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ORIGINAL ARTICLE

Temporal patterns of the burden of Alzheimer's disease and their association with Sociodemographic Index in countries with varying rates of aging 1990–2019

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Abstract

Objective: To we examine the temporal patterns of the burden of Alzheimer's disease and their association with Sociodemographic Index in countries with varying rates of aging.

Method: Data were obtained from Global Burden of Diseases studies (GBD) 2019 and were used to compare countries with different rates of change in aging population from 1990 to 2019. We collected the data of the age-standardized rates per 100,000 of disability-adjusted life years (DALYs), incidence, prevalence of Alzheimer's disease and other dementias, and the age-specific population rates per 100,000.

Results: Countries with high rates of change in their aging populations had an increase in DALYs, incidence, and prevalence of Alzheimer's disease and other dementias over the last 30 years. Countries with a high rate of change in aging population had a significantly positive association among DALYs, incidence, and prevalence of Alzheimer's disease and other dementias. In contrast, countries with a medium and low rate of change in aging population had negative associations between DALYs and incidence of Alzheimer's disease and other dementias.

Conclusion: This study highlights the significant impact of demographic changes on the burden, prevalence, and incidence of Alzheimer's disease and other dementia. The study also found that robust health care and social systems, as reflected by a higher Sociodemographic Index, can contribute to reducing the burden of Alzheimer's disease and other dementias in medium to low rates of aging populations. The findings underscore the importance of investing in health care and social systems to address the growing burden of these conditions, especially in countries with a high rate of change in the aging population.

KEYWORDS
aging, Alzheimer's disease, disability-adjusted life years (DALY), Sociodemographic Index (SDI)

1 | INTRODUCTION

Dementia is a syndrome characterized by a range of symptoms, with Alzheimer's disease being the most common type. Alzheimer's disease is primarily characterized by comprehensive dementia, including memory and cognitive disorders, executive dysfunction, and personality and behavior changes.[1] Mental disorder symptoms are also often present in patients with Alzheimer's disease.[2] Unfortunately, there are currently no specific measures available to prevent or cure Alzheimer's disease.[3] Alzheimer's disease and other dementias represent a significant public health challenge worldwide, with an estimated 50 million people living with dementia globally in 2020, a number that is projected to increase to 152 million by 2050.[4] Furthermore, Alzheimer's disease is a leading cause of disability and dependence in the elderly, with a profound impact on quality of life. It also poses a significant burden on health care systems and society. Alzheimer's disease and other dementias were the fifth leading causes of death and the second leading neurological causes of death globally, with two out of every 10 individuals diagnosed with neurological disorders having Alzheimer's disease.[5,6]

The prevalence of Alzheimer's disease varies widely across different regions and countries, with higher rates reported in low-income countries compared to high-income countries.[7] Studies have shown that the incidence and prevalence of Alzheimer's disease are strongly associated with aging, with a sharp increase in incidence and prevalence observed in individuals aged 65 years and older.[8] Although the causes of dementia are complex and multifactorial, aging is a well-established risk factor for the development of these conditions.[8–10] In high-income countries, where population aging is most pronounced, the prevalence of dementia is expected to rise substantially in the coming decades. A recent study by Global Burden of Diseases (GBD) 2019 Diseases and Injuries Collaborators estimated that the contribution of aging to the burden of Alzheimer's disease and other dementias increased substantially in the last decade across high-income countries.[11]

The Sociodemographic Index (SDI) is a composite indicator that measures a country's level of development based on three key dimensions: income, education, and fertility, which the three factors have been linked to the risk of development of Alzheimer's disease and other dementias.[12] The SDI was introduced in the GBD study's 2016 update as a replacement for the previously used Gross Domestic Product (GDP) per capita measure.[13] The SDI was developed to better capture the multidimensional nature of development and to provide a more accurate reflection of the health and well-being of populations.[13] The SDI has since become a widely used measure in global health research to better understand the social and economic context of health outcomes. By using the SDI, we can examine how the combined development factors, such as education and income, influence health outcomes, including disability-adjusted life years (DALYs), incidence, and prevalence of diseases like Alzheimer's disease and other dementias.

Although the existing literature has established the association between aging and the development of Alzheimer's disease and other dementias, there are still gaps in our understanding of how the sociodemographic factors, such as education, income, and fertility, interact with aging to impact the temporal patterns in DALYs, incidence, and prevalence of these conditions. Moreover, the temporal patterns of Alzheimer's disease and other dementias in different high-income countries with varying rates of aging are not well-understood. Therefore, this study is needed to fill these gaps in knowledge and provide a more comprehensive understanding of the global impact of Alzheimer's disease and other dementias. By examining the association between the SDI and the temporal patterns in DALYs, incidence, and prevalence of Alzheimer's disease and other dementias, this study aims to shed light on the potential drivers of changes in dementia prevalence over time and contribute to better planning and provision of adequate care for affected populations.

2 | METHODS

2.1 | Aim, study design, and setting

The study aims to examine the temporal patterns in the age-standardized rates DALYs, the incidence, and the prevalence of Alzheimer's disease and other dementias from 1990 to 2019 in different high-income countries with different rates of aging in the last 3 decades. The study also examined the association between the SDI and the DALYs, the incidence, and prevalence of Alzheimer's disease and other dementias in high-income countries with different rates of aging.

We collected data retrospectively from the World Bank on several high-income countries, namely the United States, Germany, Japan, China, Saudi Arabia, and United Arab Emirates, and classified them based on their age-specific population rates.[14] These six countries represented approximately 37.11% of the world's total population in 2019, according to the World Bank data.[14] Then, we categorized these countries into three groups based on the rate of change in their aging population (65 + years) from 1990 to 2019: high rate of change, with a range between 101.37 and 130.18, medium rate of change, with a range between 72.72 and 86.6, and low rate of change, with a range between 58.75 and 64.98.

2.2 | Data sources and variables definitions

Data was obtained from GBD studies 2019, which is a multinational collaborative project to provide high-quality estimates for 369 diseases and injuries, and 87 risk factors in 204 countries and territories from 1990 to 2019.[15] The GBD studies are a series of comprehensive assessments of health loss, caused by diseases, injuries, and risk factors, across regions and over time. These studies are led by the Institute for Health Metrics and Evaluation (IHME) at the University of Washington in Seattle and involve collaboration with researchers and public health experts from around the world.[15]

We collected the data of the age-standardized rates per 100,000 of DALYs, incidence, prevalence of Alzheimer's disease and other

dementias, and the age-specific population rates per 100,000 from 1990 to 2019. The DALYs are a measure of the overall burden of disease, injury, and disability in a population. DALYs represent the number of healthy years of life lost due to premature death and disability and are calculated by adding together the years of life lost (YLLs) and the years lived with disability (YLDs) due to a specific health condition. Essentially, one DALY is equal to 1 year of healthy life lost. The YLLs are the years of life that a person would have lived if they had not died prematurely due to a particular health condition. YLLs are calculated by subtracting the age at death from the life expectancy of a person at that age. This life expectancy is based on the lowest observed mortality rates for each age in any population. The YLDs represent the number of years that a person lives with a health condition that causes disability or reduces their quality of life. YLDs are calculated by multiplying the prevalence of a particular health condition by its disability weight, which reflects the severity of the condition's impact on a person's quality of life.

2.3 | Statistical analysis

The purpose of this study was to examine the temporal trend of the burden of Alzheimer's disease and other dementias, age-standardized incidence, and prevalence of Alzheimer's disease and other dementias from 1990 to 2019. We utilized segmented regression analysis in with two segments model. Segmented (Piecewise) regression models involve fitting a least squares regression line for each segment and assume a linear association between the predictor variable and the response variable within each of those segments.[16] We calculated the average annual percent change (AAPC) and its corresponding 95% confidence interval (CI) by weighing the segment trends. We used several generalized additive regression models (GAMs) to further examine the association between the burden of Alzheimer's disease and other dementias, age-standardized incidence, and prevalence of Alzheimer's disease and other dementias, and SDI for each country. The GAM allows us to discover patterns in the relationship between the independent and dependent variables by relaxing the typical parametric assumption of normality.[17] All analyses were performed using SAS statistical software version 9.4 (SAS Institute Inc.).

3 | RESULTS

Table 1 shows that countries with high rates of change in their aging populations, as in Japan, had a 28.63% increase in DALYs, a 15.8% increase in incidence, and a 22.2% increase in prevalence, whereas China had a 6.05% increase in DALYs, a 14.7% increase in incidence, and a 29.2% increase in prevalence over the last 30 years. The United States and United Arab Emirates, with medium rates of change in their aging populations, experienced slight decreases or stagnation in their DALYs, incidence, and prevalence of Alzheimer's disease and other dementias from 1990 to 2019. The United States had a 2.42% decrease in DALYs, a 4.45% decrease in incidence, and a 2.12% decrease in prevalence, whereas the United Arab Emirates had a 2.4% decrease in DALYs, a 0.94% decrease in incidence, and a 0.12% decrease in prevalence. Germany and Saudi Arabia, with low rates of change in their aging populations, experienced slight decreases in their DALYs, and incidence, and an increased prevalence of Alzheimer's disease and other dementias from 1990 to 2019. Germany had a 12.31% decrease in DALYs, a 4.24% decrease in incidence, and a 2.37% increase in prevalence, whereas Saudi Arabia had a 0.88% decrease in DALYs, a 1.34% decrease in incidence, and a 0.82% increase in prevalence.

Figure 1 shows the annual patterns changes for DALYs of Alzheimer's disease and other dementias over the period from 1990 to 2019. The results show that countries with a high rate of change in aging population (Japan and China) had a consistent increase of DALYs over the study period. In contrast, countries with a medium and low rate of change in aging population show consistent decrease of DALYs over the study period. In Figure 2, countries with a high rate of change in aging population had a consistent increase of both age-standardized incidence and prevalence of Alzheimer's disease and other dementias, except for Saudi Arabia, and Germany (low rate of change in aging population) had a slight increase of prevalence in the last 8 years of the study period.

Table 2 presents countries with a high rate of change in aging population (Japan and China) had a significantly positive association between DALYs, incidence, and prevalence of Alzheimer's disease and other dementias. Japan had a coefficient value of 1.95 (95% CI: 0.61 to 3.31) for DALYs, 1.13 (95% CI: 0.33 to 1.92) for incidence, and 1.51 (95% CI: 0.45 to 2.55) for prevalence. China had a coefficient value of 0.28 (95% CI: 0.24 to 0.32) for DALYs, 0.33 (95% CI: 0.23 to 0.42) for incidence, and 0.65 (95% CI: 0.49 to 0.8) for prevalence. In contrast, countries with a medium (United States and United Arab Emirates) and low (Germany and Saudi Arabia) rate of change in aging population had negative associations between DALYs and incidence of Alzheimer's disease and other dementias. The United States had a coefficient value of −0.67 (95% CI: −0.83 to −0.5) for DALYs, −0.04 (95% CI: −0.23 to 0.13) for incidence, and 0.28 (95% CI: 0.06 to 0.51) for prevalence. The United Arab Emirates had a coefficient value of −0.21 (95% CI: −0.29 to −0.12) for DALYs, −0.06 (95% CI: −0.08 to −0.04) for incidence, and −0.04 (95% CI: −0.06 to −0.03) for prevalence. Germany had a coefficient value of −2.28 (95% CI: −2.61 to −1.96) for DALYs, −0.47 (95% CI: −0.66 to −0.27) for incidence, and 0.33 (95% CI: 0.18 to 0.49) for prevalence. Saudi Arabia had a coefficient value of −0.08 (95% CI: −0.09 to −0.06) for DALYs, −0.04 (95% CI: −0.05 to −0.02) for incidence, and 0.02 (95% CI: 0.006 to 0.03) for prevalence.

4 | DISCUSSION

The study examined the temporal patterns in the age-standardized rates DALYs, the incidence, and the prevalence of Alzheimer's disease and other dementias from 1990 to 2019 in different high-income

TABLE 1 Age-standardized rates of DALYs, incident, and prevalence of Alzheimer's disease and other dementias 1990 and 2019, with percentage changes from 1990 to 2019.

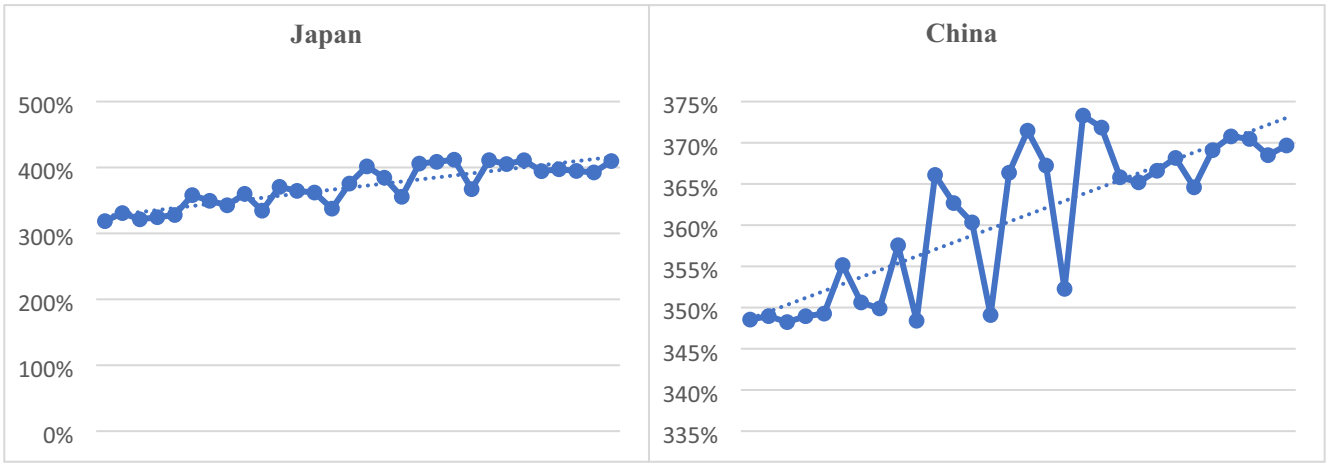
	DALY[a] Alzheimer's disease and other dementias			Incidence of Alzheimer's disease and other dementias			Prevalence of Alzheimer's disease and other dementias			SDI		
	1990	2019	• %[b]	1990	2019	%	1990	2019	%	1990	2019	%
High rate of change in the aging population (+101.37, +130.18)												
Japan	318.5	409.7	+28.63	95.81	111.03	+15.8	641.82	784.84	+22.2	0.791	0.853	+7.83
China	348.5	369.6	+6.05	90.44	103.82	+14.7	609.93	788.28	+29.2	0.433	0.638	+47.34
Medium rate of change in the aging population (+72.72, +86.6)												
United States	330.8	322.8	−2.42	111.83	106.85	−4.45	801.27	784.22	−2.12	0.768	0.839	+9.24
United Arab Emirates	386.9	377.6	−2.40	104.11	103.13	−0.94	722.19	721.31	−0.12	0.621	0.863	+38.96
Low rate of change aging population (+58.75, +64.98)												
Germany	339.6	297.8	−12.31	97.22	93.09	−4.24	658.25	673.87	+2.37	0.819	0.883	+7.81
Saudi Arabia	397.7	394.2	−0.88	109.55	108.08	−1.34	763.93	770.26	+0.82	0.48	0.75	+56.25

[a]DALYs refer to years of healthy life lost due to premature death and disability, calculated as the sum of years of life lost (YLLs) and years lived with disability (YLDs) due to Alzheimer's disease and other dementias.

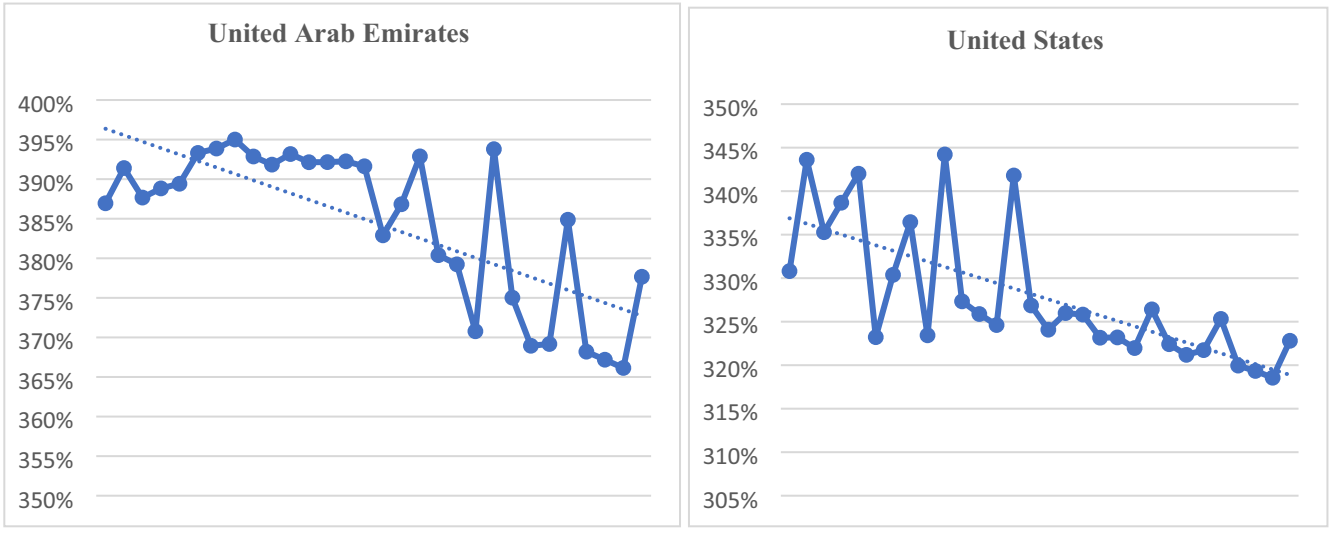
[b]Average annual percentage changes.

Abbreviations : DALYs, Disability-Adjusted Life-Years; SDI, Sociodemographic Index.

High rate of change in aging population (+101.37, +130.18)



Medium rate of change aging population (+72.72, +86.6)



Low rate of change aging population (+58.75, +64.98)

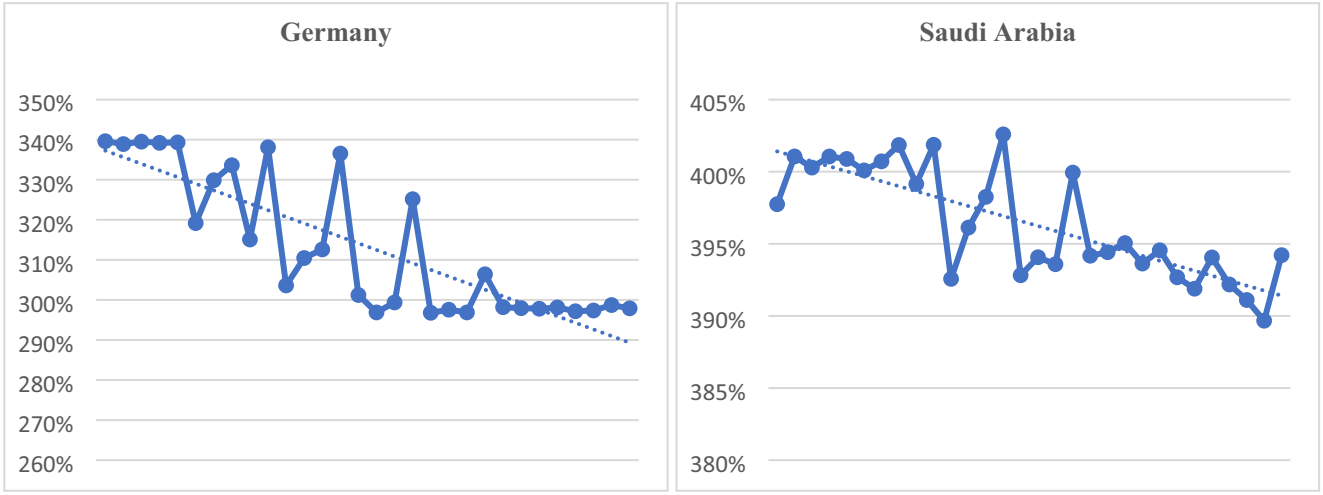
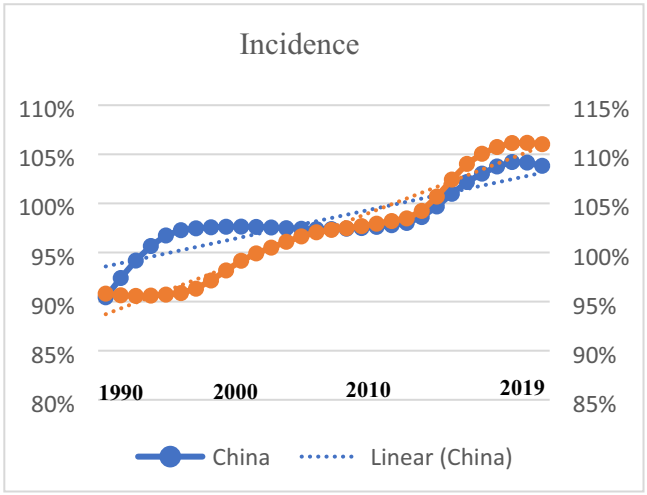
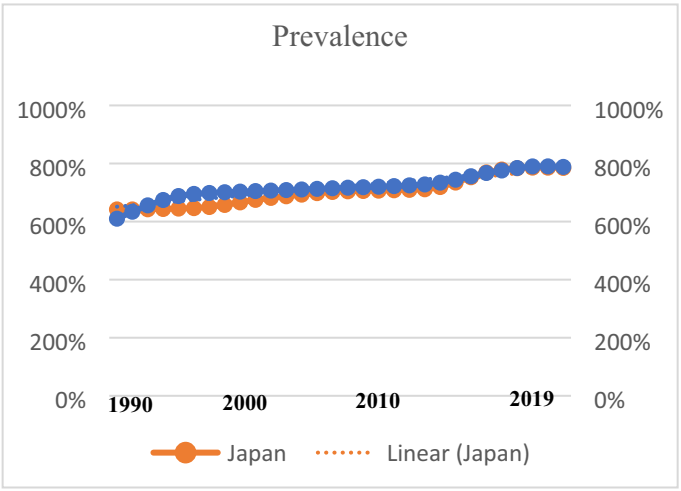


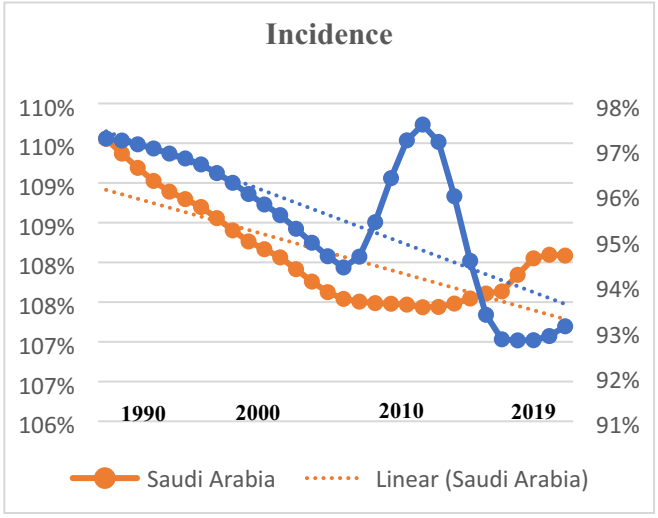
FIGURE 1 DALY Alzheimer's disease and other dementias.

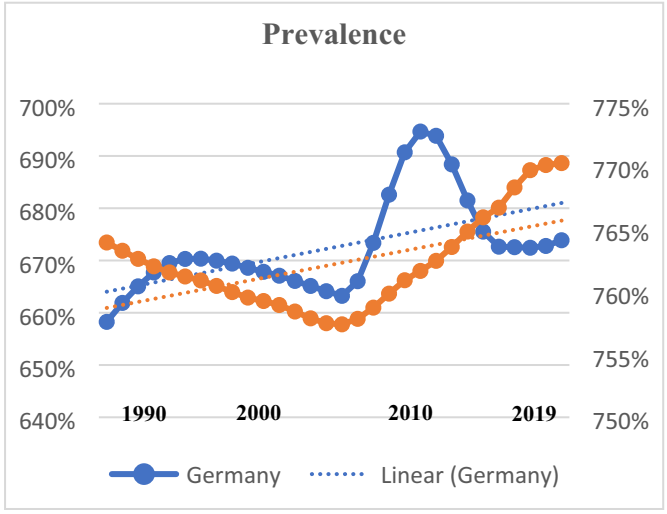
High rate of change in aging population (+101.37, +130.18)



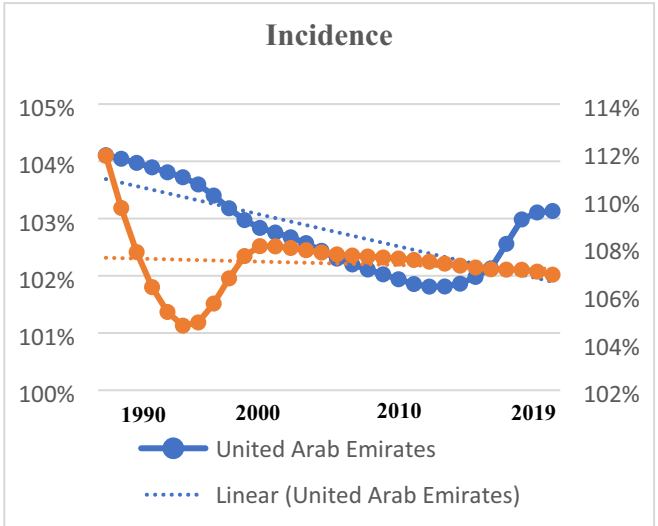


Medium rate of change aging population (+72.72, +86.6)





Low rate of change aging population (+58.75, +64.98)



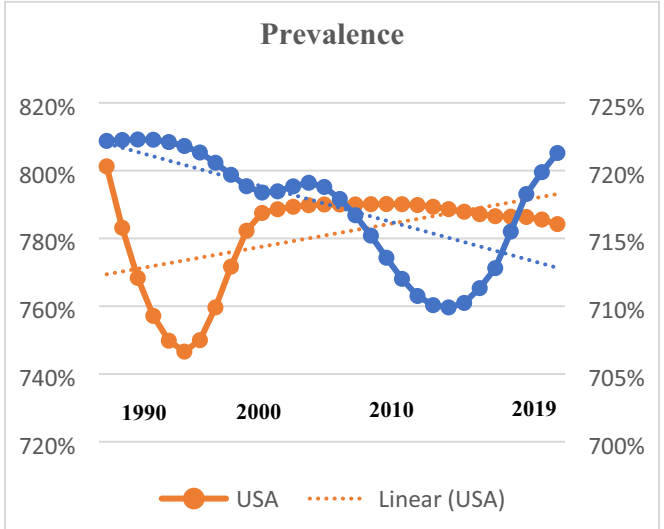


FIGURE 2 Temporal trends in incidence and prevalence of Alzheimer's disease among diverse aging populations from 1990 to 2019.

TABLE 2 Association between the age-standardized rates DALYs, incident, and prevalence of Alzheimer's disease and other dementias, and SDI from 1990 to 2019.

	DALY[a] Alzheimer's disease and other dementias			Incidence of Alzheimer's disease and other dementias			Prevalence of Alzheimer's disease and other dementias		
	Coefficient	95% CI	*P* value	Coefficient	95% CI	*P* value	Coefficient	95% CI	*P* value
High rate of change in the aging population (+101.37, +130.18)									
Japan	1.95	(0.61 to 3.31)	0.004	1.13	(0.33 to 1.92)	0.005	1.51	(0.45 to 2.55)	0.005
China	0.28	(0.24 to 0.32)	<0.001	0.33	(0.23 to 0.42)	<0.001	0.65	(0.49 to 0.8)	<0.001
Medium rate of change in the aging population (+72.72, +86.6)									
United States	−0.67	(−0.83 to −0.5)	<0.001	−0.04	(−0.23 to 0.13)	0.61	0.28	(0.06 to 0.51)	0.01
United Arab Emirates	−0.21	(−0.29 to −0.12)	<0.001	−0.06	(−0.08 to −0.04)	<0.001	−0.04	(−0.06 to −0.03)	<0.001
Low rate of change in the aging population (+58.75, +64.98)									
Germany	−2.28	(−2.61 to −1.96)	<0.001	−0.47	(−0.66 to −0.27)	<0.001	0.33	(0.18 to 0.49)	<0.001
Saudi Arabia	−0.08	(−0.09 to −0.06)	<0.001	−0.04	(−0.05 to −0.02)	<0.001	0.02	(0.006 to 0.03)	0.005

[a]DALYs refer to years of healthy life lost due to premature death and disability, calculated as the sum of years of life lost and years lived with disability due to Alzheimer's disease and other dementias.

Abbreviations : CI, confidence interval; DALYs, Disability-Adjusted Life-Years; SDI, Sociodemographic Index.

countries with different rates of aging in the last 3 decades. The study found that countries with a high rate of change in aging population (Japan and China) had a consistent increase of DALYs, prevalence, and incidence rate over the study period. This finding reflects the substantial impact of demographic changes in these countries. The study also examined the associations among DALYs, incidence, and prevalence of Alzheimer's disease and other dementias, and SDI across different countries with varying rates of change in aging population from 1990 to 2019. The study found that countries with a high rate of change in ther aging population, have a significantly higher burden of Alzheimer's disease compared to countries with a medium and low rate of change in aging population. Despite populations having sound health care and social systems, such as Japan,[18] experience a more pronounced and acute burden, prevalence, and incidence of Alzheimer's disease, probably due to their high rate of change in the aging population.[19,20]

The data suggest that countries with a high rate of change in the aging population, such as Japan and China, have a higher the incidence and prevalence of Alzheimer's disease and other dementias, whereas countries with a medium and low rate of change in aging population show a fluctuation of decreasing and increasing trend in the incidence and prevalence over time. This indicates the substantial impact of the aging factor on the incidence and prevalence of Alzheimer's disease, as suggested by several previously conducted studies.[8–10,19,20] This also could be due to several factors, such as improved access to health care, better education and awareness of the disease, and more effective treatments or preventive measures.[21,22] The data also suggest that a higher SDI is associated with a sharper decrease in the incidence and prevalence of Alzheimer's disease and other dementias among countries with medium to low rates of aging. This indicates that better health care and social systems, as reflected by a higher SDI, can contribute to reducing the burden of Alzheimer's disease and other dementias in medium to low rates of aging populations. The negative associations between DALYs and incidence of Alzheimer's disease and other dementias in countries with a medium and low rate of change in aging population (such as the United States, United Arab Emirates, Germany, and Saudi Arabia) suggest that these countries may have made some progress in reducing the burden of these conditions.

However, given the projected increase in the aging population in these countries, it is important to continue investing in strategies that promote healthy aging and prevent or delay the onset of Alzheimer's disease and other dementias. This study provides important insights into the impact of demographic changes on the health of aging populations and highlights the need for effective strategies to address the growing burden of Alzheimer's disease and other dementias in different countries. Policies and interventions aimed at addressing Alzheimer's disease should take into account the aging population and the level of SDI in a given country. Improving health care and social systems, especially in countries with higher aging rates, may help alleviate the burden of the disease. Moreover, there is a need for global collaboration and investment in Alzheimer's disease research to develop effective prevention and treatment strategies

that can be applied across different populations and contexts. The implications of the study's findings underscore the importance of a comprehensive public health approach to address the increasing burden of Alzheimer's disease in countries experiencing rapid population aging. Policymakers, health care providers, researchers, and communities must work collaboratively to implement strategies that promote early detection, improve access to quality care, create supportive environments, and advance knowledge in the field. By prioritizing public health measures, societies can better respond to the challenges posed by Alzheimer's disease and improve the well-being of individuals affected by this devastating condition.

There are several limitations for the study that should be considered. First, the study relies on estimates of DALYs, incidence, and prevalence of Alzheimer's disease and other dementias, which may be subject to measurement error. The accuracy of these estimates may be influenced by differences in diagnostic criteria, health care access, and reporting practices across different countries. Second, the study focuses on a limited number of countries, which may not be representative of the global population. The findings may not be generalizable to other countries with different sociodemographic characteristics and health systems. Third, the study does not examine potential confounding factors, such as genetics, lifestyle factors, and comorbid conditions that may influence the relationship between aging population and Alzheimer's disease and other dementias. Finally, the study does not consider potential differences in the quality of care and treatment for Alzheimer's disease and other dementias across different countries, which may influence the observed associations between the aging population and these conditions.

5 | CONCLUSION

This study highlights the significant impact of demographic changes on the burden, prevalence, and incidence of Alzheimer's disease and other dementias across different countries. The study also found that robust health care and social systems, as reflected by a higher SDI, can contribute to reducing the burden of Alzheimer's disease and other dementias in medium to low rates of aging populations. The findings underscore the importance of investing in health care and social systems to address the growing burden of these conditions, especially in countries with a high rate of change in the aging population. Although the study has several limitations, its findings provide important insights into the complex relationship among demographic changes, health systems, and Alzheimer's disease and other dementias. Policymakers and public health officials should consider these findings when developing strategies to address the growing burden of these conditions in different countries.

AUTHOR CONTRIBUTIONS

M.R. provided the conceptualization, methodology, software; data curation, writing–original draft preparation; visualization, investigation; supervision; software, validation; and writing–reviewing and editing.

FUNDING INFORMATION

No funding was received for this study.

CONFLICT OF INTEREST STATEMENT

The author declares that he has no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Global Burden of Disease Study 2019. No restrictions apply to the availability of these data, which were used under Public Use Files (PUF) data. Data are available at https://vizhub.healthdata.org.

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