16]. Considerable proportion of physicians consider the reasons might be that the invasiveness of the lumbar puncture examination caused it to be probably unacceptable for most patients. However, the actual attitude towards lumbar puncture in the diagnosis of AD in the public population is not clear.

In the present study, we used “Sojump” application in WeChat Moments to investigate the public knowledge about the role of lumbar puncture examination. Unexpectedly, the results showed that 82.1% of participants were willing to undergo lumbar puncture examination, mainly because the examination is helpful for AD diagnosis and enable patients to receive early treatment, especially among non-medical staff who were younger, highly educated, better economic status and mental work, as well as among medical staff who live in urban, better economic status, and worked in tertiary hospitals.

In general impression, lumbar puncture was considered to be invasive and most AD patients were unwilling to undergo the procedure. However, the present study showed that the willingness was as high as 82.1%, suggesting that the acceptance of lumbar puncture examination in the diagnosis of AD was seriously underestimated in the past. We thought there were several explanations. First, detecting A $\beta$ <sub>1-42</sub> and phosphorylated tau levels in CSF by lumbar puncture had been recommended by recent guidelines and its vital role in AD diagnosis had been widely accepted by the public. Second, recent clinical studies have shown that early intervention can effectively delay the progression of AD[17], which facilitate the patients to early diagnosis. Third, with the improvement of health knowledge, the public's fear of lumbar puncture had largely decreased. It was consistent with our finding that non-medical staff who were younger, had higher education levels, better economic status or mental workers were more willing to undergo lumbar puncture examination, as well as medical staff who live in urban, better economic status, and worked in tertiary hospitals. They may have a new concept of health and are more likely to accept new knowledge and new technologies, and have a stronger awareness of disease prevention and treatment.

In this study, approximately 18% of the participants were unwilling to undergo the examination. The main reason was the participants considered that AD is currently incurable and the diagnosis would be of little significance, indicating that some people are still insufficiently aware of AD treatment. Although AD cannot be completely cured at present, a large number of studies have shown that early diagnosis and reasonable treatment can effectively delay disease progression and reduce the economic burden on families and society[18–20]. In 2019, the China Food and Drug Administration (CFDA) approved Sodium Oligomannate for the treatment of mild-moderate AD, which can effectively improve the cognitive function of AD patients and delay the progression of the disease[21–23]. In 2021, the U.S. FDA approved Aducanumab for the early treatment of AD, which can reduce A $\beta$  deposition and tau phosphorylation and delay disease progression[24], all of which demonstrate that early diagnosis is important for AD patients. Therefore, we advise that physicians should put more effort into introducing the significance of early diagnosis and obtain patients' understanding.

Lumbar puncture is a common clinical operation in the clinical practice. It is relatively safe and will not bring significant harm to patients[25–28]. However, the participants were worried about the harmfulness due to lumbar puncture, which was the second reason for their reluctance to undergo the lumbar puncture. It is suggested that some people do not understand the process and invasiveness of lumbar puncture. Patiently explaining the process and safety of lumbar puncture, more patients may agree to undergo a lumbar puncture to diagnose AD.

## Strength And Limitation

This study used the “Sojump” application in WeChat to collect the questionnaire, and the participants voluntarily join in the survey. Thus, the result was neither affected by the sampling method nor affected by the researchers. In addition, the “Sojump” application is a simple and feasible survey tool with a lower cost and higher efficiency, ensuring its accessibility to the public. However, the “Sojump” survey has some

limitations. The survey was mostly released by medical staff through WeChat Moments, therefore medical colleagues were more likely to participate in the study, which may overestimate the participants' willingness to undergo lumbar puncture due to their background in medicine. In future studies, third-party platforms can be delegated to ensure that the distribution of the population is more reasonable and that the survey results are more accurate.

## Conclusion

In the general population, more than 80% of people were willing to undergo lumbar puncture for AD diagnosis. However, the desire for the lumbar puncture depends on age, education level, economic status and occupation type. These indicated that lumbar puncture is acceptable for most of the individuals in clinical diagnosis of AD.

## Abbreviations

AD: Alzheimer's disease;

CSF: cerebrospinal fluid;

PET: Positron emission tomography;

CFDA: China Food and Drug Administration.

## Declarations

### Ethics approval and consent to participate

The Ethics Committee of The First Affiliated Hospital of Xi'an Jiaotong University approved this study (No. 2019-2-27-5-1). Subject participation was voluntary, and informed consent was obtained from all participants. All methods were carried out in accordance with the relevant guidelines and regulations.

### Consent for publication

Not applicable.

### Availability of data and materials

The datasets generated during and analyzed during the current study are not publicly available due to privacy and ethical restrictions but are available from the corresponding author on reasonable request.

### Competing interests

The authors declare that they have no competing interests.

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## Contributions

Study design: Qiumin Qu, Jin Wang. Data collection: Xiaojuan Guo, Jie Liu and Wenhui Lu. Data analyses: Xiaojuan Guo, Ling Gao. Results interpretations: All authors. Manuscript writing: Xiaojuan Guo, Ling Gao. Manuscript proofing: Qiumin Qu, Jin Wang.

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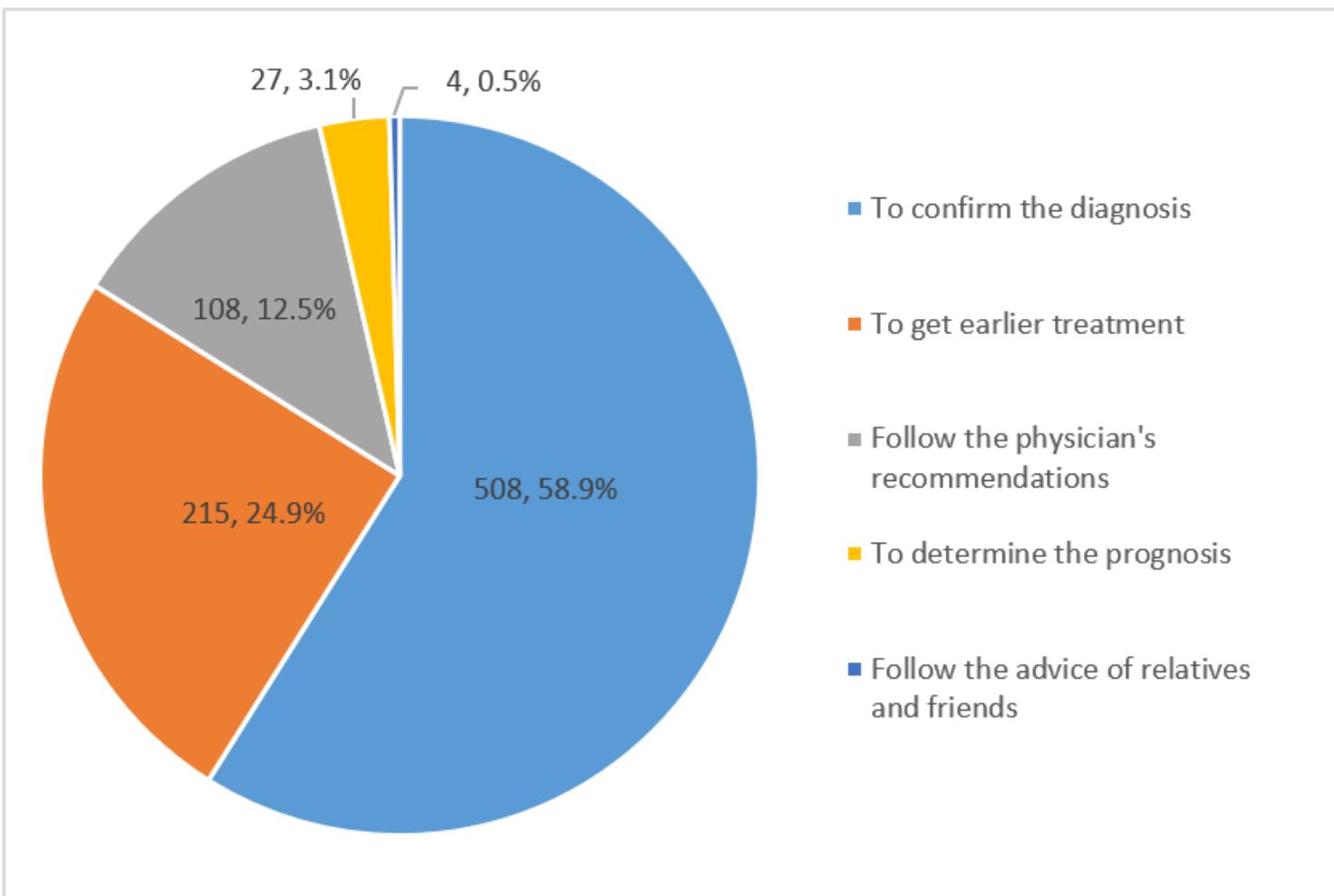
## References

1. Nichols E, Szoek CEI, Vollset SE, Abbasi N, Abd-Allah F, Abdela J, et al. Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *LANCET NEUROL*. 2019; 18(1):88–106.
2. Jia L, Du Y, Chu L, Zhang Z, Li F, Lyu D, et al. Prevalence, risk factors, and management of dementia and mild cognitive impairment in adults aged 60 years or older in China: a cross-sectional study. *The Lancet Public health*. 2020; 5(12):e661-e671.
3. Wimo A, Jönsson L, Bond J, Prince M, Winblad B. The worldwide economic impact of dementia 2010. *Alzheimer's & Dementia*. 2013; 9(1):1–11.
4. Islam BU, Jabir NR, Tabrez S. The role of mitochondrial defects and oxidative stress in Alzheimer's disease. *J DRUG TARGE*. 2019;27(9):932–942.
5. Liu Y, Zhang S, Tomata Y, Nurrika D, Sugawara Y, Tsuji I. The impact of risk factors for dementia in China. *AGE AGEING*. 2020; 49(5):850–855.
6. Jia J, Zuo X, Jia X, Chu C, Wu L, Zhou A, et al. Diagnosis and treatment of dementia in neurology outpatient departments of general hospitals in China. *Alzheimer's & Dementia*. 2016; 12(4):446–453.
7. Dubois B, Padovani A, Scheltens P, Rossi A, Dell'Agnetto G. Timely Diagnosis for Alzheimer's Disease: A Literature Review on Benefits and Challenges. *Journal of Alzheimer's Disease*. 2015; 49(3):617–631.
8. Sperling RA, Aisen PS, Beckett LA, Bennett DA, Craft S, Fagan AM, et al. Toward defining the preclinical stages of Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *ALZHEIMERS DEMENT*. 2011; 7(3):280–292.

9. Miranda LFJR, Matoso RDO, Rodrigues MV, Lima TOL, Nascimento AF, Carvalho FC, et al. Factors influencing possible delay in the diagnosis of Alzheimer's disease: Findings from a tertiary Public University Hospital. *Dementia & neuropsychologia*. 2011; 5(4):328–331.
10. McKhann GM, Knopman DS, Chertkow H, Hyman BT, Jack CR, Kawas CH, et al. The diagnosis of dementia due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & Dementia*. 2011; 7(3):263–269.
11. Frisoni GB, Boccardi M, Barkhof F, Blennow K, Cappa S, Chiòtis K, et al. Strategic roadmap for an early diagnosis of Alzheimer's disease based on biomarkers. *LANCET NEUROL*. 2017;16(8):661–676.
12. Dos SPL, Ozela PF, Fatima DBBM, Pinheiro AA, Padilha EC, Braga FS, et al. Alzheimer's Disease: A Review from the Pathophysiology to Diagnosis, New Perspectives for Pharmacological Treatment. *CURR MED CHEM*. 2018; 25(26):3141–3159.
13. Ma S, Chen G, Xu J, Liu Y, Li G, Chen T, et al. Current strategies for the development of fluorescence-based molecular probes for visualizing the enzymes and proteins associated with Alzheimer's disease. *COORDIN CHEM REV*. 2021; 427(1):213553–213572.
14. Dubois B, Feldman HH, Jacova C. Advancing research diagnostic criteria for Alzheimer's disease: the IWG-2 criteria. *LANCET NEUROL*. 2014; 13(8):757.
15. Carrillo MC, Blennow K, Soares H, Lewczuk P, Mattsson N, Oberoi P, et al. Global standardization measurement of cerebral spinal fluid for Alzheimer's disease: An update from the Alzheimer's Association Global Biomarkers Consortium. *Alzheimer's & Dementia*. 2013; 9(2):137–140.
16. Jia JJ, Zhang YL, Zeng JY. Current application of cerebrospinal fluid detection in the field of Alzheimer's disease. *Chinese Journal of Geriatric Cardiovascular and Cerebrovascular Diseases*. 2019; 21:1192–1195.
17. Barnett JH, Lewis L, Blackwell AD, Taylor M. Early intervention in Alzheimer's disease: a health economic study of the effects of diagnostic timing. *BMC NEUROL*. 2014; 14(1):101.
18. Chen R, Chan P, Chu H, Lin Y, Chang P, Chen C, et al. Treatment effects between monotherapy of donepezil versus combination with memantine for Alzheimer disease: A meta-analysis. *PLOS ONE*. 2017; 12(8):e183586.
19. Becker M, Andel R, Rohrer L, Banks SM. The effect of cholinesterase inhibitors on risk of nursing home placement among medicaid beneficiaries with dementia. *Alzheimer disease and associated disorders*. 2006; 20(3):147–152.
20. Linna M, Vuoti S, Silander K, Hörhammer I, Halminen O, Mikkola T, et al. Impact of Anti-Dementia Medication on the Risk of Death and Causes of Death in Alzheimer's Disease. *Journal of Alzheimer's Disease*. 2019; 71(4):1297–1308.
21. Wang X, Sun G, Feng T, Zhang J, Huang X, Wang T, et al. Sodium oligomannate therapeutically remodels gut microbiota and suppresses gut bacterial amino acids-shaped neuroinflammation to inhibit Alzheimer's disease progression. *CELL RES*. 2019; 29(10):787–803.
22. Syed YY. Sodium Oligomannate: First Approval. *DRUGS*. 2020; 80(4):441–444.

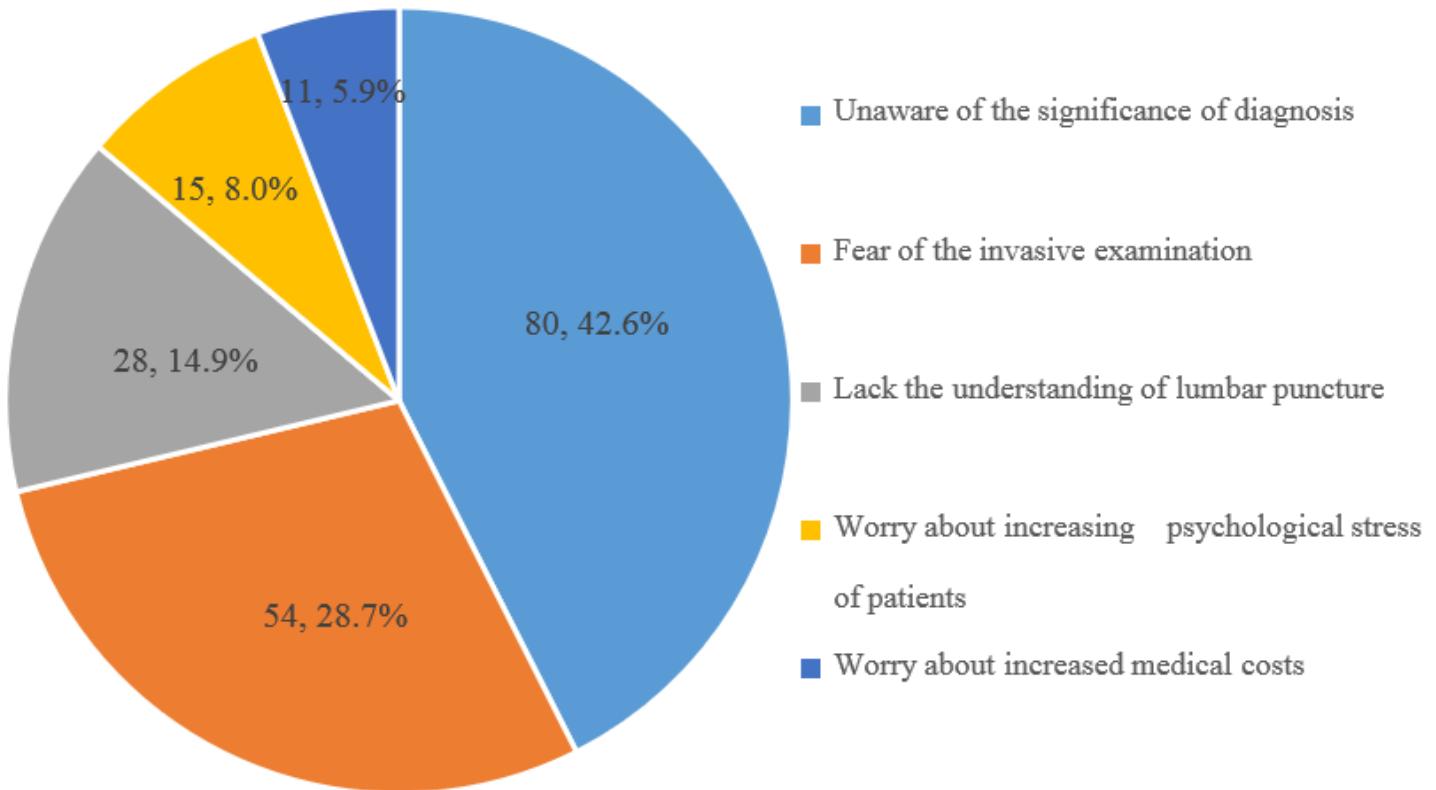
23. Xiao S, Chan P, Wang T, Hong Z, Wang S, Kuang W, et al. A 36-week multicenter, randomized, double-blind, placebo-controlled, parallel-group, phase 3 clinical trial of sodium oligomannate for mild-to-moderate Alzheimer's dementia. *Alzheimer's Research & Therapy*. 2021; 13(1):1–13.
24. Mukhopadhyay S, Banerjee D. A Primer on the Evolution of Aducanumab: The First Antibody Approved for Treatment of Alzheimer's Disease. *Journal of Alzheimer's Disease*. 2021; 83(1):1537–1552.
25. Peskind E, Nordberg A, Darreh-Shori T, Soininen H. Safety of lumbar puncture procedures in patients with Alzheimer's disease. *CURR ALZHEIMER RES*. 2009; 6(3):290–292.
26. PESKIND ER, RIEKSE R, GALASKO D, QUINN JF, KAYE J, CLARK CM, et al. Safety and acceptability of the research lumbar puncture. *Alzheimer disease and associated disorders*. 2005; 19(4):220–225.
27. Duits FH, Martinez-Lage P, Paquet C, Engelborghs S, Lleo A, Hausner L, et al. Performance and complications of lumbar puncture in memory clinics: Results of the multicenter lumbar puncture feasibility study. *ALZHEIMERS DEMENT*. 2016; 12(2):154–163.
28. Carmona-Iragui M, Santos T, Videla S, Fernandez S, Benejam B, Videla L, et al. Feasibility of Lumbar Puncture in the Study of Cerebrospinal Fluid Biomarkers for Alzheimer's Disease in Subjects with Down Syndrome. *J ALZHEIMERS DIS*. 2017; 55(4):1489–1496.

## Figures



**Figure 1**

Reasons for willingness to undergo lumbar puncture



**Figure 2**

Reasons for unwillingness to undergo lumbar puncture