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ORIGINAL ARTICLE

Secular trends in the prevalence of dementia based on a community-based complete enumeration in Japan: the Nakayama Study

Hideaki SHIMIZU [1], Takaaki MORI,[2] Taku YOSHIDA,[3] Ayumi TACHIBANA,[2] Tomoki OZAKI,[2] Yuta YOSHINO,[2] Shinichiro OCHI,[2] Naomi SONOBE,[4] Teruhisa MATSUMOTO,[5] Kenjiro KOMORI,[6] Jun-ichi IGA [2], Toshiharu NINOMIYA,[7] Shu-ichi UENO[2] and Manabu IKEDA[8]

[1]Department of Psychiatry, Heisei Hospital, Ozu, [2]Department of Neuropsychiatry, Molecules and Function, Ehime University Graduate School of Medicine and [4]Konohana Neuropsychology Clinic, Toon, [3]Department of Neuropsychiatry, Zaidan Niihama Hospital and [6]Office of Psychology, Department of Psychiatry, Juzen-Yurinoki Hospital, Niihama, [5]Department of Psychiatry, Futaiwa Hospital, Yawatahama, [7]Department of Epidemiology and Public Health, Graduate School of Medical Sciences, Kyushu University, Fukuoka and [8]Department of Psychiatry, Osaka University Graduate School of Medicine, Osaka, Japan

Correspondence: Dr Hideaki Shimizu, MD, PhD, Department of Psychiatry, Heisei Hospital, 811-1 Yunoki, Ozu, Ehime 795-0011, Japan., Email: shimizu.1685@gmail.com

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Abstract

Background: The number of dementia patients is increasing worldwide, especially in Japan, which has the world's highest ageing population. The increase in the number of older people with dementia is a medical and socioeconomic problem that needs to be prevented, but the actual situation is still not fully understood.

Methods: Four cross-sectional studies on dementia were conducted in 1997, 2004, 2012, and 2016 for complete enumeration of all residents aged 65 years and older. We examined the secular trends in the prevalence of all-cause dementia, Alzheimer's disease (AD), vascular dementia (VaD), and other/unclassified dementia.

Results: The age-standardised prevalence of all-cause dementia significantly increased (4.5% in 1997, 5.7% in 2004, 5.3% in 2012, 9.5% in 2016; *P* for trend <0.05). Similar trends were observed for AD (1.7%, 3.0%, 2.5% and 4.9%, respectively; *P* for trend <0.05) and other/unclassified dementia (0.8%, 1.0%, 1.0% and 2.2%, respectively; *P* for trend <0.05), whereas no significant change in VaD was seen (2.1%, 1.8%, 1.8%, 2.4%, respectively; *P* for trend = 0.77). The crude prevalence of all-cause dementia and AD increased from 1997 to 2016 among participants aged 75–79 years and ≥85 years (all *P* for trend <0.05). Similar trends were observed for other/unclassified dementia among participants aged ≥80 years (all *P* for trend <0.05), but not in VaD.

Conclusions: The prevalence of dementia has increased beyond the ageing of the population, suggesting that factors in addition to ageing are involved in the increase in the number of older people with dementia. To control the increase in the number of older people with dementia, elucidation of secular trends in the incidence, mortality, and prognosis of dementia as well as the factors that promote and protect against dementia, and development of preventive strategies are necessary.

INTRODUCTION

Dementia is among the main causes of disability and decreased quality of life in older people. It is also the most important determinant of healthcare service use.[1] According to a report by Alzheimer's Disease International, 50 million people were estimated to have dementia in 2019 worldwide, and this number is predicted to increase to 152 million by 2050.[2] Of Japan's total population of 125.4 million, 36.2 million are aged 65 years and older, accounting for 28.9% of the population;[3] Japan has the highest ageing rate in the world.[3,4] The increase in the number of older people with dementia has become a medical and socioeconomic problem, and prevention of the disease is necessary to solve

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the problem, but the actual situation is not fully understood. In recent years, a growing number of epidemiological studies have shown that the prevalence of dementia is decreasing or stabilising in countries such as the United States,[5] the United Kingdom,[6] and Sweden.[7] In contrast, several epidemiologic studies have suggested that the prevalence of dementia is increasing in Canada,[8] France,[9] and Japan.[10–12] As the elderly population in Japan is growing rapidly, the prevalence and patterns of dementia need to be further investigated. Considering the impact of dementia on the socioeconomic status of the population, few studies have investigated the epidemiology of dementia in Japan.

For the purpose of revealing secular trends in the prevalence of all-cause dementia in the Japanese elderly population, we have performed community-based complete enumeration of dementia subtypes[13] over the last two decades from 1997 to 2016 in Nakayama town, Ehime prefecture, Japan. Here we report these results.

METHODS

Participants

Nakayama town is a rural community located about 27 km south of the centre of Matsuyama City, Ehime prefecture, Shikoku Island, Japan. We chose this town because of its population size (5038 people; 1418 were aged 65 years and older in 1997), population stability (only 3.1% of the population aged 65 years and older moved out of the town, including in institutions, in the 3 years prior to the first survey), and active cooperation by family doctors. A cross-sectional survey on dementia was conducted four times in 1997, 2004, 2012, and 2016 among all residents aged 65 years and older in Nakayama town. The Nakayama Study in 1997 was conducted from January 1997 to March 1998, using a door-to-door survey protocol for all residents aged 65 years and older. Of 1418 inhabitants, 1220 (86.0%) completed the survey protocol. Approximately 7 years later, the second study (the Nakayama Study in 2004) was conducted on all residents aged 65 years and older in the same town from April 2004 to April 2006. The total population of Nakayama town in 2004 was 4077. Of 1599 inhabitants aged 65 years and older in 2004, 1290 (80.7%) completed the same survey protocol. Approximately 8 years later, the third study (the Nakayama Study in 2012) was conducted on all residents aged 65 years and older in the same town from November 2012 to March 2014. The total population of Nakayama town in 2012 was 3451. Of 1493 inhabitants aged 65 years and older in 2012, 1129 (75.6%) completed the same survey protocol. Approximately 4 years later, the fourth study (the Nakayama Study in 2016) was conducted on all residents aged 65 years and older in the same town from September 2016 to February 2018. However, the survey protocol in 2016 was different from the previous one because the 2016 Nakayama Study was conducted as one target region of the Japan Prospective Studies Collaboration for Aging and Dementia (JPSC-AD), which was designed as a population-based prospective cohort study for 10 000 community-dwelling older people aged 65 years and older in eight regions of Japan. The total population of Nakayama town in 2016 was 3180. Of 1512 inhabitants aged 65 years and older in 2016, 927 (61.3%) completed the survey protocol. In Nakayama town, the total population decreased from 5038 to 3180 and the aging rate increased from 28.1% to 47.5% between 1997 and 2016. In Japan, many rural towns are shrinking and ageing, because young people are moving to urban areas for schools and jobs, leaving mainly the elderly behind. This issue is also described in several papers and web articles.[14–16] Thus, the population trend in Nakayama town is common in rural towns of Japan.

Survey protocol

The details of the survey protocol have been previously reported.[13,17] The survey methods for each year are shown in Table 1. The flow of the survey is shown in Figure 1 for 1997, 2004, and 2012, and Figure 2 for 2016. All surveys followed a three-phase diagnostic approach, with the first stage being a screening interview, the second stage a clinical evaluation, and the third stage diagnostic procedures.

First phase (screening interview)

The screening interview was conducted using questionnaires on medical history, education, activities of daily living, smoking habits, alcohol consumption, medications, diet, and sleep. The screening test for

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Table 1 Demographic characteristics of participants and diagnostic procedures of dementia in each survey

	Year of survey			
	1997 ($N = 1220$)	2004 ($N = 1290$)	2012 ($N = 1129$)	2016 ($N = 927$)
Age, years	74.1 ± 6.9	75.8 ± 7.0	78.0 ± 7.1	77.1 ± 7.8
Women, %	58.2	60.2	60.8	58.4
Participation rate, %	86.0 (1418)	80.7 (1599)	75.6 (1493)	61.3 (1512)
Neuropsychological test	MMSE	MMSE	MMSE	MMSE LM-WMS Noise Pareidolia Test TMT
Diagnosis of dementia	DSM-III-R	DSM-III-R	DSM-III-R	DSM-III-R
Diagnosis of AD	NINCDS-ADRDA	NINCDS-ADRDA	NINCDS-ADRDA	NINCDS-ADRDA
Diagnosis of VaD	DSM-IV	DSM-IV	DSM-IV	NINDS-AIREN

MMSE, Mini-Mental State Examination; LM-WMS, the delayed recall of the Logical Memory IIA subscale of the Wechsler Memory Scale-Revised; TMT, trail-making test; DSM-III-R, Diagnostic and Statistical Manual of Mental Disorders, third edition, revised version; NINCDS-ADRDA, National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, fourth edition; NINDS-AIREN, National Institute of Neurological Disorders and Stroke-Association Internationale pour la Recherche et l'Enseignement en Neurosciences; AD, Alzheimer's disease; VaD, vascular dementia.

dementia was the Mini-Mental State Examination (MMSE).[18] In addition, the Short-Memory Questionnaire (SMQ)[19] and Karasawa's Clinical Criteria of Senility (Karasawa's scale)[20] were administered to caregivers in the 1997, 2004, and 2012 surveys. On the other hand, in the 2016 survey, participants underwent brain magnetic resonance imaging (MRI) scans using a mobile MRI machine and blood tests including thyroid function. Regarding the criteria for conducting the second phase of the survey, in the 1997, 2004, and 2012 surveys, those who met one or more of the following criteria were included: (i) MMSE ≤23 points; (ii) SMQ ≤39 points; (iii) Karasawa's scale ≥ +1; and (iv) in the three-word recall (in the MMSE), unable to recall all three. In addition, the 2016 survey included those who met one or more of the following criteria and who participated in the second phase of the survey: (i) MMSE ≤26 points; (ii) three-word recall (in the MMSE) score of 4 or less out of 6 points (i.e., 2 points for a correct answer without a clue, 1 point for a correct answer with a clue, and 0 points for an incorrect answer); (iii) failed to copy a double pentagon and/or cube (in the MMSE);[21] and (iv) suspected presence of cognitive dysfunction based on speaking to the person and his/her behaviours.

Second phase (clinical evaluation)

We interviewed caregivers to obtain a detailed medical history of the participants and performed neurological and neuropsychological examinations on the participants. In the 1997, 2004, and 2012 surveys, the Neuropsychiatric Inventory[22] and Clinical Dementia Rating scale[23] were used as neuropsychological tests to assess behavioural and psychological symptoms of dementia and severity of dementia, respectively. The 2016 survey used the delayed recall of the Logical Memory IIA subscale of the Wechsler Memory Scale-Revised (LM-WMS),[24] the Noise Pareidolia Test,[25] and the Trail Making Test[26] as neuropsychological tests to assess memory, visual cognition, and executive function. Based on these results, we conducted a comprehensive clinical evaluation and selected the subjects who needed to advance to the third phase.

Third phase (diagnostic procedures)

In the 1997, 2004, and 2012 surveys, participants underwent brain computed tomography (CT) and blood tests including serum vitamin B_{12} and thyroid function. The diagnosis of dementia was made by several dementia specialists and clinical psychologists using the Diagnostic and Statistical Manual of Mental Disorders, third edition, revised version.[27] In addition, participants diagnosed with dementia were subjected to subtype diagnosis according to the following diagnostic criteria. Alzheimer's disease (AD) was diagnosed according to the National Institute of Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorders Association criteria.[28] Vascular dementia (VaD) was diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition[29] in the 1997, 2004, and 2012 surveys and the National Institute of Neurological Disorders and Stroke-Association Internationale pour la Recherche et l'Enseignement en Neurosciences criteria[30] in the 2016 survey. Frontotemporal lobar degeneration was diagnosed according to the consensus clinical diagnostic criteria.[31] Dementia with Lewy bodies (DLB) was diagnosed according to the

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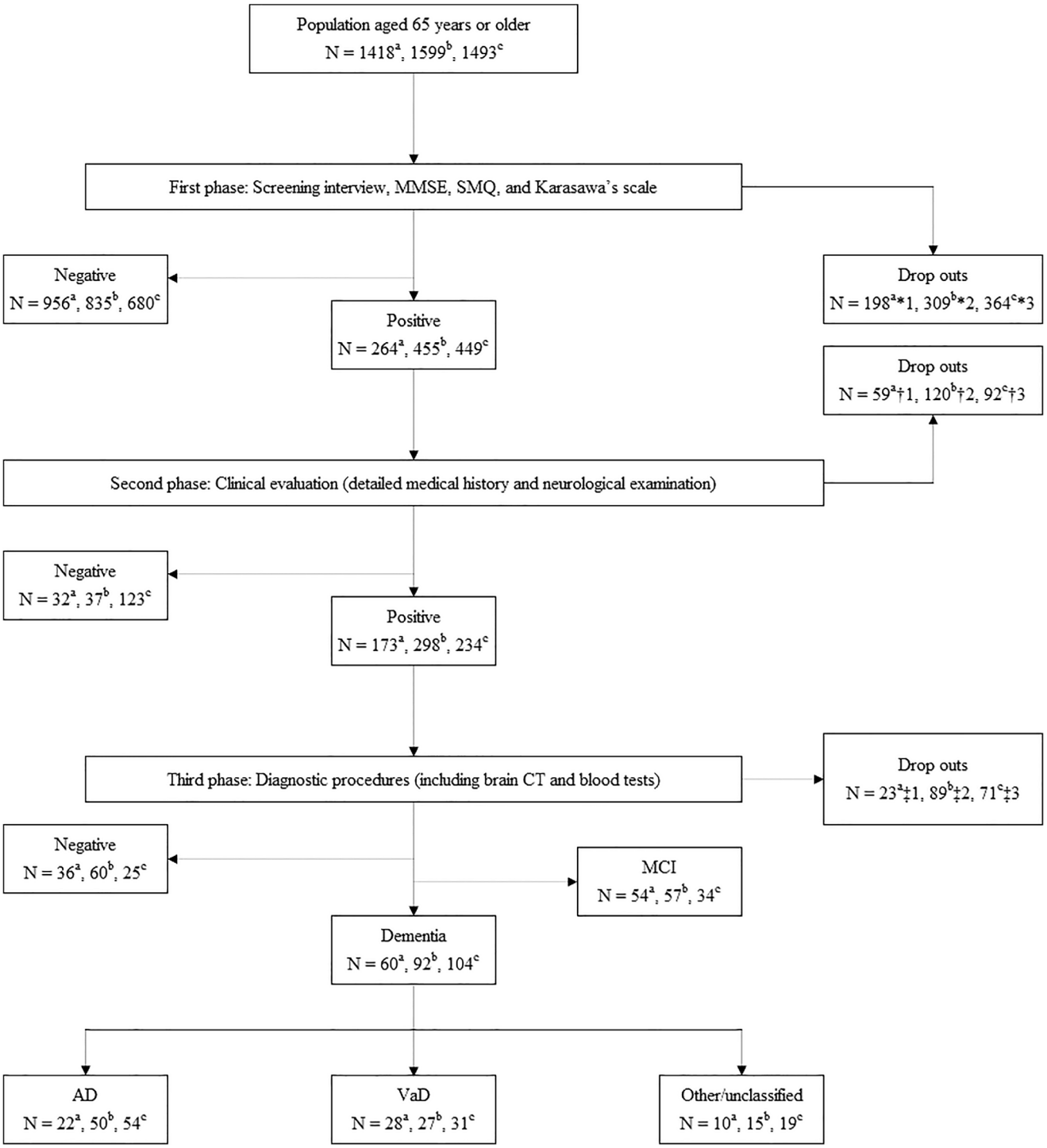

Figure 1 General design of the three phases of the survey protocol in 1997, 2004, and 2012. (a) the Nakayama Study in 1997, (b) the Nakayama Study in 2004, (c) the Nakayama Study in 2012. The number of participants involved in each step is shown in parentheses. MMSE, Mini-Mental State Examination; SMQ, Short-Memory Questionnaire; CT, computed tomography; MCI, mild cognitive impairment; AD, Alzheimer's disease; VaD, vascular dementia. *1 (died, $n = 25$), (institutionalised, $n = 45$), (refused, $n = 30$), (others, $n = 98$). †1 (died, $n = 9$), (institutionalised, $n = 5$), (refused, $n = 14$), (others, $n = 31$). ‡1 (died, $n = 3$), (institutionalised, $n = 4$), (refused, $n = 6$), (others, $n = 10$). *2 (died, $n = 45$), (institutionalised, $n = 33$), (refused, $n = 186$), (others, $n = 45$). †2 (died, $n = 23$), (institutionalised, $n = 8$), (refused, $n = 77$), (others, $n = 12$). ‡2 (died, $n = 3$), (institutionalised, $n = 0$), (refused, $n = 85$), (others, $n = 1$). *3 (died, $n = 28$), (institutionalised, $n = 31$), (refused, $n = 175$), (others, $n = 130$). †3 (died, $n = 9$), (institutionalised, $n = 11$), (refused, $n = 42$), (others, $n = 30$). ‡3 (died, $n = 4$), (institutionalised, $n = 4$), (refused, $n = 10$), (others, $n = 53$).

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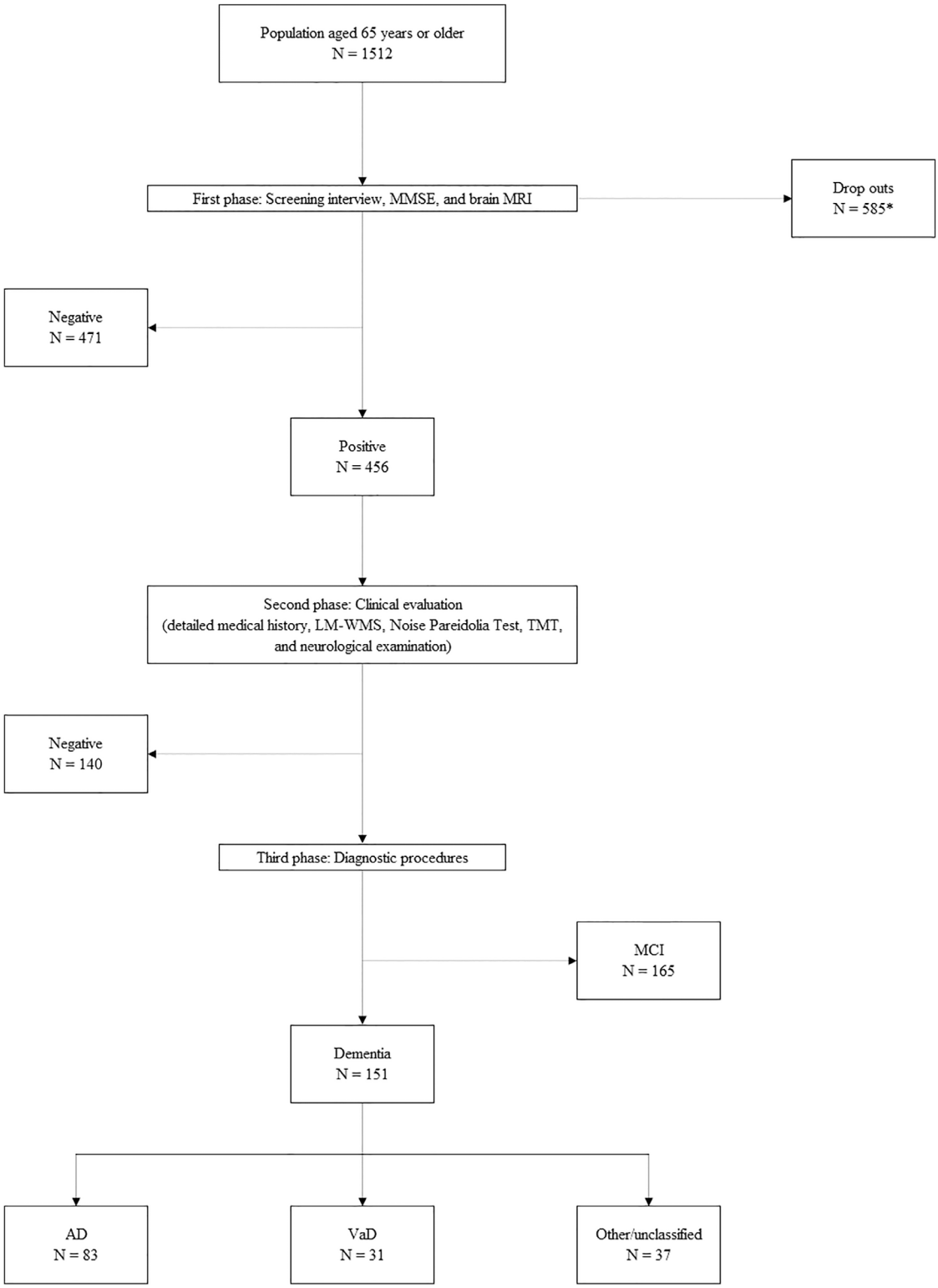

Figure 2 General design of the three phases of the survey protocol in 2016. The number of participants involved in each step is shown in parentheses. MMSE, Mini-Mental State Examination; MRI, magnetic resonance imaging; LM-WMS, the delayed recall of the Logical Memory IIA subscale of the Wechsler Memory Scale-Revised; TMT, Trail Making Test; MCI, mild cognitive impairment; AD, Alzheimer's disease; VaD, vascular dementia. *(died, $n = 88$), (institutionalised, $n = 50$), (refused, $n = 100$), (others, $n = 347$).

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Table 2 Final diagnosis of dementia from 1997 to 2016

Diagnosis	Year of survey			
	1997	2004	2012	2016
AD (including AD with CVD or VaD)	22	50	54	83
VaD	28	27	31	31
DLB	1	2	1	3
Frontotemporal lobar degeneration	2	0	0	0
Progressive supranuclear palsy	0	2	0	0
Dementia resulting from normal-pressure hydrocephalus	3	3	3	2
Dementia resulting from subdural hematoma/hydrocele	2	1	3	0
Dementia resulting from head trauma	1	1	1	2
Dementia resulting from head tumour	0	0	1	1
Dementia with unknown causes	1	6	10	29
Total	60	92	104	151

AD, Alzheimer's disease; CVD, cerebrovascular disease; VaD, vascular dementia; DLB, dementia with Lewy bodies.

Table 3 Secular trends in the prevalence of all-cause dementia from 1997 to 2016

	Year of survey				
	1997 (N = 1220)	2004 (N = 1290)	2012 (N = 1129)	2016 (N = 927)	P for trend
Gender (women:men)	710:510	777:513	686:443	541:386	
All-cause dementia					
No. of cases	60	92	104	151	
Crude prevalence, %	4.9 (3.9–5.9)	7.1 (6.1–8.2)	9.2 (8.3–10.2)	16.3 (14.7–17.8)	<0.05
Age-standardised prevalence, %	4.5 (3.5–5.6)	5.7 (4.7–6.8)	5.3 (4.3–6.2)	9.5 (8.0–11.1)	<0.05
Women					
No. of cases	38	55	66	104	
Crude prevalence, %	5.4 (4.0–6.7)	7.1 (5.7–8.4)	9.6 (8.4–10.8)	19.2 (17.1–21.4)	<0.05
Age-standardised prevalence, %	4.7 (3.4–6.1)	5.4 (4.1–6.8)	4.9 (3.7–6.1)	10.3 (8.2–12.5)	<0.05
Men					
No. of cases	22	37	38	47	
Crude prevalence, %	4.3 (2.6–6.0)	7.2 (5.4–9.0)	8.6 (6.7–10.5)	12.2 (10.1–14.3)	<0.05
Age-standardised prevalence, %	4.5 (2.7–6.2)	6.2 (4.4–8.0)	5.9 (4.0–7.8)	7.8 (5.7–9.9)	<0.05

Table 4 Secular trends in the prevalence of dementia subtypes from 1997 to 2016

	Year of survey				
	1997 (N = 1220)	2004 (N = 1290)	2012 (N = 1129)	2016 (N = 927)	P for trend
Alzheimer's disease					
No. of cases	22	50	54	83	
Crude prevalence, %	1.8 (1.4–2.3)	3.9 (3.2–4.5)	4.8 (4.2–5.4)	9.0 (7.9–10.0)	<0.05
Age-standardised prevalence, %	1.7 (1.2–2.1)	3.0 (2.4–3.6)	2.5 (1.9–3.1)	4.9 (3.9–5.9)	<0.05
Vascular dementia					
No. of cases	28	27	31	31	
Crude prevalence, %	2.3 (1.8–2.8)	2.1 (1.7–2.5)	2.8 (2.5–3.0)	3.3 (2.7–4.0)	0.10
Age-standardised prevalence, %	2.1 (1.6–2.6)	1.8 (1.4–2.2)	1.8 (1.5–2.1)	2.4 (1.8–3.1)	0.77
Other/unclassified dementia					
No. of cases	10	15	19	37	
Crude prevalence, %	0.8 (0.5–1.1)	1.2 (0.9–1.5)	1.7 (1.5–1.8)	4.0 (3.5–4.5)	<0.05
Age-standardised prevalence, %	0.8 (0.5–1.1)	1.0 (0.7–1.2)	1.0 (0.8–1.1)	2.2 (1.7–2.8)	<0.05

consensus guidelines for the clinical and pathological diagnosis of DLB[32] in the 1997, 2004, and 2012 surveys and according to the Fourth Consensus Report of the DLB Consortium[33] in the 2016 survey. Diagnosis of mild cognitive impairment was made according to Petersen's criteria.[34] Normal-pressure hydrocephalus and chronic

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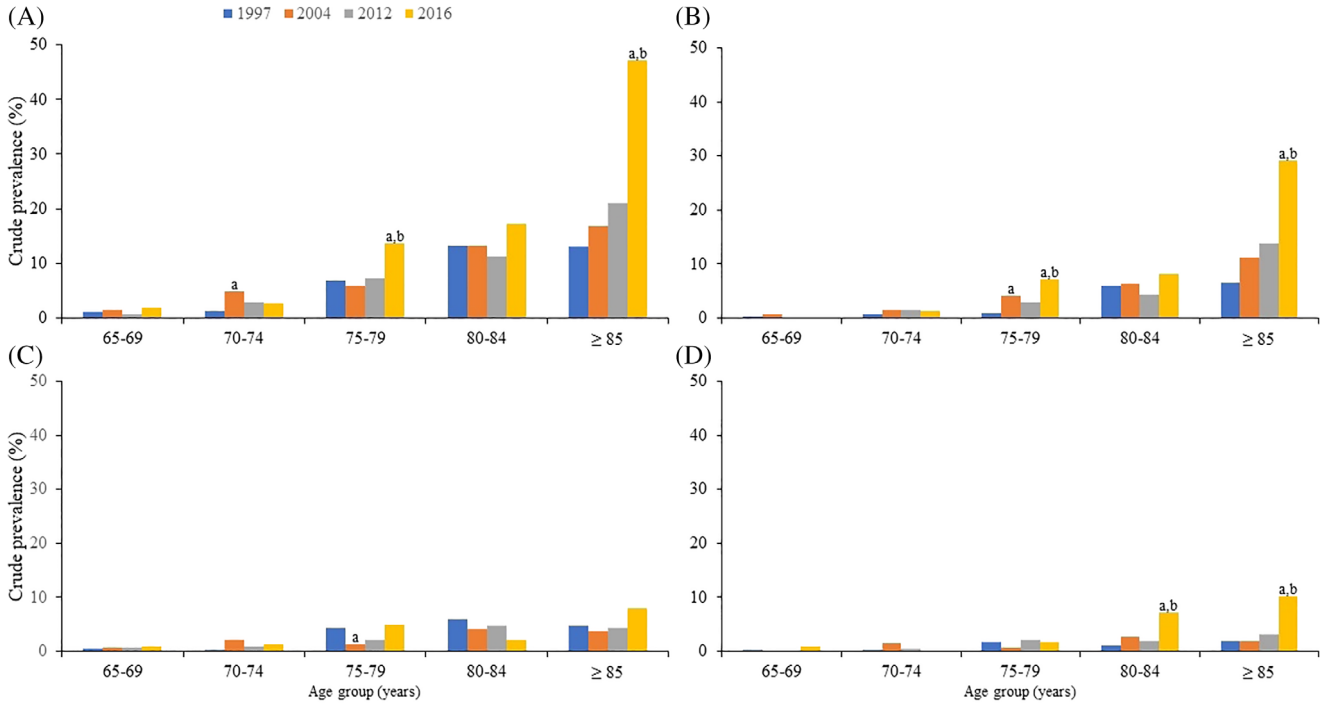

(A) All-cause dementia. (B) Alzheimer's disease. (C) Vascular dementia. (D) Other/unclassified dementia. [a]$P < 0.05$ vs 1997, [b]P for trend < 0.05

Figure 3 Secular trends in the crude prevalence of all-cause dementia and its subtypes by 5-year age groups.

subdural hematoma/hydrocele were detected by brain CT.

Statistical analysis

The age-standardised prevalence of dementia was estimated by the direct method using the World Health Organization World Standard Population (2000–2025) with 5-year age groups. Trends in the crude and age-standardised prevalence of dementia were estimated by using the logistic regression model. Differences in the crude prevalence were estimated by using the logistic regression model with 1997 as the reference year. All analyses were performed with the Statistical Package for the Social Sciences (SPSS ver. 26: SPSS Inc., Chicago, IL, USA). Two-sided $P < 0.05$ was considered statistically significant in all analyses.

Ethics consideration

This study was approved by the institutional ethics committee of Ehime University Hospital. We obtained informed consent from the participants or their relatives. This study was also conducted in accordance with the provisions of the Declaration of Helsinki and Japan's Ethical Guidelines for Medical and Health Research Involving Human Subjects.

RESULTS

Demographic characteristics of the participants in the surveys conducted in 1997, 2004, 2012, and 2016 are shown in Table 1. The mean age slightly increased from 74.1 years in 1997 to 78.0 years in 2012, but slightly decreased to 77.1 years in 2016. Women accounted for approximately 60% of total participants over the four surveys. Final diagnoses of dementia from 1997 to 2016 are shown in Table 2. The number of cases of AD with cerebrovascular disease (CVD) was one in 1997, 24 in 2004, 17 in 2012, and 24 in 2016. Similarly, the number of cases of AD with VaD was none, three, 12, and 19, respectively. The core conditions in cases of AD with CVD or VaD were AD, and all of them were included in the AD group. The number of AD cases increased, but the number of VaD cases remained almost constant. Other/unclassified dementia included DLB, frontotemporal lobar degeneration, progressive supranuclear palsy, normal-pressure hydrocephalus, subdural hematoma/

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hydrocele, head trauma, head tumour, and dementia with unknown causes. Table 3 shows the secular trends in the prevalence of all-cause dementia from 1997 to 2016. The age-standardised prevalence of all-cause dementia significantly increased from 4.5% in 1997 to 9.5% in 2016 (P for trend <0.05). This trend was observed in the age-standardised prevalence of all-cause dementia for both genders (P for trend <0.05). Table 4 shows the secular trends in the prevalence of dementia subtypes from 1997 to 2016. Similar trends were observed for AD and other/unclassified dementia (P for trend <0.05), but such trends were not seen for VaD (P for trend = 0.77). The age-standardised prevalence of AD showed an increasing trend from 1.7% to 3.0% between 1997 and 2004, but then showed a decreasing trend to 2.5% in 2012, and started to increase again to 4.9% in 2016 (P for trend <0.05). Figure 3 shows the secular trends in the crude prevalence of all-cause dementia and its subtypes by 5-year age groups. The crude prevalence of all-cause dementia and AD increased from 1997 to 2016 among participants aged 75–79 years and ≥85 years (all P for trend <0.05). Similar trends were observed for other/unclassified dementia among participants aged ≥80 years (all P for trend <0.05), whereas no clear secular change was seen in the crude prevalence of VaD in any age group.

DISCUSSION

The current analysis of repeated cross-sectional studies of the Japanese elderly population revealed a significant increase in the prevalence of all-cause dementia from 1997 to 2016. Similar trends were seen in AD and other/unclassified dementia, but not in VaD. In all four surveys, the proportion of women was consistently high in the number of dementia cases. In Japan, the incidence of AD in women is reported to be more than twice that of in men,[35] and the difference in the incidence of AD by gender may have a small influence on the proportion of dementia cases.

Epidemiological studies investigating the prevalence of dementia over time have been conducted around the world, with mixed results. In three countries, the prevalence of dementia has decreased or stabilised,[5–7] whereas the prevalence of dementia has been reported to be increasing in three countries including Japan.[8–12] In this study, the prevalence of all-cause dementia was increasing, which was consistent with previous reports from Japan.[10–12] These discrepancies in dementia prevalence trends can be attributed to differences in survey methods, changes in population health due to economic transition, improved risk factor management, differences in survival rates, increased awareness of public health and dementia, and higher levels of education.[36] In Japan, increases in the prevalence of dementia have been postulated to be linked to increases in the prevalence of metabolic risk factors, reduced mortality, and therapeutic advances in managing ageing-related diseases.[36] In this study, the age-standardised prevalence of all-cause dementia increased significantly, indicating that factors other than the ageing of the population are responsible for the increase in prevalence. We will examine trends in the incidence and survival of dementia and study the causes of the increasing prevalence of dementia in the future.

The prevalence of AD increased from 1997 to 2004, decreased in 2012, and then began to increase again in 2016, with a significant increase in the trend. The trend in the prevalence of AD in this study was consistent with the results of the Hisayama study.[12] The cause of the significant increase in the prevalence of AD was not clear, but several factors may be considered. The increase in the prevalence of dementia, especially AD, in Japan can be attributed to the rapid ageing of the population as well as the increasing incidence and survival of dementia.[12] The increase in the prevalence of AD in this study is increasing beyond the ageing of the population, which may contribute to its increased incidence and survival. In several studies conducted in Japanese-Americans in the early 1990s, the ratio of the prevalence of AD to that of VaD was higher than that reported in Japanese living in Japan and similar to that reported in Caucasian populations.[37,38] These results suggest that environmental factors may play a crucial role in the development of AD. The rising prevalence of AD may be related to the lifestyle or nutrition transition from a traditional Japanese style to a Western style.[39] Another factor may be the impact of changes in survey methodology. Although the area in which this study was conducted has remained the same since its inception in 1997, the survey methodology was partially different between, on the one hand, the three surveys conducted in 1997, 2004, and 2012, and on the other of the survey conducted in 2016. In the 2016 survey, LM-WMS

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was added as a neuropsychological test, which detected episodic memory impairment more acutely than in previous surveys and may have contributed to the increased prevalence of AD.

The crude prevalence of VaD showed an increasing trend, but this trend disappeared after age adjustment, except in 2016 when the survey methodology was different. This result suggests that the increasing trend in the crude prevalence of VaD was due to the ageing of the population. The trend in the prevalence of VaD in this study was also similar to the results of the Hisayama study.[12] Although the Nakayama Study is a non-interventional study, the whole town is working on early detection of dementia with the full cooperation of general practitioners. After the survey, we continued to visit the elderly in the town twice a month and immediately referred residents diagnosed with VaD or CVD to general practitioners for thorough follow-up, including active control of cardiovascular risk factors such as hypertension, diabetes, and hyperlipidemia.[40] Therefore, the efforts of the whole town approach to dementia may have contributed to the absence of a significant increase in the prevalence of VaD.

All participants diagnosed with DLB in this study had probable DLB, but its percentage of the total dementia cases was lower than that reported to account for 15%–20% of all dementia at autopsy.[41] The reason for this may be that DLB has more severe behavioural and psychological symptoms of dementia[42] and is more rapidly progressing than AD,[43] which may have forced residents with DLB to be admitted to nursing homes or to hospitals, and thus they could not participate in this study.

With the increase in dementia with unknown causes, the prevalence trend in other/unclassified dementia significantly increased. Dementia with unknown causes refers to cases in which activities of daily living are impaired due to cognitive impairment, but the patient shows no clinical symptoms or brain imaging findings that meet the clinical diagnostic criteria for a specific subtype of dementia. The frequency of tauopathies such as argyrophilic grain dementia (AGD) and senile dementia with neurofibrillary tangles (SD-NFT) increases with age.[44,45] The mean age of the population in this study also increased, and the increase in other/unclassified dementia may be attributed to the development of AGD and SD-NFT. These tauopathies are frequently diagnosed as AD and might contribute to increased prevalence of AD, partially. In participants with dementia with unknown causes, we will observe the clinical course and confirm the diagnosis.

Strengths and limitations

The strengths of this study include the fact that it is a community-based complete enumeration study, the long observation period of about 20 years, the complete follow-up of all participants, and the high frequency of neuroimaging for diagnosing dementia. However, four limitations should also be considered. First, the survey participation rates decreased to 86.0%, 80.7%, 75.6%, and 61.3% in 1997, 2004, 2012, and 2016, respectively. Both surveys in 1997 and 2004 were conducted before and immediately after the start of the public long-term care insurance system in Japan, and also serve as surveys of the actual conditions of the system. Hence, we repeatedly encouraged residents to participate in the survey or visited them in their homes, which may have resulted in a participation rate of over 80% in both surveys. By age group, the decline in participation rates was particularly obvious in both the 65–69 years and ≥85 years age groups, falling below 60% in 2016. More people in the 65–69 years group refused to participate because they had no health problems, whereas more people in the ≥85 years were unable to participate because they were placed in nursing homes. In addition, the change in brain imaging from CT to MRI in 2016 may have increased participant burden and led to lower participation rates. Second, a participation rate of at least 70% of the target population is required to practically eliminate the threat of selection bias by non-participants in a population-based study.[46,47] The participation rate in 1997, 2004, and 2012 was above 70%, whereas the participation rate in 2016 was 61.3%, suggesting that selection bias may have affected the prevalence of dementia in 2016. Third, no pathological confirmation of the diagnosis of dementia was performed. However, all participants diagnosed with dementia in the 1997 survey showed progressive deterioration in the subsequent follow-up survey.[13] Fourth, we have no information on the factors that influenced trends in the dementia prevalence.

CONCLUSIONS

In conclusion, the prevalence of dementia in this study has increased beyond the ageing of the

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population, suggesting that factors in addition to ageing are involved in the background of the increase in the number of older people with dementia. To control the increase in the number of older people with dementia, elucidation of the secular trends in the incidence, mortality, and prognosis of dementia and the factors that promote and protect against dementia, and development of preventive strategies, are necessary.

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DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request. However, the permission of the AMED is required for the 2016 dataset.

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