University Library



A gateway to Melbourne's research publications

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:
Adair, T;Li, H;Temple, J;Anstey, KJ

Title:
Large Discrepancies in Dementia Mortality Reported in Vital Statistics: The Need for Improved Data to Inform Policy

Date:
2023-07-01

Citation:
Adair, T., Li, H., Temple, J. & Anstey, K. J. (2023). Large Discrepancies in Dementia Mortality Reported in Vital Statistics: The Need for Improved Data to Inform Policy. Alzheimer Disease and Associated Disorders, 37 (3), pp.207-214. https://doi.org/10.1097/WAD.0000000000000562.

Persistent Link:
https://hdl.handle.net/11343/337169

Large discrepancies in dementia mortality reported in vital statistics: The need for improved data to inform policy

Tim Adair, PhD, The Nossal Institute for Global Health, Melbourne School of Population and Global Health, The University of Melbourne, Melbourne, Victoria, Australia

Hang Li, PhD, The Nossal Institute for Global Health, Melbourne School of Population and Global Health, The University of Melbourne, Melbourne, Victoria, Australia

Jeromey Temple, PhD, Demography and Ageing Unit, Centre for Health Policy, Melbourne School of Population and Global Health, University of Melbourne, Melbourne, Victoria, Australia

Kaarin J. Anstey, PhD, UNSW Ageing Futures Institute, University of New South Wales, Australia; Neuroscience Research Australia, Sydney, NSW, Australia

Correspondence: Tim Adair, Nossal Institute for Global Health, Melbourne School of Population and Global Health, The University of Melbourne, Level 2, 32 Lincoln Square North. The University of Melbourne, Victoria 3010 Australia. Email: timothy.adair@unimelb.edu.au. Phone: +61 3 8344 9379.

Acknowledgments

The authors wish to thank Saman Gamage for providing information on ICD-11.

Conflicts of Interest and Source of Funding

The authors declare no conflicts of interests.

JT was supported by the Australian Research Council's (ARC) Centre of Excellence in Population Ageing Research (CE1101029). KJA was supported by ARC Laureate Fellowship FL190100011 and acknowledges support from ARC Grant CE170100005. The funders had no role in this study.

Abstract

Purpose

There is limited understanding of the inter-country comparability of dementia mortality data. This study compares reported dementia mortality in national vital statistics between countries and over time. In countries with low dementia reporting, this study identifies other causes to which dementia may be misclassified.

Methods

Using the World Health Organization (WHO) Mortality Database, we calculated the ratio of reported to expected (Global Burden of Disease estimated) age-standardized dementia death rates in 90 countries from 2000-19. Other causes to which dementia may be misclassified were identified as having relatively high cause fractions compared with other countries.

Patients

No patients were involved.

Results

There is large inter-country variation in reported dementia mortality rates. The ratio of reported to expected dementia mortality exceeded 100% in high-income countries but was below 50% in other super-regions. In countries with low reported dementia mortality, cardiovascular diseases, ill-defined causes and pneumonia have relatively high cause fractions and may be misclassified from dementia.

Discussion

Large discrepancies in dementia mortality reporting between countries, including often implausibly low reported mortality, makes comparison extremely difficult. Improved guidance for and training of certifiers and use of multiple cause of death data can help strengthen the policy utility of dementia mortality data.

Keywords

Dementia, Alzheimer disease, mortality, causes of death, vital statistics, ageing.

Introduction

Dementia is a condition of major public health importance and will become a more significant issue in coming decades in all regions of the world due to population ageing and growth.[1,2] As a result, public health practitioners and policy makers have shown growing interest in reliable and comparable data to improve clinical understanding of the condition and its burden.[3] Some studies in high-income countries suggest that the age-specific incidence and prevalence of dementia is either stable or decreasing, while projections commonly assume that its age-standardized prevalence will remain constant in future.[4-10] Data from low- and middle-income countries are far sparser and estimates of prevalence and its trends are far harder to identify. Projected population ageing means that even if age-standardized prevalence remains steady, the overall proportion of the population and number of people with dementia will rise.[1] Reliable data on dementia as a cause of death are particularly important to estimate its burden of disease; the World Health Organization (WHO) estimates that Alzheimer Disease and other dementias is the 2nd leading cause of death in high-income countries and an increasingly important cause in middle-income countries experiencing population ageing.[11]

The leading source of dementia mortality data worldwide are official mortality statistics reported by national statistical offices that are derived from routine vital statistics systems that seek to register all deaths. These data sources provide the potential to compare dementia mortality spatially between countries and across time. Official mortality statistics are based on the underlying cause of death, defined as the disease or injury which initiated the train of events leading directly to death, and are determined by what a medical certifier (mostly a physician) reports in the International Form of Medical Certificate of Cause of Death (or death certificate).[12] The death certificate requires the certifier to report the diseases leading directly to death (Part 1 of the certificate) or any other significant condition contributing to death (Part 2 of the certificate); this information and International Classification of Diseases (ICD) coding rules determine the underlying cause, which in almost all cases requires dementia to be reported in Part 1. Classification of the type of dementia, for example Alzheimer Disease, vascular dementia and unspecified dementia, can enable understanding of the risk factors for and nature of dementia in the population.

Dementia mortality statistics have the potential to be of much use to understand the extent of country differences in death rates, risk factors, treatment and care of the condition, and facilitate international benchmarking. However, there remains a gap in our understanding about how comparable official dementia mortality statistics are between countries. Levels of reported dementia mortality are determined not only by the "true" or latent level of dementia mortality in each country, but can be biased by differences in practices of the certifier that impact whether and in which part of the death certificate dementia is noted. Certification practices are affected by knowledge and recognition of the condition, diagnostic practices and preferences, which are also all subject to change over time.[13] Furthermore, the application of ICD coding rules may differ between countries and over time. In some populations, these issues can cause dementia mortality to be under-reported and misclassified to other causes of death.

There has not previously been a global assessment of the quality of reporting of dementia mortality in vital statistics. This study fills this gap by making use of the comprehensive data on causes of death in the WHO Mortality Database to improve understanding inter-country and temporal differences in reported dementia mortality rates in official statistics.[14] Specifically, the study aims to:

- compare reported dementia mortality rates by sex and type of dementia between countries,

- compare reported dementia mortality rates over time,
- assess variation across countries in the difference between reported and expected levels of dementia mortality rates, and
- in countries with very low reported dementia mortality rates, identify unusually high reporting of other causes of death that may be misclassified from dementia.

Methods

The reported dementia mortality data used in this study is from the WHO Mortality Database, which comprises official mortality data reported annually to the WHO by member states from civil registration and vital statistics systems (further detail in Text S1, Supplemental Digital Content).[14] Using WHO Mortality Database data from 2000-2019, we calculated reported age-standardized dementia death rates by sex for ages 75 years and over in each country. We classified dementia as including the following ICD codes: G30 (Alzheimer disease), F01 (vascular dementia), G31 (other specified dementias), and F03 (Unspecified dementia). Population data from the GBD were used to calculate age-standardized death rates.[15] Application of criteria to exclude countries and country-years (see Text S1, Supplemental Digital Content) resulted in a final dataset comprising 1,333 country-years from 90 countries in 2000-19 (Table S1, Supplemental Digital Content).

For each country-year, we compared the reported age-standardized dementia death rate to an *expected* age-standardized dementia death rate calculated from the GBD 2019 Study's estimated number of dementia deaths by age and sex.[16,17] The expected dementia death rate is the comparator because it is an estimate of dementia deaths in each country-year calculated from the GBD's standardized methods that are independent of the number of deaths reported in the WHO Mortality Database (see Text S1, Supplemental Digital Content for further detail about the GBD's methods). This expected dementia death rate according to the GBD 2019 is not regarded by our study as "true", but rather a valuable comparator against which to measure reported dementia death rates. Where this ratio is less than 1 then dementia mortality is regarded as "under-reported", possibly because the condition itself is under-diagnosed or that certifiers in that country do not regard it as a true cause of death. Where the ratio is greater than 1, dementia mortality is regarded as "over-reported", and possibly reported as the cause of death when in fact the actual cause is another condition.

We conducted several analyses that compare the reported (WHO) and expected (GBD) dementia death rate between countries, by GBD super-region (which are classified according to epidemiological similarity and geographic closeness), over time including using a log-linear regression described in Text S1, Supplemental Digital Content, and by type of dementia.[16] Next, we focused on countries where the ratio of reported to expected age-standardized dementia death rates in the most recent year of data is very low – i.e. is less than 10% or where dementia is a negligibly reported cause of death – which includes 25 countries for males and 21 countries for females. In these countries we sought to identify which other causes of death that dementia is misclassified to. To do this, we identified the three causes of death (other than dementia) with the highest ratio of age-standardized cause-specific mortality fraction (i.e. age-standardized cause-specific mortality rate divided by the age-standardized all-cause mortality rate) to the average age-standardized cause-specific mortality fraction for all countries, as measured in both relative and absolute terms. For example, where the reported dementia death rate is lower than the expected rate, we can expect this is due to higher than expected reporting of causes of death which

"compensate" for lower than expected dementia reporting. These causes of death are broadly grouped as (see Text S1, Supplemental Digital Content for further detail):

- Causes that should not be reported as an underlying cause ("ill-defined" or "garbage" causes).
- Causes which are genuine underlying causes of death and which are commonly reported in place of dementia, depending on the certification practices and coding rules being used [18]
- A separate category grouping all other causes (but excluding dementia) together.

We scored each cause as 3 points if it was first-ranked, 2 if second-ranked, and 1 if third-ranked. We then summed the score for each cause across relative and absolute ranks for males and females.

Results

Figure 1 shows the large variation in reported age-standardized dementia mortality rates between the 90 countries, ranging from 0 to 1506 per 100,000 for males, and 0 to 1667 per 100,000 for females. For females, there is no correlation with GBD estimated mortality rates, which range approximately +/- 100 around a median of 527 per 100,000, while for males there is a negative correlation, with the GBD estimated mortality rates ranging also approximately +/- 100 around a median of 450 per 100,000 for males (Figure 1).

[Figure 1 about here]

For all 90 countries, the average reported dementia death rate for the most recent year is 69% of the average GBD estimated death rate for males and 64% for females (Table 1). In all super-regions, except for high-income countries, the average reported dementia mortality rate is much lower than the average GBD estimated rate. For males, the ratio ranges from 20% in Southeast Asia, East Asia, and Oceania to 42% in Central Europe, Eastern Europe, and Central Asia, and for females, from 16% in Southeast Asia, East Asia, and Oceania to 41% in Central Europe, Eastern Europe, and Central Asia. In high-income countries, the reported rates are, on average, higher than the GBD estimated rates, being 138% for males and 121% for females. The lowest average reported dementia death rate is in Southeast Asia, East Asia, and Oceania; and lowest average cause fraction is in North Africa and Middle East. The average reported dementia mortality rate in high-income countries and cause fraction is much higher than in other super-regions. There are small variations in GBD estimated mortality rates of dementia in these super-regions.

[Table 1 about here]

For individual countries, based on the most recent year of reported data, the highest reported dementia mortality rates were in Finland (3·9 times highest than GBD), Kazakhstan, and United Kingdom (Table S2, Supplemental Digital Content). The lowest WHO reported dementia mortality rate in males were in Singapore, Sri Lanka, and Uzbekistan, and for females in Republic of Moldova, Sri Lanka, Uzbekistan, and Singapore, all with rates less than 5 and ratios to GBD estimates of less than 1%; these exclude countries with no reported deaths (two for males, five for females). Results for all country-years can be found in Data S1 at doi.org/10.26188/21691754.

From 2000 to 2018, the average of the ratio of the reported to estimated GBD dementia mortality rate increased annually for both males and females. For males and females the average ratio at least doubled in this period, with a slight decline for both sexes (Figure 2). A regression analysis of the

natural log of the ratio of reported to estimated dementia death rates that controls for region shows that the coefficient of year is positive and statistically significant (males: b=0.059, p<0.01; female b=0·061, p<0.01) (Table S3, Supplemental Digital Content). That is, over the period 2000-2019 the ratio of reported to estimated dementia death rates increased by 5·9% annually for males and 6.1% for females, controlling for region. Some countries experienced sudden and substantial year-to-year increases in reported dementia mortality rates, such as UK 2010-2011 (female 568 to 803); Portugal 2012-2013 (male 150 to 323), Thailand 2018-2019 (male 199 to 392) and Japan 2016-17 (male 111 to 185) (Table S4, Supplemental Digital Content).

[Figure 2 about here]

The most common type of dementia was Alzheimer disease (average of countries about 50%), followed by unspecified dementia at slightly over 30%, vascular dementia about 10% and other dementias 8% (Table 2). However, in different super-regions these fractions varied considerably. Alzheimer disease was ranked first in Central Europe, Eastern Europe, and Central Asia, Latin America and Caribbean and North Africa and Middle. In high-income countries, unspecified dementia ranked first, followed by Alzheimer's disease, with vascular dementia and other dementias far lower. Results for each country are shown in Table S5, Supplemental Digital Content.

[Table 2 about here]

In countries where the ratio of reported to expected age-standardized dementia death rates is lowest, the leading other causes (i.e. highest ranked) comprise cardiovascular diseases of other heart disease, ischemic heart disease, essential hypertension and stroke, other ill-defined causes, senility and ill-defined and unknown cause of mortality, and pneumonia (Table 3). The cardiovascular diseases (except essential hypertension) generally rank more highly in terms of their absolute difference because of they comprise a higher proportion of deaths than other causes, while senility, ill-defined and unknown cause of mortality, other ill-defined causes tend to rank more highly in relative difference. Senility, ill-defined and unknown cause of mortality, other ill-defined causes, and essential hypertension tend to be more highly ranked among males compared with females.

[Table 3 about here]

For individual countries, there are a wide range of causes which are highly ranked (Tables S6-S9, Supplemental Digital Content). For example, in Singapore it is pneumonia, Sri Lanka senility and other ill-defined causes, Uzbekistan hypertensive heart disease and Georgia ill-defined and unknown cause of mortality. In Japan, a country consistently ranked as having one of the oldest populations in the world, senility, pneumonia and other respiratory diseases are highest ranked. Data for all causes in all countries can be found in Data S2 at doi.org/10.26188/21691754.

Discussion

This study showed that there are enormous discrepancies in reported dementia mortality rates globally according to official statistics compiled by individual countries, including when compared with the expected dementia mortality rate calculated by the GBD. There is a strong regional pattern to dementia mortality rate differences, with high-income countries having relatively high rates compared with all other regions. In individual countries, reported dementia ranges from not being

reported at all or implausibly very low (e.g. Singapore) to very high (almost four times higher than expected in Finland). The overall trend is an increase in recent years in reported compared with expected dementia mortality rates, with considerable temporal changes within countries such as Japan.[16] Furthermore, there is large variation in the reporting of type of dementia, with unspecified dementia comprising most dementia deaths in several regions.

Our findings indicate the need for much caution when using dementia mortality rates from official statistics to compare between and within countries over time. Our analysis of other causes did not find a clear single cause or group of causes with unusually high deaths rates that dementia may be misclassified to and therefore would explain why some countries have very low reported dementia mortality. In some countries like Sri Lanka and Japan the reporting of ill-defined causes and senility was particularly high, suggesting that deaths due to dementia are being misclassified to causes of death that have little public policy value. In some countries with low dementia mortality, specific cardiovascular diseases were much higher than in other countries, suggesting the possible reporting of co-morbid cardiovascular deaths as dementia. A similar issue is found with pneumonia mortality in Singapore, a country otherwise known to have high quality data.[19] A previous analysis of multiple cause of death data in Australia and the US found that pneumonia and cardiovascular diseases are among the most common co-morbidities for dementia deaths, so such a result is unsurprising.[20]

The limitations of dementia mortality data demonstrate the challenges involved in reporting it as a cause of death, particularly as a single underlying cause. Differences in dementia mortality between countries and over time may be explained by variations in diagnostic practices and preferences, and knowledge and recognition of its presence and role in leading to death. For example, some studies show that reporting of dementia on death certificates compared to clinical evaluations of its prevalence is low but increasing, with one study showing that dementia is the underlying cause for just 25% of female decedents recorded as having dementia at any stage of their life.[4,13,21-25] In India, qualitative studies have found that dementia is seen as a normal component of ageing and so medical care is not sought for it, likely resulting in it being under-reported on death certificates.[26] One study of Australian and US data found that much of the recent growth in dementia death rates was due to the increasing tendency of certifiers to report dementia in Part 1 of the death certificate rather than in Part 2, concurrent with declining reporting of cardiovascular diseases.[20] For specific countries, changes in ICD coding rules can also bias trends in dementia mortality rates.

Reduced use of garbage causes of death will help improve the utility of data, despite the challenges of measurement of dementia and other causes of death in older age across countries. The 11th Revision of the ICD (ICD-11) has introduced an extension code XT9T for “ageing-related diseases” which allow for any age-related condition to be indicated as such and may reduce reporting of senility.[27,28] Improved standardized guidance and coding practices for dementia and training of certifiers would reduce the confusion between whether dementia or another co-morbid conditions such as cardiovascular disease is the underlying cause of death. The use of one underlying cause of death is insufficient for reliable measurement of the role of co-morbidities in mortality that are common across at older ages and is the cause of several issues found in measurement of dementia mortality between countries, as well as for other chronic diseases. Further use of multiple cause of death data has much potential, and some methods have sought to weight each co-morbid condition as a fraction of a death.[29]

The importance of accurate dementia mortality data is heightened by the considerable challenges that continued population ageing presents for global public health. An increasing proportion of the world’s population are surviving to older ages, with an increase in deaths at ages 75 years and above

from 25% in 1990 to 40% in 2019 globally, and from 52% to 64% in high-income countries.[16] Older ages are typified by a complex interaction of multiple co-morbidities that require more resources for care and support for this population. Hence, reliable data on the causes of death at these ages are necessary to estimate the burden of disease attributable to various conditions, to understand differences by socio-economic characteristics and to inform health care planning.[30]

Interpretation of these results should recognize their limitations. GBD estimates of dementia mortality are heavily reliant on statistical models and are best interpreted as "expected" mortality given known prevalence and socio-economic and other indicators of the population and health system. However, we know of no other more reliable estimate of expected dementia mortality. Our study was limited to about half of the world's countries in the WHO Mortality Database, not including several countries with large elderly populations such as China, India and Russia. Finally, we could not more directly measure reasons for very low reported dementia mortality in some countries, and directly assumed the primary reason based on high fractions of deaths from other causes.

This study is the first global assessment of the quality of dementia mortality reported in vital statistics. The results provide critical information for policy makers on the characteristics and quality of dementia mortality data and are valuable to inform improved guidance on standardizing the reporting by national authorities of dementia as well as other conditions associated with older age mortality. They reveal that these data are inconsistent and requires major amelioration to improve their utility as evidence for policy. This is particularly important in middle-income countries experiencing population ageing and where dementia is becoming a leading cause of death but where it is clearly under-reported in official statistics. Given the increasing proportion of global deaths occurring at older ages, there is considerable scope for improved guidance for and training of certifiers, and to explore methods to exploit multiple cause of death data that measure the role of co-morbid conditions in mortality.

References

1. United Nations Department of Economic and Social Affairs. *World Population Ageing 2019*. 2020.

2. United Nations Population Division. *World Population Prospects: The 2022 Revision*. 2022. *World Population Prospects*. https://population.un.org/wpp/

3. Launer LJ. Statistics on the burden of dementia: need for stronger data. *Lancet Neurol*. Jan 2019;18(1):25-27. doi:10.1016/S1474-4422(18)30456-3

4. Australian Institute of Health and Welfare. *Dementia in Australia*. 2012. Cat. no. AGE 70.

5. Brown L, Hansnata E, La HA. *Economic cost of dementia in Australia: 2016-2056*. 2017.

6. Prince M, Ali GC, Guerchet M, Prina AM, et al. Recent global trends in the prevalence and incidence of dementia, and survival with dementia. *Alzheimers Res Ther*. Jul 30 2016;8(1):23. doi:10.1186/s13195-016-0188-8

7. Langa KM, Larson EB, Crimmins EM, et al. A Comparison of the Prevalence of Dementia in the United States in 2000 and 2012. *Jama Intern Med*. Jan 1 2017;177(1):51-58. doi:10.1001/jamainternmed.2016.6807

8. Wolters FJ, Chibnik LB, Waziry R, et al. Twenty-seven-year time trends in dementia incidence in Europe and the United States: The Alzheimer Cohorts Consortium. *Neurology*. Aug 4 2020;95(5):e519-e531. doi:10.1212/WNL.0000000000010022

9. Wu YT, Beiser AS, Breteler MMB, et al. The changing prevalence and incidence of dementia over time - current evidence. *Nat Rev Neurol*. Jun 2017;13(6):327-339. doi:10.1038/nrneurol.2017.63

10. G. B. D. Dementia Forecasting Collaborators. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health*. Jan 6 2022;doi:10.1016/S2468-2667(21)00249-8

11. World Health Organization. *Global Health Estimates 2019*. 2020.

12. World Health Organization. *International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10): 2016 Version*. 2016.

13. Kuller LH, Ives DG. Vital records and dementia. *Neuroepidemiology*. 2009;32(1):70-1. doi:10.1159/000170909

14. World Health Organization. Data from: WHO Mortality Database. 2021. *Geneva,*.

15. G.B.D. Demographics Collaborators. Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950-2019: a comprehensive demographic analysis for the Global Burden of Disease Study 2019. *Lancet*. Oct 17 2020;396(10258):1160-1203. doi:10.1016/S0140-6736(20)30977-6

16. Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (GBD 2019) Results. Accessed 3 February 2021. http://ghdx.healthdata.org/gbd-results-tool

17. G.B.D. Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. Oct 17 2020;396(10258):1204-1222. doi:10.1016/S0140-6736(20)30925-9

18. Naghavi M, Richards N, Chowdhury H, et al. Improving the quality of cause of death data for public health policy: are all 'garbage' codes equally problematic? *Bmc Med*. Mar 9 2020;18(1):55. doi:10.1186/s12916-020-01525-w

19. Mikkelsen L, Phillips DE, AbouZahr C, et al. A global assessment of civil registration and vital statistics systems: monitoring data quality and progress. *Lancet*. Oct 3 2015;386(10001):1395-1406.

20. Adair T, Temple J, Anstey KJ, et al. Is the Rise in Reported Dementia Mortality Real? Analysis of Multiple Cause of Death Data for Australia and the United States. *Am J Epidemiol*. Jun 27 2022;191(7):1270-1279. doi:10.1093/aje/kwac047

21. Gao L, Calloway R, Zhao E, et al. Accuracy of death certification of dementia in population-based samples of older people: analysis over time. *Age Ageing*. Jul 2018;47(4):589-594. doi:10.1093/ageing/afy068

22. Perera G, Stewart R, Higginson IJ, et al. Reporting of clinically diagnosed dementia on death certificates: retrospective cohort study. *Age Ageing*. Sep 2016;45(5):668-73. doi:10.1093/ageing/afw077

23. Dementia Australia. Early diagnosis of dementia. Dementia Australia. Accessed 30 September, 2021. https://www.dementia.org.au/information/diagnosing-dementia/early-diagnosis-of-dementia

24. Lang L, Clifford A, Wei L, et al. Prevalence and determinants of undetected dementia in the community: a systematic literature review and a meta-analysis. *BMJ Open*. Feb 3 2017;7(2):e011146. doi:10.1136/bmjopen-2016-011146

25. Xu Z, Hockey R, McElwee P, et al. Accuracy of death certifications of diabetes, dementia and cancer in Australia: a population-based cohort study. *BMC Public Health*. May 6 2022;22(1):902. doi:10.1186/s12889-022-13304-8

26. Patel V, Prince M. Ageing and mental health in a developing country: who cares? Qualitative studies from Goa, India. *Psychol Med*. Jan 2001;31(1):29-38. doi:10.1017/s0033291799003098

27. World Health Organization. *ICD-11 for Mortality and Morbidity Statistics*. 2022. https://icd.who.int/browse11/l-m/en

28. The Lancet Diabetes Endocrinology. Opening the door to treating ageing as a disease. *Lancet Diabetes Endo*. Aug 2018;6(8):587-587. doi:Doi 10.1016/S2213-8587(18)30214-6

29. Piffaretti C, Moreno-Betancur M, Lamarche-Vadel A, et al. Quantifying cause-related mortality by weighting multiple causes of death. *Bull World Health Organ*. Dec 1 2016;94(12):870-879. doi:10.2471/BLT.16.172189

30. GBD Dementia Collaborators. Global, regional, and national burden of Alzheimer's disease and other dementias, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol*. Jan 2019;18(1):88-106. doi:10.1016/S1474-4422(18)30403-4

Figures

Figure 1: Scatterplot of WHO (reported) dementia death rate versus estimated GBD (expected) dementia death rate (per 100,000), 75+ years, 90 countries, 2000-2019

Note: Dashed line show equivalence between WHO and GBD dementia death rate. Correlation coefficient: male -0·4899 ($p<0.001$), female 0·0064 (non-significant).

Figure 2: Average of WHO reported dementia mortality rate / GBD estimated dementia mortality rate by year, 75+ years, 90 countries, 2000-2019

Supplemental Digital Content

Text S1: Further detail of Methods

Table S1: Available countries and years of dementia data in the WHO Mortality Database

Table S2: WHO reported dementia mortality and GBD estimated dementia mortality age-standardized death rate, by country and sex, 75+ years, most recent year

Table S3: Regression analysis of WHO reported dementia mortality rate / GBD estimated dementia mortality rate, by sex, 90 countries, 2000-2019

Table S4: WHO reported dementia mortality and GBD estimated dementia mortality age-standardized death rate, by sex, 75+ years, Japan, Portugal, Thailand, United Kingdom, 2000-2018

Table S5: Type of dementia mortality reported by country (% of dementia deaths), 75+ years, most recent year

Table S6: Leading three causes by relative difference of CSMF with average age-standardized CSMF, males, countries with ratio of reported to expected dementia age-standardized death rate of less than 10%, most recent year

Table S7: Leading three causes by absolute difference of CSMF with average age-standardized CSMF, males, countries with ratio of reported to expected dementia age-standardized death rate of less than 10%, most recent year

Table S8: Leading three causes by relative difference of CSMF with average age-standardized CSMF, females, countries with ratio of reported to expected dementia age-standardized death rate of less than 10%, most recent year

Table S9: Leading three causes by absolute difference of CSMF with average age-standardized CSMF, females, countries with ratio of reported to expected dementia age-standardized death rate of less than 10%, most recent year