Iran J Public Health, Vol. 54, No.5, May 2025, pp.1064-1073

Original Article

Population Forecasting with Alzheimer's Disease in Iran Using a System Dynamic Model

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(Received 10 Aug 2024; accepted 24 Oct 2024)

Abstract

Background: The prevalence of Alzheimer's disease in Iran, attributed to the demographic shift towards an aging population, holds considerable importance. We aimed to estimate the prevalence and number of Alzheimer's disease in Iran by 2029.

Methods: Dynamic modeling techniques were employed to project the number of Alzheimer's disease (AD) among the elderly population in Iran by the year 2029. Two interconnected models were developed to facilitate this estimation. The initial model is a demographic model that captures the aging population's growth dynamics. The subsequent model, an AD evaluation model, that assess potential impacts on disease. This approach enables a comprehensive analysis of the factors influencing AD trends within the context of Iran's aging demographic.

Results: The results show the number of individuals aged over 60 is expected to rise from approximately 9.1 million in 2020 to around 13.7 million in 2029. As the older adult population grows, the number of AD is also anticipated to increase. The number of Alzheimer's patients is predicted to grow from about 464,400 in 2020 to roughly 729,900 by 2029.

Conclusion: Forecasting future trends in AD, especially in developing countries, is crucial for policymakers because of its growing impact on healthcare systems and economies globally. The findings of this study can aid in assessing the economic burdens associated with treating Alzheimer's patients, providing valuable insights for planning and resource allocation.

Keywords: Alzheimer's disease (AD); Aging population; Older adults

Introduction

Dementia is defined as a clinical syndrome characterized by the development of multiple cognitive deficits severe enough to impair daily functioning such as social and occupational activities. These cognitive deficits include memory impairment and at least one deficit in other cognitive

DOI: https://doi.org/10.18502/ijph.v54i5.18641

domains, such as aphasia, apraxia, agnosia, or executive function deficit (1).
Alzheimer's is one of leading causes of dementia, posing a significant public health challenge that impacts interpersonal and social relationships (2). Patients with Alzheimer's typically experience chronic and progressive memory impairment, along with language impairments, impaired spatial visual skills, and executive function deficits. Diagnosing Alzheimer's in its early stages is challenging, and a diagnosis is considered accurate only when the cognitive functions are completely impaired (3). Given the prevalence of Alzheimer's and its impact on healthcare systems, policymakers and planners should receive a precise assessment of the disease's prevalence. This is crucial because all countries, including developing countries like Iran, are experiencing a significant increase in elderly population, which is expected to influence the prevalence of AD (4).
In 2012, the WHO introduced dementia as a public health priority and recommended health systems, especially in developing countries, obtain relatively precise estimates of dementia prevalence within their respective countries (5). According to Alzheimer's Association report in 2017, 47 million people worldwide suffer from dementia. This includes an estimated 9.9 million new cases annually, equating to one new case every three seconds. Notably, 63% of those affected reside in low or middle-income countries, a figure expected to rise 71% by 2050 (6). Despite the fact that the risk of developing dementia doubles every five years for individuals over the age of 65, and the prevalence of this disease in those over 85 ranges from 25% to 45%, research indicates that the majority of dementia patients do not receive a formal and registered diagnosis
According to the Alzheimer's Association of Iran, there are currently no precise statistics on the prevalence of AD in Iran. However, with the aging of the Iranian population, the incidence of AD, which increases with age, is expected to rise. The proportion of the elderly population in Iran has been growing for some years and is expected to reach 25% of the total population in the next two to three decades. Given the association between Alzheimer's and aging, 8% to 10% of this elderly population will develop Alzheimer's (4). Unfortunately, the Alzheimer's Association of Iran reports that the current rate of AD in the country is based on data from individuals seeking assistance from the association. Given the aging trend and the anticipated increase in Alzheimer's prevalence, it is crucial to employ precise methods, such as dynamic systems, to accurately estimate the prevalence of AD in Iran. Dynamic system approach is a mathematical modeling method used for frame complex problems in dynamic data analysis, such as data that changes over time. Compared to non-dynamic methods, dynamic approaches can provide a clearer understanding of the structure governing complex nonlinear systems and the factors influencing a phenomenon or disease over time (7).
To achieve the objectives of this study, the dynamical system approach will be used because the key factors affecting Alzheimer's are interrelated leading to complexities in estimating its prevalence. The dynamic system approach can be used to control these factors over time, providing a more accurate estimate of the prevalence of the disease in the future. Additionally, this approach offers a clearer insight into the relationships between factors affecting the disease over time (8).

Methods

The present study was approved by the National Institute for Medical Research Development (NIMAD) Ethics Committee (Code: IR.NIMAD.REC.1399.109).

Model description

Dynamic models are one of the most effective tools for describing and predicting a phenomenon over time. Time plays a crucial role in dynamic modeling, implying that the model's structure is influenced by the state of the system at previous time points (9). Forrester was a pioneer in the development of dynamic models, introducing them in 1961 (10). In our study, we employed dynamic models to estimate the number of elderly patients with AD by 2029 in Iran. To achieve this, we developed two interconnected models: a demographic model, and an AD evaluation model.

Evaluation of population structure and prediction

The most recent census in Iran was conducted in 2016, with census information being reported in 5-year cohorts. In this study, we utilized dynamic models and the latest census information to predict the population, serving as input to the model, with projections extending up to the year 2029. Dynamics model, characterized by their stock and flow structures, are akin to demographic models in that they represent age groups as stocks and the variable rates of change between these age groups as flows.

For this reason, these models align well with demographic models. In this study, age groups were considered from 0-4 years to +75 years. Each age group in the model was characterized by specific input and output rates. The input rate for the age group of 0-4 years was the birth rate. For the +75-age group, the input rate included entry from the preceding age group, with death serving as the output rate. Growth and death rates are called auxiliary variables. Since the model was implemented on an annual basis and considered 5-year age categories, input or output of each age category to another was subject to a delay rate of 0.2. The stock and flow diagram of the population model can be found in Fig. 1. Key parameters that influence population models include the birth rate, as a measure of population input, and the death rate within each age group. Death rates were sourced from the Statistical Centre of Iran, while birth rates were calculated by multiplying the crude birth rate by the total population in 2018 (11). The World Bank website provided information on Iran's crude birth rate (12).

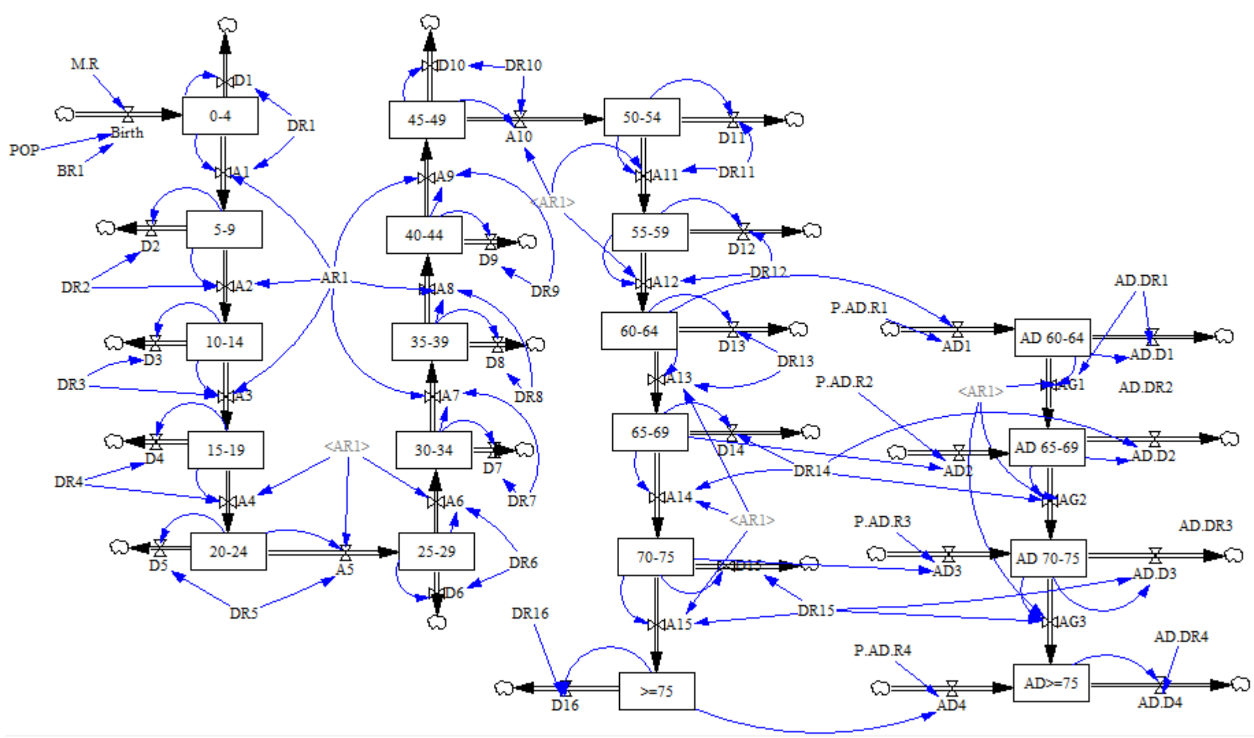

Fig. 1: Stock and flow chart of population and Alzheimer's patients

Evaluation of AD's model

It was assumed that AD begins at the age of 60. A dynamic model was used to predict the number of Alzheimer's patients across the age groups of 60-65, 65-69, 70-74 and +75. The modeling commenced with the year 2018 as its starting point. The number of Alzheimer's patients in each age group is influenced by the annual incidence and death rate within that category. In this model, stock variables were considered as Alzheimer's patients. Incidence of Alzheimer's for the year 2016 extracted from the IHME website (13). Incidence of disease (i) in an age group (x) was calculated as the number of new cases of the disease within a year, divided by the total number of at-risk populations at the beginning of the year. Accordingly, the variable (i) was incorporated into the model as an auxiliary variable.

Uncertainty intervals

The number of deaths and the incidence of the disease are subject to uncertainty. The values reported by the GBD for mortality and disease incidence were provided as confidence intervals, meaning that for each value, and for each age and gender group, we had a point estimate accompanied by a confidence interval. To construct uncertainty intervals, we treated the mean as the point estimate and used the 95% confidence intervals provided by the GBD as the uncertainty bounds. Through the Monte Carlo method, we generated 10,000 random samples and calculated the 2.5th and 97.5th percentiles as the 95% uncertainty intervals. Subsequently, the estimated values for Alzheimer's disease were summed across all age groups for each gender, and the results were reported accordingly.

Results

Check the validity of the model

The model utilized data from 2016, with results projected up to 2018, as presented in Table 1. We compared the forecasted numbers generated by the model with actual data from the GBD, calculating the relative absolute difference for the years 2017 and 2018. As shown in Table 1, for the 60–64 age group, the relative absolute difference in 2017 was 5.33% for males and 4.33% for females. In the 75 and older age group, the differences were 1.61% for males and 0.45% for females. In 2018, the relative absolute difference for the 60–64 age group was 8.58% for males and 7.29% for females, while for the 75 and older age group, it was 0.85% for males and 0.82% for females. Across all age groups and both genders, the relative absolute difference consistently remained below 9%.

Table 1: Forecast number of Alzheimer diseases and GBD data according to gender and age groups, 2017 and 2018

Age Groups	2017				Relative absolute value of difference (%)*		2018				Relative absolute value of difference (%)*	
	Forecast from Model		GBD				Forecast from Model		GBD			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
60-64	12,260 (11,259;13,261)	14,011 (12,880;15,128)	12,951 (9,820;16,688)	14,645 (11,194;18,734)	5.33	4.33	12,501 (10,655;14,348)	14,321 (12,232;16,384)	13,675 (10,387;17,644)	15,448 (11,815;19,770)	8.58	7.29
65-69	16,720 (15,902;17,534)	20,827 (19,705;21,944)	16,520 (12,603;21,236)	20,491 (15,794;26,051)	1.21	1.64	17,959 (16,437;19,474)	22,261 (20,190;24,320)	17,726 (13,568;22,738)	21,716 (16,704;27,661)	1.31	2.51
70-74	22,663 (21,471;23,773)	27,365 (26,496;28,283)	22,151 (17,154;28,414)	27,211 (21,442;34,829)	2.31	0.56	24,100 (21,922;26,130)	30,036 (27,937;32,263)	23,140 (17,955;29,669)	28,775 (22,644;36,874)	4.15	4.38
>=75	145,475 (143,928;147,593)	146,203 (143,603;149,689)	147,857 (119,782;179,084)	146,870 (119,771;177,287)	1.61	0.45	153,324 (148,064;158,722)	152,993 (147,226;159,197)	152,038 (12,3192;184,194)	151,751 (123,835;183,457)	0.85	0.82

* ((Absolute value (Forecast-GBD))/GBD) *100

The results of the study indicated that the projected number of elderly individuals (aged 60 and older) by gender is expected to increase annually from 2020 to 2029 (Table 2). Specifically, the population of elderly individuals aged 60–64 for each gender is forecasted to grow from 1.5 million in 2020 to 2.1 million by 2029. Similarly, the population of individuals aged 75 and older is projected to rise from 1.1 million for each gender in 2020 to nearly 1.8 million by 2029.

Table 2: Forecast number of elderly people according to gender and age groups (Per million)

Year	M/F	60-64	65-69	70-74	>=75	Total
2020	Male	1.506	1.088	0.7336	1.156	4.4836
	Female	1.544	1.162	0.8045	1.137	4.6475
2021	Male	1.561	1.145	0.778	1.179	4.663
	Female	1.601	1.219	0.853	1.183	4.856
2022	Male	1.617	1.199	0.8241	1.214	4.8541
	Female	1.657	1.274	0.902	1.239	5.072
2023	Male	1.681	1.262	0.8771	1.278	5.0981
	Female	1.72	1.335	0.9574	1.316	5.3284
2024	Male	1.747	1.324	0.9306	1.348	5.3496
	Female	1.785	1.396	1.013	1.397	5.591
2025	Male	1.814	1.386	0.9846	1.422	5.6066
	Female	1.852	1.458	1.068	1.483	5.861
2026	Male	1.884	1.448	1.039	1.501	5.872
	Female	1.921	1.519	1.124	1.573	6.137
2027	Male	1.956	1.51	1.093	1.584	6.143
	Female	1.992	1.581	1.179	1.667	6.419
2028	Male	2.029	1.574	1.148	1.671	6.422
	Female	2.066	1.645	1.235	1.763	6.709
2029	Male	2.104	1.638	1.202	1.762	6.706
	Female	2.142	1.71	1.291	1.863	7.006

Based on the model, The forecasted number of AD cases in elderly people (age >60) for both genders showed an increase from 2020 to 2029 (Table 3). The results for all age groups within each gender were aggregated and presented in Fig. 2, along with 95% uncertainty intervals.

In 2020, there were 14,466 cases of AD among elderly males aged 60-64 (95% CI: 13,239; 15,672), and for elderly females in the same age group, there were 16,495 cases (95% CI: 15,169; 17,855). Moreover, in the age group of those older than 75 years, the number of cases was 163,659 for elderly males (95% CI: 159,537 to 167,785) and 165,237 for elderly females (95% CI: 161,309 to 169,263) in 2020. This trend of increase continues through the years and across specific age groups. For example, by 2029, the projected number of AD cases for elderly males aged 60-64 is 18,724 (95% CI: 11,976 to 25,353), and for elderly females in the same age group, it is 21,570 (95% CI: 14,234 to 29,102). Furthermore, for elderly males aged over 75 years, the projected number of cases in 2029 is 250,173 (95% CI: 218,171 to 282,451), and for elderly females in that age group, it is 266,803 (95% CI: 233,377 to 300,532).

Table 3: Forecast number of Alzheimer diseases according to gender and age groups

Year	M/F	60-64	65-69	70-74	>=75	Total
2020	Male	14,466 (13,239;15,672)	20,549 (19515;21,599)	26,136 (24803;27,455)	163,659 (159,537;167,785)	224,810 (217,094;232,511)
	Female	16,495 (15,169;17,855)	24,853 (23,558;26,115)	33,011 (31,320;34,712)	165,237 (161,309;169,263)	239,596 (231,356;247,945)
2021	Male	14,676 (12,432;16,881)	21,791 (19,870;23,739)	27,906 (25,434;30,338)	166,409 (158,633;174,168)	230,782 (216,369;245,126)
	Female	16,819 (14,389;19,313)	26,421 (24,018;28,798)	35,337 (32,240;38,477)	170,063 (162,545;177,767)	248,640 (233,192;264,355)
2022	Male	14,956 (11,865;17,992)	22,942 (20,221;25,696)	29,768 (26,310;33,179)	170,797 (159,775;181,748)	238,463 (218,171;258,615)
	Female	17,199 (13,846;20,642)	27,875 (24,483;31,241)	37,754 (33,425;42,132)	176,646 (165,822;187,723)	259,474 (237,576;281,738)
2023	Male	15,357 (11542;19106)	24,206 (20,684;27,722)	31,879 (27463;36235)	180,313 (166,020;194,537)	251,755 (225,709;277,600)
	Female	17,690 (13,546;21,945)	29,407 (25,130;33,657)	40,452 (35,000;45,979)	187,210 (173,006;201,675)	274,759 (246,682;303,256)
2024	Male	15,815 (11,372;20,181)	25,448 (21,230;29,674)	34,040 (28,767;39,255)	190,379 (172,979;207,662)	265,682 (234,348;296,772)
	Female	18,235 (13,406;23,193)	30,906 (25,764;35,973)	43,198 (36,655;49,868)	198,549 (181,146;216,213)	290,888 (256,971;325,247)
2025	Male	16,321 (11,325;21,229)	26,681 (21,795;31,566)	36,239 (30,164;42,290)	20,1041 (180,672;221,459)	280,282 (243,956;316,544)
	Female	18,825 (13,394;24,402)	32,389 (26422;38264)	45,975 (38,396;53,635)	210,670 (190,132;231,618)	307,859 (268,344;347,919)
2026	Male	16869 (11,379;22,263)	27916 (22,381;33,491)	38468 (31,595;45,292)	212,335 (189,151;235,844)	295,588 (254,506;336,890)
	Female	19,456 (13,487;25,585)	33,869 (27,120;40,564)	48,773 (40,190;57,386)	22,3571 (199,924;247,681)	325,669 (280,721;371,216)
2027	Male	17,455 (11,515;23,290)	29,161 (22,966;35,365)	40,721 (33116;48334)	224,281 (198137;250705)	311,618 (265,734;357,694)
	Female	20,125 (13,667;267,57)	35,355 (27,849;42,738)	51,587 (42,008;61,219)	237,238 (21,0216;26,4516)	344,305 (293740;395230)
2028	Male	18,074 (11,717;24,318)	30,423 (23,584;37,226)	42,997 (34,616;51,404)	236,893 (207,745;266,223)	328,387 (277,662;379,171)
	Female	20,830 (13,920;27,926)	36857 (28642;44932)	54,416 (43,858;65,015)	251,656 (221,469;282,200)	363,759 (307,889;420,073)
2029	Male	18,724 (11976;25353)	31,707 (24,292;39,058)	45,294 (36,143;54,485)	250,173 (218,171;282,451)	345,898 (290,582;401,347)
	Female	21,570 (14,234;29,102)	38,381 (29,470;47,138)	57,261 (45,820;68,803)	266,803 (233,377;300,532)	384,015 (322,901;445,575)

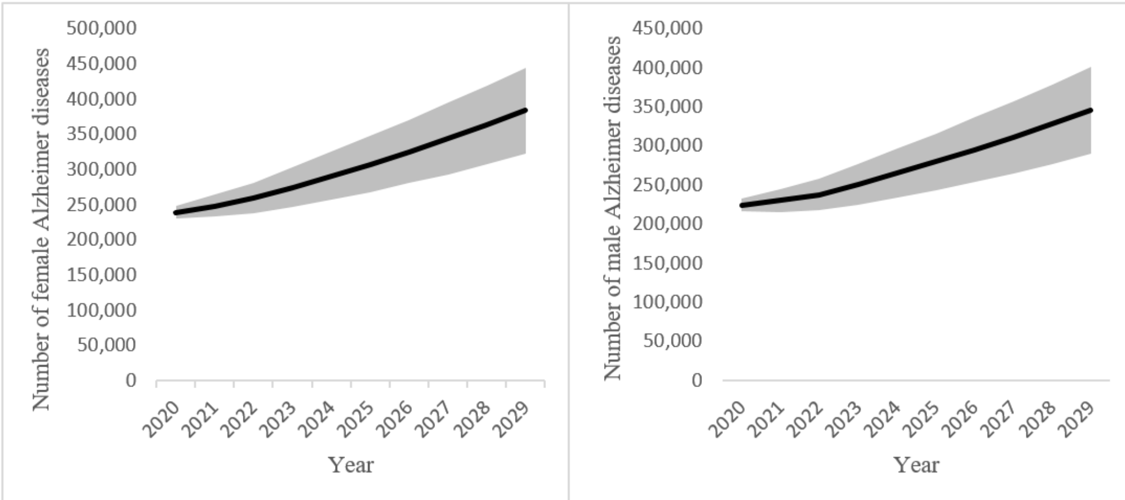

Fig. 2: Number of male and female Alzheimer diseases from 2020-2029

The forecasted prevalence of AD across both genders and various age groups per 1000 individuals showed that there is no consistent trend of increase or decrease in the forecasted prevalence of AD from 2020 to 2029. However, there are significant increases in forecasted prevalence with transitions to older age groups (Table 4). Specifically, the forecasted prevalence in age groups (60-64), (65-69), (70-74), and +75, respectively, ranges from (8.9 to 10.68), (18.89 to 22.45), (35.63 to 44.35), and (140.69 to 143.21) per 1000 persons from 2020 to 2029.

Table 4: Forecast prevalence of Alzheimer diseases according to gender and age groups (Per 1000 persons)

Year	M/F	60-64	65-69	70-74	>=75	Total
2020	Male	9.61(8.79;10.41)	18.89(17.94;19.85)	35.63(33.81;37.43)	141.57(138.01;145.14)	50.14(48.42;51.86)
	Female	10.68(9.82;11.56)	21.39(20.27;22.47)	41.03(38.93;43.15)	145.33(141.87;148.87)	51.55(49.78;53.35)
2021	Male	9.40(7.96;10.81)	19.03(17.35;20.73)	35.87(32.69;38.99)	141.14(134.55;147.73)	49.49(46.4;52.57)
	Female	10.51(8.99;12.06)	21.67(19.7;23.62)	41.43(37.8;45.11)	143.76(137.4;150.27)	51.20(48.02;54.44)
2022	Male	9.25(7.34;11.13)	19.13(16.86;21.43)	36.12(31.93;40.26)	140.69(131.61;149.71)	49.13(44.95;53.28)
	Female	10.38(8.36;12.46)	21.88(19.22;24.52)	41.86(37.06;46.71)	142.57(133.84;151.51)	51.16(46.84;55.55)
2023	Male	9.14(6.87;11.37)	19.18(16.39;21.97)	36.35(31.31;41.31)	141.09(129.91;152.22)	49.38(44.27;54.45)
	Female	10.28(7.88;12.76)	22.03(18.82;25.21)	42.25(36.56;48.02)	142.26(131.46;153.25)	51.57(46.30;56.91)
2024	Male	9.05(6.51;11.55)	19.22(16.03;22.41)	36.58(30.91;42.18)	141.23(128.32;154.05)	49.66(43.81;55.48)
	Female	10.22(7.51;12.99)	22.14(18.46;25.77)	42.64(36.18;49.23)	142.13(129.67;154.77)	52.03(45.96;58.17)
2025	Male	9.00(6.24;11.7)	19.25(15.73;22.77)	36.81(30.64;42.95)	141.38(127.05;155.74)	49.99(43.51;56.46)
	Female	10.16(7.23;13.18)	22.21(18.12;26.24)	43.05(35.95;50.22)	142.06(128.21;156.18)	52.53(45.78;59.36)
2026	Male	8.95(6.04;11.82)	19.28(15.46;23.13)	37.02(30.41;43.59)	141.46(126.02;157.12)	50.34(43.34;57.37)
	Female	10.13(7.02;13.32)	22.30(17.85;26.70)	43.39(35.76;51.06)	142.13(127.1;157.46)	53.07(45.74;60.49)
2027	Male	8.92(5.89;11.91)	19.31(15.21;23.42)	37.26(30.30;44.22)	141.59(125.09;158.27)	50.73(43.26;58.23)
	Female	10.10(6.86;13.43)	22.36(17.61;27.03)	43.75(35.63;51.92)	142.31(126.1;158.68)	53.64(45.76;61.57)
2028	Male	8.91(5.77;11.99)	19.33(14.98;23.65)	37.45(30.15;44.78)	141.77(124.32;159.32)	51.13(43.24;59.04)
	Female	10.08(6.74;13.52)	22.41(17.41;27.31)	44.06(35.51;52.64)	142.74(125.62;160.07)	54.22(45.89;62.61)
2029	Male	8.90(5.69;12.05)	19.36(14.83;23.84)	37.68(30.07;45.33)	141.98(123.82;160.3)	51.58(43.33;59.85)
	Female	10.07(6.65;13.59)	22.45(17.23;27.57)	44.35(35.49;53.29)	143.21(125.27;161.32)	54.81(46.09;63.6)

Discussion

This study utilized dynamic models to estimate the number of old patients with AD in Iran until 2029. Moreover, using population dynamics, it estimated and predicted the number of older adults as well as the prevalence of AD.

The findings of this study indicated an increase in the older adult population in Iran from 2020 to 2029. Thus, the number of older adults (over 60 years old) is expected to rise from about 9.1 million people in 2020 to about 13.7 million people in 2029. With an increase in the number of older populations, the prevalence of diseases commonly associated with aging, especially AD, is also expected to increase. The data in the current study showed that the population of Alzheimer's patients will grow from approximately 464.4 thousand individuals in 2020 to about 729.9 thousand individuals in 2029.

Various demographic studies conducted in Iran have indicated that Iran's population is aging, in line with global trends, and has progressed beyond the initial stages of demographic transition. Data from the general population and housing censuses show that the number of older adults in Iran has increased in recent decades. United Nations forecasts for Iran (in 2015) show that the percentage of the population over 60 years old was about 8.2% in 2015, and it is projected to reach 14.4% by 2030 and 31.2% by 2050 (14).

Population aging is associated with various economic, social, political, and especially health consequences and challenges (15). In the past decades, Iran has been involved in contagious and infectious diseases, focusing its health sector efforts on preventing, treating, and rehabilitating complications caused by such diseases. However, in the coming decades, the country is encountering an epidemiological transition towards non-communicable and chronic diseases (16). Moreover, a significant issue that need special attention is the increase in cognitive disorders, including AD, driven by the aging population. The prevalence of AD and the number of people affected by it are predicted using different methods and data types. However, the future prevalence of AD in subgroups of older adults (usually age- and gender-specific) is usually assumed to remain constant. What changes is the size of the population at risk (due to population aging) and thus the number of people with AD attributable to population aging. According to the dynamically analyzed Eurostat data, the population of the European Union was 508 million in 2013, with 7.5 million Alzheimer's patients. The population of the European Union is forecasted to reach 524 million people by 2040 and the number of patients with AD will reach 13.1 million people. By 2080, the population of the European Union will reach 520 million people and the number of patients with AD will reach 13.7 million people. The number of Alzheimer's patients is expected to increase by approximately 75% from 2013 to 2040, a span of 27 years (17). In contrast, in Iran, a significant growth of about 57% is anticipated over just about 10 years (from 2020 to 2029), highlighting a more rapid increase in the older adult population. Similarly, the prevalence of AD remained stable from 2017 to 2028 (18).

According to GBD Dementia Forecasting Collaborators, the global number of people with dementia in 2019 was 57.4 million. This number is projected to reach 83.2 million people by 2030 (approximately 0.97% of the total population), 116 million people by 2040, and 152.8 million people by 2050. The study also noted that women are more affected by dementia, with the number of affected individuals expected to more than triple by 2050 (19).

The findings of another study indicated that the number of people with dementia in Canada is expected to double from 2011 to 2031 (20).

While the findings from the present study showed that the population of Alzheimer's patients in Iran will reach 1.57 times from 2020 to 2029. The data in this study also indicated that in 2029, the ratio of Alzheimer's patients to the total population will reach approximately 0.83%. Given that Alzheimer's is the most common type of dementia, an increase in Alzheimer's cases can be predicted.

This study had three significant limitations. The first and most important was the lack of precise data on the prevalence of Alzheimer's disease (AD) in Iran. Despite the high prevalence of AD in the country, few studies have been conducted, and most rely on estimated data. The incidence rate of AD is typically derived from evidence-based referrals to specialists or from cross-sectional studies involving limited population samples. Consequently, the researchers of this study were compelled to use GBD data to estimate both the prevalence and the number of affected individuals.

The second limitation involved assumptions about factors influencing the population structure. Specifically, it was assumed that factors such as increased life expectancy, which contributes to an aging population, would not significantly change in Iran between 2020 and 2029. Thus, the population growth trend was considered to follow the pattern observed in previous years.

The third limitation pertained to assumptions regarding disease-related factors. It was assumed that no fully effective treatment capable of completely curing the disease would emerge by 2029, and that no new factors, other than those already identified, would lead to a significant increase in the prevalence of AD. These assumptions shaped the projections made in this study.

Conclusion

Understanding future trends of AD, particularly in developing countries, is of critical importance to policymakers and planners who seek to estimate the future demand for healthcare services and the economic burden associated with this condition. These projections offer valuable insights into key trends, enabling the development and implementation of effective policies and programs to address the growing challenges posed by AD.

One of the most significant challenges associated with an aging population at the macro level is the rising healthcare costs for older adults. Ensuring that older adults have access to essential health services and support is crucial. Furthermore, planning efforts must prioritize the development of end-of-life care, including palliative services and hospice care, areas that are currently under-developed in Iran. Increasing awareness about these services is also critical for improving the quality of care provided to patients with AD.

The findings from this study can contribute to a better understanding of the economic burden associated with treating AD patients. Moreover, similar simulations can be applied with varied input data across different regions to forecast the prevalence of various non-communicable diseases, further informing public health planning and resource allocation.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

This study was supported by National Institute for Medical Research Development (NIMAD), Grant No. 989818.

Conflict of Interest

The authors declare that there is no conflict of interests.

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