The global macroeconomic burden of Alzheimer's disease and other dementias: estimates and projections for 152 countries or territories

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Summary

Background Alzheimer's disease and other dementias (ADODs) severely threaten the wellbeing of older people, their families, and communities, especially with projected exponential growth. Understanding the macroeconomic implications of ADODs for policy making is essential but under-researched.

Methods We used a health-augmented macroeconomic model to calculate the macroeconomic burden of ADODs for 152 countries or territories, accounting for: the effect on labour supply of reduced working hours of informal caregivers; the effect on labour supply of ADODs-related mortality and morbidity; age–sex-specific differences in education, work experience, labour market participations, and informal caregivers; and treatment and formal care costs diverting from savings and investments.

Findings ADODs will cost the world economy 14 513 billion international dollars (INT$, measured in the base year 2020; 95% uncertainty interval [UI] 12 106–17 778) from 2020 to 2050, equivalent to 0·421% (95% UI 0·351–0·515) of annual global GDP. Japan incurs the largest annual GDP loss at 1·463% (1·225–1·790). China (INT$2961 billion [2507–3564]), the USA (INT$2331 billion [1989–2829]), and Japan (INT$1758 billion [1471–2150]) face the largest absolute economic burdens. The economic burden of informal care ranges from 60·97% in high-income countries to 85·45% in lower-middle-income countries, and treatment and formal care costs range from 10·50% in lower-middle-income countries to 30·80% in high-income countries.

Interpretation The macroeconomic burden of ADODs is substantial and unequally distributed across countries and regions. Global efforts to reduce the burden, especially with regard to informal care, are urgently needed.

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Introduction

The world's population is rapidly ageing and has a longer life expectancy than ever before. Researchers have projected that the proportion of the global population aged 65 years and older will nearly double from 8·5% in 2015 to 16·7% in 2050.[1] The UN General Assembly declared 2021–30 as "The Decade of Healthy Ageing" in May, 2020, fostering worldwide and long-term collaborations among governments, civil society, international agencies, professionals, academia, the media, and the private sector to improve the lives of older people, their families, and the communities in which they live. Alzheimer's disease and other dementias (ADODs) pose a severe threat to this worldwide initiative. ADODs are a set of neurodegenerative conditions that primarily affect older adults, inhibiting cognitive capacity, mobility, independence, and activities of daily living, ultimately leading to death. In 2019, an estimated 57 million people globally lived with dementia—of which ADODs are the most common form—and the prevalence is projected to grow to 153 million people by 2050 (appendix pp 2–3).[2]

Previous studies[3] of the economic effect of ADODs have primarily focused on cost of illness, including direct medical and non-medical costs as well as indirect costs. Some research, like that of Jia and colleagues,[3] estimated the global cost without comparing countries, whereas others, such as the World Alzheimer Report 2015,[4] provided detailed country-specific estimates. Alternative approaches, such as the value of a statistical life (VSL) approach,[5] take a willingness-to-pay perspective. Macroeconomic models, such as the Economic Projections for Illness and Cost of Treatment (EPIC)[6] and the health-augmented macroeconomic model (HMM),[7] measure the broader economic effect. EPIC focuses on mortality and economic adjustments but overlooks morbidity, whereas HMM includes age-specific and sex-specific differences in education, work

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See Online for appendix

Research in context

Evidence before this study

We scoured titles and abstracts for the terms "ADODs" (or "Alzheimer's disease and other dementias", "Alzheimer's disease and related dementias", or "dementia") and "economic burden" (including the variants "economic cost" and "economic loss") included in MEDLINE, PubMed, and Google Scholar dated between June 1, 1960, and Sept 1, 2023, and in the references from relevant articles. Historically, most studies have either aggregated the direct and indirect costs of Alzheimer's disease and other dementias (ADODs), employing a cost-of-illness approach, or gauged the monetary value individuals place on averting the risks associated with these conditions through the value of a statistical life approach. Although the direct medical costs of ADODs remain minimal due to there being no known treatments to prevent or stop the progression of dementia, the care needs are great, leading to a substantial care burden. However, estimating this accurately is challenging due to the variability in conditions of affected individuals, family preferences, and particularly the appropriate valuation of formal care and informal care. Contrary to viewing formal care solely as an expenditure, it should be recognised as economic activity that generates employment for formal care providers rather than a pure economic loss. A comprehensive understanding of the macroeconomic burden of ADODs requires an analysis beyond mere costs that considers broader economic effects, including effects on human and physical capital.

Added value of this study

To address the shortcomings in the existing literature, we used a theory-based simulation model describing how workers, weighted by their human capital as determined by education and experience, combine with physical capital in producing final output to estimate the macroeconomic burden of ADODs for 152 countries or territories. Unlike previous work, this study distinguishes between formal and informal caregiving. Informal caregiving, although it does not directly contribute to gross domestic product (GDP), involves a portion of the potential workforce. We examine its hidden economic value by estimating the economic loss attributed to informal care. This loss is calculated on the basis of the economic gains that would result from the counterfactual presence of informal caregivers in the labour force, assuming a constant age–sex-specific labour participation rate. On the other hand, formal caregiving is recognised as productive employment due to its contribution to caregivers' income and, consequently, to GDP. The economic effect of formal caregiving is evaluated similarly to treatment costs, taking into account its effect on savings and investment. This approach allows us to explore its potential effect on GDP through the dynamics of capital accumulation. In doing so, we project that ADODs will cost the world economy 14 513 billion international dollars (INT$, with base year 2020; 95% uncertainty interval [UI] 12 106–17 778) from 2020 to 2050, which is equivalent to an annual loss of 0·421% (95% UI 0·351–0·515) of global GDP during this period. Japan incurs the largest annual loss from ADODs as a percentage of GDP, at 1·463% (1·225–1·790). China (INT$2961 billion [2507–3564]), the USA (INT$2331 billion [1989–2829]), and Japan (INT$1758 billion [1471–2150]) face the largest total economic burdens of ADODs from 2020 to 2050 in absolute terms. Our data further reveal that lower-middle-income nations have a heightened reliance on informal care, constituting 85·45% of the economic burden, versus 60·97% in high-income countries. Conversely, the proportion of expenditure directed towards treatment and formal care is diminished in lower-middle-income countries (10·50%) compared with high-income countries (30·80%).

Implications of all the available evidence

Our study provides crucial insights addressing existing knowledge gaps. Foremost, projections suggest that between 2020 and 2050, ADODs will impose a staggering cost of INT$14 513 billion (95% UI 12 106–17 778) on the global economy—equivalent to the total global health expenditure in 2020. Notably, although high-income nations will face the largest macroeconomic burden of ADODs in absolute figures, the profound health impact predominantly afflicts low-income and middle-income countries. When viewed as a proportion of GDP, the economic weight of ADODs looms largest for affluent countries. The disparate economic evolution of nations potentially elucidates this uneven allocation of health and economic consequences stemming from ADODs. The pronounced human impact of ADODs in low-income and middle-income territories highlights a need to bolster health infrastructures and enact resilient public health policies tailored to long-term ADODs care. Our findings sound an alarm: if left unchecked, a surge in the global economic ramifications of ADODs could be witnessed in the ensuing decades. This accentuates the urgency to channel investments into global initiatives aimed at mitigating both the disease and its consequent economic challenges.

experience, and morbidity, offering a more comprehensive analysis.

Within the HMM framework, two previously overlooked aspects are now included. First, formal care costs, previously unaccounted for, are integrated as part of treatment costs, and they are recognised for their contribution to employment and income rather than viewed as direct economic losses. Second, informal care is evaluated for its effect on reducing caregivers' labour time, which affects overall labour supply and GDP. In 2019, informal dementia caregivers provided more than 89 billion hours of care, averaging about 5 h daily per person with dementia,[8] indicating a huge burden on the families of individuals with ADODs.

We thus estimated the looming economic and social costs of ADODs from a novel perspective of macroeconomic-level physical and human capital accumulation, offering a new view to assist decision makers in how to invest optimally to alleviate the burden. Specifically, ADODs affect the economy along several pathways (figure 1). The pathway in which informal or unpaid care reduces the labour supply of informal caregivers, previously overlooked by the HMM method, is nevertheless an important component of the disease burden for ADODs, highlighting the need for comprehensive evaluations that incorporate the economic effect of lost labour and productivity among informal caregivers. Taking into account the age and sex distribution of these informal caregivers, we calculated the effect of informal care on human capital accumulation.

Methods

Data sources

We used data from 152 countries or territories, including saving rates from the World Bank, GDP projections from the Global Burden of Disease Health Financing Collaborator Network, and mortality and morbidity data from the GBD 2019 study.[2] As with all studies of similar scale and scope, where data were not directly available, this study had to rely on extrapolation and assumptions, such as projections of health-related data on mortality, morbidity, or prevalence in certain scenarios, and labour force participation rates and health expenditure related to ADODs. More details about data source of diseases, population, labour, education, and macroeconomic figures, as well as the parameter values and data sources used in the macroeconomic model, are presented in the appendix (pp 3–5). To make estimates comparable across countries, all costs were converted to 2020 international dollars (INT$).

Model design and parameters

We directly calculated the macroeconomic burden of ADODs for all the 152 countries or territories for which we had all data inputs using the HMM described in previous studies[7,9–15] and in the appendix (pp 5–9). ADODs affect the economy in our model via reduced human capital or physical capital by four separate pathways. The main difference between our work and previous studies is the new pathway of informal care (figure 1). Informal care is provided by family members or friends—which constitutes a substantial proportion of ADODs care—and thus reduces the labour market output of informal caregivers. The quantity of informal care labour associated with ADODs is based on WHO estimates of worldwide dementia informal caregiver hours provided by family members and friends[16] and adjusted by the production loss due to informal care with the age–sex distribution of those caregivers.[17,18] This addresses the limitations observed in many current studies that overlook age–sex disparities in informal caregivers versus the total

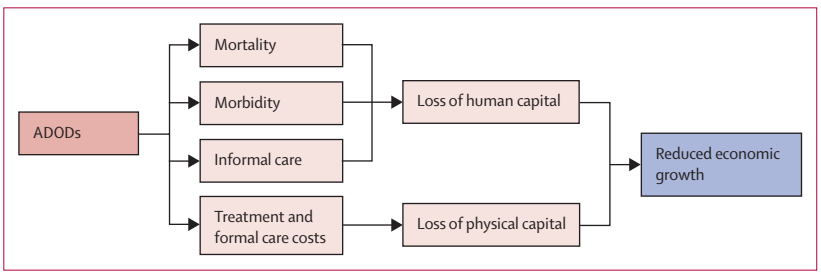

Figure 1: **Health-augmented macroeconomic model for estimating the economic burden of ADODs**
ADODs=Alzheimer's disease and other dementias.

	Economic cost, INT$ million	Proportion of total GDP in 2020–50	Per capita cost, INT$
East Asia and Pacific			
Australia	177 924 (148 674–219 985)	0·486 (0·406–0·601)	6069 (5071–7504)
Brunei	767 (626–957)	0·132 (0·108–0·165)	1611 (1315–2012)
Cambodia	2611 (2047–3396)	0·106 (0·083–0·137)	133 (105–174)
China	2 961 075 (2 506 748–3 564 112)	0·433 (0·366–0·521)	2046 (1732–2463)
Fiji	539 (427–695)	0·168 (0·133–0·216)	543 (430–700)
Indonesia	139 438 (106 105–184 288)	0·133 (0·102–0·176)	454 (346–600)
Japan	1 758 075 (1 471 250–2 150 038)	1·463 (1·225–1·790)	15 049 (12 594–18 405)
South Korea	366 152 (303 373–451 976)	0·686 (0·568–0·846)	7312 (6058–9026)
Malaysia	40 332 (31 395–52 285)	0·146 (0·114–0·189)	1086 (845–1407)
Mongolia	1958 (1520–2503)	0·157 (0·122–0·200)	503 (390–643)
Myanmar	14 877 (12 189–18 241)	0·151 (0·124–0·186)	250 (205–307)
New Zealand	27 612 (23 023–34 143)	0·512 (0·427–0·634)	5231 (4362–6469)
Philippines	37 894 (29 563–49 397)	0·125 (0·097–0·163)	294 (229–383)
Singapore	49 873 (40 746–63 039)	0·370 (0·302–0·468)	7929 (6478–10 022)
Solomon Islands	51 (39–70)	0·074 (0·056–0·102)	53 (40–72)
Thailand	132 509 (107 517–162 761)	0·403 (0·327–0·495)	1915 (1554–2353)
Timor-Leste	203 (167–258)	0·121 (0·100–0·155)	120 (99–153)
Vanuatu	34 (26–45)	0·094 (0·074–0·126)	79 (62–106)
Viet Nam	47 296 (35 964–63 462)	0·179 (0·136–0·240)	449 (342–603)
Europe and Central Asia			
Albania	4090 (3241–5304)	0·457 (0·362–0·592)	1518 (1203–1968)
Armenia	5951 (4777–7275)	0·590 (0·474–0·721)	2035 (1634–2488)
Austria	76 754 (66 057–88 222)	0·622 (0·536–0·715)	8379 (7211–9631)
Azerbaijan	7497 (5906–9543)	0·192 (0·151–0·245)	693 (546–882)
Belarus	18 502 (15 587–21 771)	0·414 (0·349–0·488)	2036 (1715–2396)
Belgium	94 072 (79 411–110 409)	0·640 (0·540–0·751)	7850 (6626–9213)
Bosnia and Herzegovina	6074 (4853–7630)	0·535 (0·428–0·673)	2016 (1611–2532)
Bulgaria	18 192 (13 743–24 672)	0·500 (0·378–0·678)	2957 (2234–4011)
Croatia	24 241 (21 022–28 007)	0·932 (0·808–1·076)	6468 (5609–7472)
Cyprus	4636 (3957–5379)	0·403 (0·344–0·467)	3581 (3057–4155)
Czech Republic	80 863 (70 565–95 076)	0·739 (0·645–0·869)	7578 (6613–8910)
Denmark	36 496 (30 950–43 796)	0·443 (0·376–0·531)	6025 (5109–7230)
Estonia	11 129 (9303–13 804)	0·978 (0·818–1·213)	8918 (7455–11 062)
Finland	38 210 (32 839–45 073)	0·584 (0·502–0·688)	6883 (5915–8119)
France	586 232 (494 875–711 649)	0·796 (0·672–0·966)	8758 (7393–10 632)
Georgia	3096 (2748–3595)	0·214 (0·190–0·248)	822 (729–954)
Germany	901 482 (716 489–1 178 615)	0·827 (0·657–1·081)	10 939 (8694–14 302)
Greece	56 978 (47 783–67 879)	0·868 (0·728–1·034)	5863 (4917–6985)

(Table 1 continues on next page)

	Economic cost, INT$ million	Proportion of total GDP in 2020–50	Per capita cost, INT$
(Continued from previous page)			
Hungary	57 633 (51 182–65 668)	0·785 (0·697–0·895)	6329 (5621–7211)
Iceland	1978 (1603–2479)	0·408 (0·331–0·512)	5437 (4405–6814)
Ireland	47 479 (41 403–55 776)	0·401 (0·350–0·471)	8867 (7732–10 417)
Italy	585 270 (495 075–705 934)	1·036 (0·876–1·250)	10 104 (8546–12 187)
Kazakhstan	29 692 (24 090–36 297)	0·209 (0·169–0·255)	1382 (1121–1689)
Kyrgyzstan	2643 (2082–3369)	0·244 (0·192–0·311)	336 (265–428)
Latvia	12 409 (10 377–15 097)	0·962 (0·804–1·170)	7475 (6251–9094)
Lithuania	19 413 (15 803–24 561)	0·892 (0·726–1·128)	8111 (6603–10 263)
Luxembourg	5653 (4665–6745)	0·340 (0·281–0·406)	7905 (6523–9433)
Moldova	5974 (5040–7232)	0·588 (0·496–0·711)	1595 (1346–1931)
Montenegro	1152 (892–1526)	0·354 (0·274–0·469)	1873 (1452–2483)
Netherlands	125 625 (104 410–153 481)	0·542 (0·451–0·662)	7233 (6012–8837)
Norway	40 728 (34 871–48 647)	0·445 (0·381–0·532)	6726 (5759–8034)
Poland	184 298 (158 916–216 130)	0·619 (0·534–0·726)	5124 (4419–6010)
Portugal	58 455 (50 139–68 359)	0·767 (0·658–0·897)	6021 (5164–7041)
Russia	320 169 (264 125–383 037)	0·357 (0·294–0·427)	2268 (1871–2714)
Serbia	13 872 (11 056–17 485)	0·375 (0·299–0·473)	1745 (1391–2199)
Slovakia	24 484 (20 552–30 027)	0·582 (0·488–0·714)	4632 (3888–5681)
Slovenia	16 110 (13 905–18 769)	0·879 (0·758–1·024)	7955 (6866–9268)
Spain	303 064 (261 996–358 569)	0·712 (0·616–0·843)	6647 (5747–7865)
Sweden	66 139 (57 410–77 718)	0·466 (0·404–0·547)	6125 (5317–7197)
Switzerland	89 334 (71 181–115 406)	0·598 (0·476–0·772)	9574 (7628–12 368)
Tajikistan	1634 (1248–2115)	0·148 (0·113–0·191)	128 (98–166)
Türkiye	163 219 (131 741–202 254)	0·273 (0·220–0·338)	1785 (1441–2212)
Ukraine	45 856 (36 664–57 209)	0·388 (0·310–0·484)	1162 (929–1450)
UK	325 133 (269 900–403 625)	0·437 (0·363–0·542)	4557 (3782–5657)
Uzbekistan	8580 (6665–11 166)	0·102 (0·079–0·133)	221 (172–288)
Latin America and Caribbean			
Argentina	50 742 (39 108–67 200)	0·205 (0·158–0·272)	1005 (774–1331)
Bahamas, The	747 (650–889)	0·208 (0·181–0·247)	1714 (1491–2041)
Barbados	375 (317–454)	0·415 (0·351–0·502)	1308 (1107–1584)
Belize	108 (75–156)	0·122 (0·085–0·176)	219 (152–316)
Bolivia	2727 (2015–3844)	0·101 (0·075–0·142)	196 (145–277)
Brazil	200 039 (162 542–246 712)	0·240 (0·195–0·296)	889 (723–1097)
Chile	53 185 (45 956–63 703)	0·466 (0·403–0·558)	2686 (2321–3218)
Colombia	50 633 (40 292–64 616)	0·258 (0·206–0·330)	936 (745–1194)
Costa Rica	5414 (4252–6887)	0·210 (0·165–0·267)	977 (768–1243)
Dominican Republic	6778 (5337–8933)	0·122 (0·096–0·161)	564 (444–743)
Ecuador	8414 (6891–10 581)	0·156 (0·128–0·196)	406 (333–511)
El Salvador	2699 (2086–3557)	0·176 (0·136–0·232)	396 (306–522)
Guatemala	6372 (5036–8523)	0·131 (0·103–0·175)	281 (222–376)
Guyana	489 (382–639)	0·135 (0·106–0·177)	595 (465–778)
Haiti	462 (352–628)	0·065 (0·049–0·088)	35 (27–47)
Honduras	1619 (1234–2213)	0·085 (0·065–0·116)	134 (102–184)
Jamaica	1349 (1105–1704)	0·204 (0·167–0·257)	446 (366–564)
Mexico	95 201 (74 593–124 042)	0·141 (0·111–0·184)	659 (517–859)
Nicaragua	1027 (804–1343)	0·098 (0·077–0·129)	134 (105–175)
Panama	7769 (6172–10 060)	0·187 (0·148–0·242)	1506 (1197–1951)
Paraguay	3784 (3075–4770)	0·156 (0·127–0·196)	459 (373–579)
Peru	21 525 (17 199–28 137)	0·217 (0·174–0·284)	580 (463–758)

(Table 1 continues on next page)

workforce. However, this method is also contingent upon the accuracy of data on age and sex distributions.

To quantify the macroeconomic burden of ADODs, we compared GDP from 2020 to 2050 under two scenarios: a status quo scenario with no interventions reducing ADODs mortality and morbidity, and a counterfactual scenario in which ADODs are absent. We calculated the burden as the cumulative difference in projected annual GDP between these scenarios. Future projections were discounted at an annual rate of 2%, following previous studies.[7,19]

Uncertainty and sensitivity analyses

We conducted a series of uncertainty and sensitivity analyses. Our analysis carefully accounts for variations in disease-related factors, like mortality, morbidity rates, and prevalence, by offering uncertainty intervals (UIs) and sensitivity analyses. These analyses also explore variations in other parameters, including discount rates, currency units, caregiving hours, and different disease reduction scenarios (appendix pp 9–38).

Role of the funding source

The funders had no role in the data collection, study design, analysis, interpretation, writing of the manuscript, or decision to submit for publication.

Results

We calculated the macroeconomic burden of ADODs as the difference in total GDP in 2020–50 between the status quo scenario and the counterfactual scenario in which ADODs are eliminated.

We obtained results for 152 countries or territories with complete data, representing about 93% of the world's population (table 1). The parentheses include the lower and upper 95% UIs calculated in the sensitivity analysis by varying disease data. China has the largest estimated economic burden of ADODs with INT$2961 billion (95% UI 2507–3564), followed by the USA with INT$2331 billion (1989–2829) and Japan with INT$1758 billion (1471–2150). The cost of ADODs as a percentage of GDP ranges from 0·059% (95% UI 0·044–0·079) in Guinea-Bissau to 1·463% (1·225–1·790) in Japan, the country that has progressed most in terms of ageing. The per capita estimates range from INT$12 (95% UI 10–16) in Burundi to INT$15 049 (12 594–18 405) in Japan. Figure 2 shows the total macroeconomic burden and the cost in percentage of GDP by means of world maps. The darker a country's colour as displayed on the map, the higher its economic burden in terms of the specific measure considered. Grey indicates the absence of data for a country.

Table 2 displays the aggregated results for World Bank regions and country income groups. Globally, the total cost of ADODs in 2020–50 is INT$14 513 billion (95% UI 12 106–17 778), equivalent to a tax of 0·421% (0·351–0·515) on global GDP or a per capita burden of INT$1728

(1442–2117). By varying discount rates, the total cost would be INT$21 106 billion (17 537–25 962) at a discount rate of 0% and INT$12 115 billion (10 126–14 806) at a discount rate of 3%. Country-specific and region-specific estimates under different discount rates are shown in the appendix (pp 9–19). Country-specific and region-specific costs of ADODs in 2020 US dollars are shown in the appendix (pp 19–24), with the aggregate burden for 152 countries or territories estimated at US$10 756 billion (9011–13 153). To estimate economic losses for the 52 countries missing key data, we used available GDP and disability-adjusted life-year (DALY) information. Data requirements, imputation methods, and preliminary estimates are detailed in the appendix (pp 24–27).

By World Bank region, the aggregate macroeconomic burden of ADODs is highest in East Asia and Pacific, with a total economic loss of INT$5759 billion (95% UI 4821–7022). Europe and Central Asia has the second largest total economic loss of INT$4530 billion (3771–5556). North America has the third largest total economic loss of INT$2562 billion (2184–3107) but the highest per capita loss of INT$6415 (5468–7781). This loss corresponds to 0·454% (0·387–0·551) of the region's annual GDP. By income group, the economic burden of ADODs increases as income rises; high-income countries bear the greatest burden with a total economic loss of INT$8989 billion (7552–10 996) and a per capita loss of INT$7514 (6313–9191). By contrast, ADODs cost low-income countries INT$51 billion (40–66) in total and INT$70 (55–91) per capita. In terms of percentage loss of GDP, high-income countries shoulder the highest burden with 0·637% (0·535–0·779), whereas low-income countries face the lowest burden with 0·108% (0·084–0·139).

Table 3 compares the global distribution of economic losses and the lifetime disease burden attributable to ADODs. The economic burden is not distributed in proportion to population size and DALYs. For example, South Asia accounts for 11 DALYs (19·75%) of 56 DALYs in 2050 but for only INT$564 billion (3·88%) of the INT$14 513 billion economic loss in 2020–50, whereas North America accounts for only 3 DALYs (4·62%) in 2050 but for INT$2562 billion (17·65%) of the economic loss in 2020–50. East Asia and Pacific shoulders both a large health burden and a large economic burden, accounting for 10 DALYs (40·12%) of 25 DALYs in 2020, 20 DALYs (36·60%) of 56 DALYs in 2050, and INT$5759 billion (39·68%) of the economic loss. The share of total DALYs occurring in low-income and lower-middle-income countries will increase, and the share in high-income countries will decrease. By 2050, low-income and middle-income countries are projected to contribute 74·10% of the DALYs.

We first analysed the influence of varying hours of informal care on the country-specific and region-specific costs of ADODs. By examining different types

	Economic cost, INT$ million	Proportion of total GDP in 2020–50	Per capita cost, INT$
(Continued from previous page)			
Uruguay	9055 (7776–10 653)	0·464 (0·398–0·546)	2525 (2168–2971)
Venezuela	4809 (3637–6347)	0·102 (0·077–0·134)	141 (107–186)
Middle East and North Africa			
Algeria	47 393 (37 813–59 020)	0·369 (0·295–0·460)	897 (715–1117)
Bahrain	2266 (1960–2688)	0·133 (0·115–0·158)	1090 (943–1293)
Djibouti	127 (98–165)	0·106 (0·082–0·138)	110 (85–143)
Egypt	89 187 (69 978–112 167)	0·211 (0·166–0·266)	682 (535–857)
Iran	78 894 (63 142–97 927)	0·328 (0·262–0·407)	830 (664–1030)
Israel	41 615 (33 976–53 830)	0·384 (0·313–0·497)	3901 (3185–5047)
Jordan	7920 (6368–9743)	0·267 (0·215–0·329)	697 (560–857)
Kuwait	10 449 (8245–13 508)	0·276 (0·218–0·356)	2124 (1676–2746)
Libya	9587 (7684–11 946)	0·251 (0·201–0·313)	1224 (981–1526)
Malta	2858 (2410–3440)	0·523 (0·441–0·629)	6472 (5457–7789)
Morocco	27 683 (22 467–34 578)	0·315 (0·256–0·394)	656 (533–820)
Oman	4394 (3653–5415)	0·124 (0·103–0·152)	716 (595–882)
Saudi Arabia	47 966 (39 283–58 918)	0·145 (0·119–0·178)	1182 (968–1452)
Syria	21 967 (16 795–28 770)	0·157 (0·120–0·206)	798 (610–1045)
Tunisia	12 428 (9903–15 414)	0·347 (0·277–0·431)	957 (762–1187)
North America			
Canada	230 950 (194 769–277 684)	0·488 (0·411–0·586)	5495 (4634–6607)
USA	2 330 825 (1 988 866–2 829 409)	0·451 (0·385–0·548)	6524 (5567–7919)
South Asia			
Bangladesh	40 411 (32 837–49 708)	0·152 (0·124–0·188)	222 (180–273)
Bhutan	325 (258–418)	0·104 (0·082–0·133)	380 (301–488)
India	460 270 (367 302–576 714)	0·141 (0·112–0·176)	299 (239–375)
Maldives	724 (560–937)	0·216 (0·167–0·280)	1325 (1026–1715)
Nepal	3384 (2952–3986)	0·096 (0·084–0·113)	101 (88–119)
Pakistan	37 623 (28 735–49 944)	0·086 (0·066–0·115)	134 (102–177)
Sri Lanka	20 865 (15 907–27 563)	0·250 (0·191–0·331)	950 (724–1255)
Sub-Saharan Africa			
Angola	7464 (5811–9756)	0·074 (0·058–0·097)	141 (109–184)
Benin	1198 (960–1531)	0·083 (0·067–0·106)	67 (54–86)
Botswana	1824 (1439–2350)	0·125 (0·099–0·161)	616 (486–794)
Burkina Faso	1419 (1120–1810)	0·079 (0·062–0·101)	45 (36–57)
Burundi	225 (179–285)	0·061 (0·049–0·078)	12 (10–16)
Cabo Verde	267 (217–332)	0·213 (0·174–0·266)	425 (346–529)
Cameroon	3004 (2331–3921)	0·075 (0·058–0·097)	79 (61–103)
Central African Republic	111 (90–140)	0·072 (0·058–0·090)	17 (14–21)
Chad	618 (480–816)	0·060 (0·046–0·079)	25 (19–33)
Comoros	134 (108–172)	0·148 (0·119–0·189)	115 (92–147)
Congo, DR	4003 (3142–5160)	0·107 (0·084–0·139)	29 (23–37)
Congo (Brazzaville)	1252 (1066–1491)	0·132 (0·113–0·157)	157 (134–187)
Côte d'Ivoire	4273 (3329–5480)	0·087 (0·068–0·112)	112 (87–144)
Eritrea	186 (141–249)	0·082 (0·062–0·110)	39 (30–53)
Eswatini	336 (264–436)	0·101 (0·079–0·132)	238 (187–309)
Ethiopia	11 044 (8847–13 978)	0·099 (0·080–0·126)	69 (55–87)
Gabon	2082 (1724–2522)	0·184 (0·152–0·222)	692 (573–838)
Gambia, The	167 (127–218)	0·079 (0·061–0·104)	46 (35–60)
Ghana	6137 (4724–8034)	0·114 (0·088–0·150)	148 (114–194)

(Table 1 continues on next page)

	Economic cost, INT$ million	Proportion of total GDP in 2020–50	Per capita cost, INT$
(Continued from previous page)			
Guinea	925 (716–1194)	0·070 (0·054–0·090)	48 (37–62)
Guinea-Bissau	98 (74–132)	0·059 (0·044–0·079)	36 (27–48)
Kenya	7225 (5611–9420)	0·076 (0·059–0·099)	99 (77–129)
Lesotho	254 (204–318)	0·122 (0·099–0·153)	105 (85–132)
Madagascar	1204 (942–1567)	0·082 (0·064–0·106)	30 (23–39)
Mali	1418 (1108–1818)	0·067 (0·052–0·086)	45 (35–58)
Mauritania	1022 (845–1260)	0·119 (0·099–0·147)	152 (125–187)
Mauritius	2612 (2100–3257)	0·330 (0·265–0·411)	2088 (1679–2604)
Mozambique	1551 (1323–1877)	0·081 (0·069–0·097)	33 (28–40)
Namibia	1191 (961–1510)	0·141 (0·114–0·179)	366 (295–464)
Niger	1037 (830–1323)	0·091 (0·073–0·116)	24 (19–31)
Nigeria	41 269 (32 859–51 083)	0·104 (0·083–0·129)	138 (110–171)
Rwanda	964 (746–1277)	0·088 (0·068–0·117)	54 (42–71)
Senegal	3042 (2456–3791)	0·144 (0·116–0·179)	124 (100–155)
Sierra Leone	430 (332–564)	0·084 (0·065–0·110)	41 (32–54)
South Africa	34 800 (28 018–43 177)	0·172 (0·139–0·214)	509 (410–632)
South Sudan	240 (184–311)	0·069 (0·053–0·089)	16 (12–20)
Tanzania	7520 (6316–9274)	0·115 (0·097–0·142)	82 (69–101)
Togo	433 (331–581)	0·083 (0·063–0·111)	37 (28–50)
Uganda	2883 (2252–3761)	0·072 (0·056–0·094)	43 (34–56)
Zambia	2293 (1905–2853)	0·087 (0·072–0·108)	82 (68–102)

Data are mean (95% UI). UIs are calculated based on the lower and upper bounds of 95% UIs for Global Burden of Disease mortality and morbidity data. INT$=international dollars, calculated from base year 2020. GDP=gross domestic product. UI=uncertainty interval.

Table 1: **Total economic cost, cost as a percentage of GDP in 2020–50, and per capita cost, by country and World Bank region**

of informal care—ranging from supervision time alone to support and assistance with both basic and instrumental activities of daily living, or a combination thereof—we estimated the global cost of ADODs to be between INT$11 986 billion and INT$19 554 billion (appendix pp 27–32). The *Lancet* Commission[20] reported that up to 40% of dementias could potentially be prevented or delayed. We modelled a hypothetical 40% reduction in ADODs, predicting a 28·6% decrease in the macroeconomic burden to INT$10 358 billion (95% UI 8916–12 308; appendix pp 32–37). Our analysis also shows that informal care constitutes the majority of ADODs costs in all regions, with a higher proportion in lower-middle-income countries (85·45%) compared with high-income countries (60·97%). Treatment and formal care costs are higher in high-income countries (30·80%) than in lower-middle-income countries (10·50%; appendix pp 37–38).

Discussion

This study estimated the global macroeconomic burden of ADODs in 2020–50 for 152 countries or territories using a macroeconomic model that accounts for the loss of capital and labour resulting from ADODs mortality, morbidity, and informal care. ADODs are estimated to cost the world economy INT$14 513 billion (95% UI 12 106–17 778), which is equivalent to an annual tax of 0·421% (95% UI 0·351–0·515) on global GDP during 2020–50 and equal to the global health expenditure in 2020.[21]

Our methodology has several strengths compared with the previous literature. First, our model calculates the effect of the diseases on the economy through their influence on two of the most important drivers of economic growth: physical capital accumulation and human capital accumulation. Using a simulated production function, we captured the causal effect of ADODs on the economic value of output and GDP growth. This approach is superior to cross-country regression analysis of the effects of ADODs on GDP because the latter could suffer from reverse causal relationships (eg, higher GDP might improve ADODs prevention and formal care). Second, compared with cost-of-illness methods, which use country-specific data that might not be available in other contexts, our method uses macroeconomic indicators such as population size, ageing, economic development level, labour force participation rate, education level, and saving rate, which are available across countries. Our estimates are therefore internationally comparable. Third, we consider economic adjustment mechanisms that account for the effect of ADODs on labour and capital dynamics, which are more inclusive measures than lost earnings or health-care costs. Fourth, we consider the long-term cumulative macroeconomic effect of ADODs. In addition to the growing health burden of ADODs, the economic burden also increases year by year due to the accumulation of human and physical capital losses.

Previous studies, such as that by Wimo and colleagues,[8] used a cost-of-illness approach to estimate the direct cost of ADODs to be 0·65% of global GDP in 2015 and 0·76% in 2019, whereas the informal care costs were 0·44% of global GDP in 2015 and 0·75% in 2019. In comparison, our results show a lower total estimate of 0·421% of global GDP. WHO recently projected the global cost of ADODs to be US$1·7 trillion by 2030, and stated that it could even reach US$2·8 trillion if adjusted for increases in costs of informal and formal care.[16] The difference between our study (US$1·1 trillion) and these three reports lies in the approach to cost of illness. Unlike the other reports, we account for adjustment mechanisms where individuals who die or have reduced productivity due to ADODs are replaced by other workers or physical capital, like machines or robots. Additionally, we consider treatment and paid care costs (43% of the total cost[18]) as part of the economic cycle rather than an economic loss. Paid care costs represent a transfer of wealth from care recipients to formal caregivers and not a pure reduction in GDP or macroeconomic output. Another potential method of estimating global ADODs cost is the use of the VSL metric.[22] Nandi and colleagues[5] estimated the VSL-based economic burden of ADODs to be

US$2·8 trillion in 2019 and US$16·9 trillion in 2050, which is a larger estimate than ours. As VSL relies on the subjective valuation of pain and suffering, it provides a preference-based valuation of the willingness to pay for the elimination of ADODs, whereas our estimates focus on the macroeconomic costs of ADODs and, thus, an objective lower bound.

More specifically, our approach focuses on the effect of ADODs on potential GDP growth. The attribution analysis results indicate that informal caregiving is the most influential factor affecting the burden. This suggests that in areas with a higher prevalence of ADODs (such as those with larger elderly population shares or where disease prevention and control are poor), and where formal elderly care is not available or insufficient, there is likely to be a greater economic burden. Treatment and formal care costs form the secondary burden. In high-income countries, these costs occupy a greater portion, reflecting the countries' advanced health-care systems and a larger role for institutionalised formal care. Our findings suggest that even when treatment and formal care costs for ADODs are not considered as a pure burden but affect the accumulation of physical capital, ADODs still inflict substantial damage to overall economic development, based on a comprehensive assessment of declining investment. Furthermore, it can be observed that in developed countries, improving the model of formal care for the elderly and reducing the workforce involved in caregiving can also lead to economic growth.

Across regions, East Asia and Pacific faces the largest economic toll due to ADODs, followed by Europe and Central Asia and North America. The high economic burdens in these regions are attributable mainly to three large countries: China, Japan, and the USA. For China, the high economic burden of ADODs is due to the huge health burden the country faces as a result of its large population and fast growth in the elderly population. In contrast, in the USA, a typical high-income country, high per capita human capital loss (associated with high educational attainment and per capita GDP) drives the high absolute productive loss of affected individuals and informal caregivers. Furthermore, the USA faces a high burden in terms of treatment and formal care costs and, thus, a substantial loss of savings and capital formation. Japan, as a super-aged society, has the longest life expectancy in the world and the largest share of the population aged 65 years or older in 2019. People aged 65 years or older are estimated to make up one-third of Japan's population by 2050.[23] The macroeconomic burden of ADODs is substantial in Japan because age is a major risk factor for ADODs.

ADODs present varied health and economic challenges across income groups, with high-income and upper-middle-income countries bearing the greatest economic burden. This disparity arises largely from their substantially ageing populations and the intense

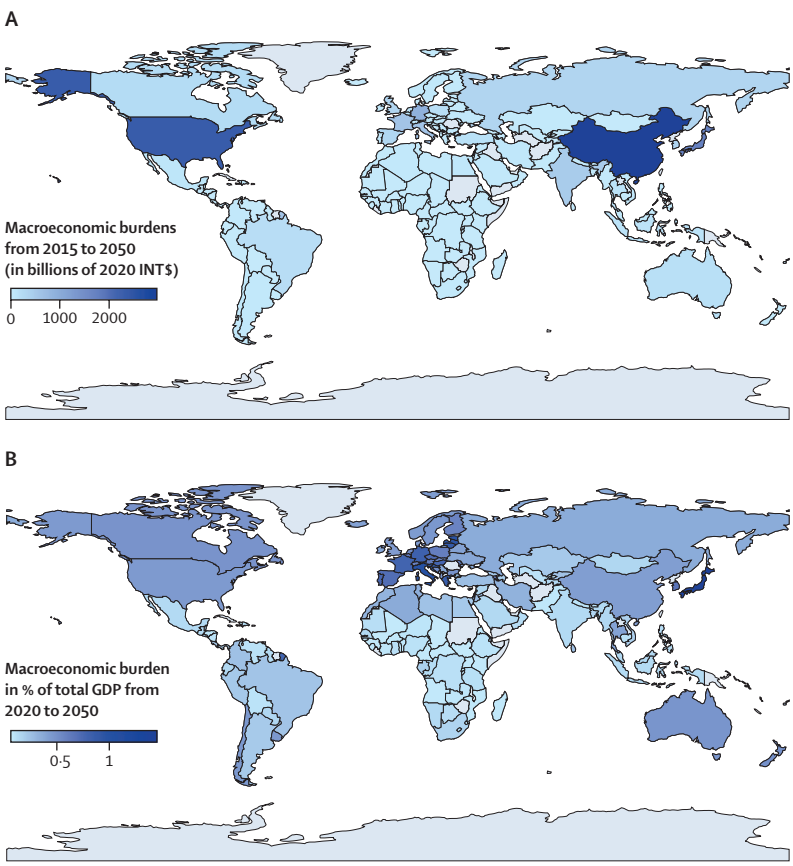

Figure 2: **Macroeconomic burden of ADODs from 2020 to 2050**
Burden expressed (A) in billions of INT$ and (B) as a percentage of total GDP over the same period. ADODs=Alzheimer's disease and other dementias. GDP=gross domestic product. INT$=international dollars, measured in the base year 2020.

	Economic burden, INT$ billion	Proportion of total GDP in 2020–50	Per capita loss, INT$
By World Bank region			
East Asia and Pacific	5759 (4821–7022)	0·501 (0·419–0·611)	2410 (2018–2938)
Europe and Central Asia	4530 (3771–5556)	0·598 (0·498–0·733)	5014 (4174–6150)
Latin America and Caribbean	535 (431–677)	0·208 (0·167–0·263)	763 (614–964)
Middle East and North Africa	405 (324–508)	0·244 (0·195–0·306)	906 (725–1136)
North America	2562 (2184–3107)	0·454 (0·387–0·551)	6415 (5468–7781)
South Asia	564 (449–709)	0·138 (0·109–0·173)	274 (218–345)
Sub-Saharan Africa	158 (126–199)	0·108 (0·086–0·136)	106 (84–133)
By World Bank income group			
Low income	51 (40–66)	0·108 (0·084–0·139)	70 (55–91)
Lower-middle income	1217 (961–1544)	0·153 (0·121–0·194)	312 (247–396)
Upper-middle income	4251 (3549–5166)	0·356 (0·298–0·433)	1669 (1393–2028)
High income	8989 (7552–10 996)	0·637 (0·535–0·779)	7514 (6313–9191)
Total	14 513 (12 106–17 778)	0·421 (0·351–0·515)	1728 (1442–2117)

Data are mean (95% UI). UIs are calculated based on the lower and upper bounds of 95% UIs for Global Burden of Disease mortality and morbidity data. Countries are classified into World Bank regions as in table 1. INT$=international dollars, calculated from base year 2020. GDP=gross domestic product. UI=uncertainty interval.

Table 2: **Economic burden, cost as a percentage of total GDP in 2020–50, and per capita economic burden by World Bank region, by World Bank income group, and globally**

	Economic burden, INT$ billion (%)	DALYs in 2020 (%)	DALYs in 2050 (%)	Annual GDP 2020–50, INT$ billion (global %)	Annual population 2020–50, millions (global %)
By World Bank region					
East Asia and Pacific	5759 (39·68%)	9953 (40·12%)	20 317 (36·60%)	37 086 (32·26%)	2390 (27·06%)
Europe and Central Asia	4530 (31·22%)	5938 (23·93%)	10 183 (18·34%)	24 445 (21·27%)	904 (10·23%)
Latin America and Caribbean	535 (3·69%)	2131 (8·59%)	5436 (9·79%)	8304 (7·22%)	702 (7·95%)
Middle East and North Africa	405 (2·79%)	789 (3·18%)	2672 (4·81%)	5350 (4·65%)	447 (5·06%)
North America	2562 (17·65%)	2306 (9·29%)	2563 (4·62%)	18 189 (15·82%)	399 (4·52%)
South Asia	564 (3·88%)	2714 (10·94%)	10 996 (19·75%)	13 220 (11·50%)	2058 (23·31%)
Sub-Saharan Africa	158 (1·09%)	979 (3·95%)	3376 (6·08%)	4728 (4·11%)	1498 (16·96%)
By World Bank income group					
Low income	51 (0·35%)	468 (1·88%)	1753 (3·16%)	1523 (1·33%)	722 (8·18%)
Lower-middle income	1217 (8·39%)	5358 (21·59%)	18 577 (33·46%)	25 658 (22·32%)	3898 (44·14%)
Upper-middle income	4251 (29·29%)	9623 (38·78%)	20 657 (37·21%)	38 474 (33·47%)	2547 (28·84%)
High income	8989 (61·94%)	9282 (37·41%)	14 375 (25·90%)	45 514 (39·60%)	1196 (13·55%)
Total	14 513 (100%)	24 811 (100%)	55 513 (100%)	111 322 (96·85%)	8397 (95·10%)

Data are mean (95% UI) or n (%). UIs are calculated based on the lower and upper bounds of 95% UIs for Global Burden of Disease mortality and morbidity data. Countries are classified into World Bank regions as in table 1. INT$=international dollars, calculated from base year 2020. DALY=disability-adjusted life-year. GDP=gross domestic product. UI=uncertainty interval.

Table 3: **Macroeconomic loss and lifetime disease burden measured in DALYs by World Bank region and country income group**

demands of both formal and informal caregiving. However, emerging health concerns in lower-income countries also warrant close scrutiny. As these countries witness growth in health burdens posed by ADODs, the health challenges could translate into great economic pressures in the future, especially if the ageing trend affects their burgeoning labour force. Furthermore, informal caregiving plays a pivotal role in supporting those with ADODs, particularly in the advanced stages of the disease, regardless of the region. ADODs progressively hinder individuals from managing daily activities, such as bathing or preparing meals. The burden from informal care outweighs the burden of formal care or treatments across all regions. Additionally, due to traditional societal norms in many countries, women often assume a larger share of this informal caregiving role, hindering their strides towards equal representation in the workforce.[24]

The WHO Global Dementia Action Plan 2017–2025 seeks to enhance the lives of individuals with dementia and their informal caregivers,[25] measuring progress through data on dementia prioritisation at the ministry level, the presence of dementia plans, funding allocation, and relevant legislation.[26] Similarly, the US National Plan sets ambitious targets to prevent and effectively treat ADODs by 2025, aiming to boost care quality, expand support for affected individuals and their families, increase public awareness, improve progress tracking data, and expedite action for healthy ageing and risk reduction.[27] Towards reducing the burden of dementia, the US 2024 President's Budget request includes US$20 billion in mandatory resources to support pandemic preparedness, including approximately US$3767 million for ADODs to accelerate scientific progress on dementia.[28] Our results show that the economic burden for ADODs is INT$2331 billion (95% UI 1989–2829; about US$75 billion average annual cost) from 2020 to 2050 in the USA, far larger than the investment in ADODs. This result highlights the macroeconomic value of investing in ADODs mitigation in the USA and globally.

Addressing ADODs requires a strategic approach anchored in three key areas: advancing research and development for new therapies and assistive technologies, implementing innovative patient-centred care models, and initiating public health measures to mitigate risk factors. First, substantial investment in research and development is essential for discovering therapies that could alter ADODs progression or lead to a cure, alongside developing technologies to improve affected individuals' quality of life. Emerging disease-modifying treatments show promise in substantially affecting the course of dementia, offering new hope for people with ADODs and their families.[29] Second, the adoption of innovative, patient-centred care models is crucial. These models integrate comprehensive care strategies to better meet the evolving needs of individuals with dementia, enhancing both their and their caregivers' experiences.[30] Third, public health initiatives that target the reduction of known risk factors for ADODs, such as alcohol consumption, smoking, and unmanaged diabetes, are crucial. The *Lancet* Commission on dementia prevention, intervention, and care[20] highlights that addressing these risk factors can substantially prevent or delay the onset of dementia for many individuals.

Our model has several limitations. First, the absence of specific country-level data on treatment and formal care costs for ADODs led us to use average costs from corresponding income groups, potentially resulting in inaccurate estimates. Second, limited data availability restricts our ability to account for the diverse backgrounds of informal caregivers, such as educational levels. Despite these limitations, our age-differentiated and sex-differentiated approach offers broader analytical depth than many existing studies. Third, our data cover 152 countries or territories, representing 93% of the global population but leaving 7% unaccounted for. Fourth, for a study to incorporate such extensive macroeconomic data worldwide, we had to rely on assumptions on projections for mortality, morbidity, prevalence, GDP, and labour participation, which could affect the accuracy of cost estimates (appendix pp 38–39).

In conclusion, this study shows that the global economic burden of ADODs is substantial, amounting to INT$14 513 billion (12 106–17 778) from 2020 to 2050. The economic burden and the health burden are distributed unequally, with East Asia and Pacific being the region with the largest economic burden, followed by Europe and Central Asia and North America. The findings emphasise the urgent need to invest in global efforts to curb the ADODs epidemic. Informal care, a major contributor to the macroeconomic burden of ADODs, should be reconsidered and managed appropriately as the population ages.

Contributors

SC, CW, and DEB conceptualised and designed the study. SC and ZC acquired the data and information for this study, conducted the analyses, visualised and interpreted the data, and reviewed the literature. AN, NC, LJ, KP, MK, BS, DT, and DV contributed to the literature review and the interpretation of the data. SC, ZC, MK, KP, and AN wrote the article. NC, LJ, BS, DT, DV, CW, and DEB critically revised the article. SC and ZC accessed and verified the data, and had final responsibility for the decision to submit the manuscript for publication. All authors had full access to all data used in the study and approved the final version.

Declaration of interests

We declare no competing interests.

Data sharing

No individual-level data were used in this modelling study. Data from this modelling study are available with publication. The data are available to anyone who requests them for any non-commercial purposes. The data can be accessed by contacting SC (simiao.chen@uni-heidelberg.de), who will provide guidance on how to use and interpret the data.

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