

# Reducing the Number of People with Dementia Through Primary Prevention in Mozambique, Brazil, and Portugal: An Analysis of Population-Based Data

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Accepted 21 November 2018

## Abstract.

**Background:** Most people with dementia live in low- and middle-income countries and little is known about the potential for reducing these numbers by reducing key risk factors.

**Objective:** To investigate the potential for dementia incidence reduction in Brazil, Mozambique, and Portugal (a culturally related, high-income country).

**Methods:** We replicated previously published methods and based on the relative risks from previous studies, we estimated the population-attributable risk (PAR) of dementia in Mozambique, Brazil, and Portugal for seven modifiable risk factors associated with dementia (low educational attainment, physical inactivity, midlife hypertension, midlife obesity, depression, smoking, and diabetes mellitus). The combined PAR was calculated and adjusted for associations between risk factors. The potential for risk factor reduction was assessed by examining the effect of relative reductions of 10% and 20% per decade for each of the risk factors on projections for dementia cases for each decade until 2050.

**Results:** After adjusting for non-independence of risk factors, 24.4%, 32.3%, and 40.1% of dementia cases could be related to seven potentially modifiable risk factors in Mozambique, Brazil, and Portugal, respectively. Reducing the prevalence of each risk factor by 20% per decade could, by 2050, potentially reduce the prevalence of dementia in Mozambique, Brazil, and Portugal by 12.9%, 16.2%, and 19.5%, respectively.

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**Conclusion:** There is a substantial difference between the countries on in the percentage of dementia cases that could be attributable to the seven potentially modifiable risk factors. The proportion of cases that could be prevented by 2050 if measures were taken to address these main risk factors was higher in Portugal than in Brazil and Mozambique. Each country or region should consider their unique risk factor profile when developing dementia risk reduction programs.

Keywords: Alzheimer's disease, dementia, low- and middle-income countries, prevention, risk reduction

## INTRODUCTION

The number of people living with dementia is increasing rapidly worldwide. It has been estimated that around 50 million people had dementia in 2017, and this number is expected to reach 131.5 million in 2050 [1]. About 58% of these individuals are living in low- and middle-income countries (LMICs) and this is expected to rise to 68% by 2050. Attempts to stop its progression or cure dementia have so far failed, meaning that delaying the disease onset is currently the only way to reduce the number of people affected by this set of conditions in the near future [2].

Around a third of dementia cases may be attributable to potentially modifiable risk factors and the incidence of the disease might be reduced by targeting these. The most important are cardiovascular related risk factors (e.g., physical inactivity, smoking, midlife hypertension, midlife obesity, and diabetes), education level, and depression [2, 3]. Delaying the onset of dementia by one year is likely to reduce the prevalence of dementia by 11% by 2050. If the incidence could be delayed by five years, the total number of people living with dementia could be halved by 2050 [4]. However, the common risk factors for dementia have been established based on data from high-income countries [2], and it is unclear which factors will have an effect on dementia prevalence in LMICs. These countries have different demographic and epidemiological profiles, which might have important implications for the effectiveness of preventive actions.

Brazil, Mozambique, and Portugal are three Lusophone countries that have markedly different demographic, epidemiological, and economic conditions. Brazil is a middle-income country with a life expectancy of almost 75 years of age and with an older population (over 65) of around 12% [5]. Life expectancy in Brazil will reach 82 years of age by 2050, when 29% of the population will be aged over 65. Mozambique, on the other hand, is a low-income country with a life expectancy of 56 years of age and an older population (over 65) of around 5% [6]. Their life expectancy is expected to increase to 69 by

2050, when the proportion of older people will reach 6%. Portugal is a high-income country that has a life expectancy of 82 years of age and 27% are aged over 65. By 2050, these figures are expected to increase to 87 and 41%, respectively [7].

Understanding the relationship between the prevalence of risk factors and dementia prevalence in LMICs countries is important to inform public policy and take cost-effective steps to help reduce the high prevalence of this condition in the future and the consequent financial burden imposed on such countries. The prevalence of several communicable diseases, such as malaria and HIV, is still high in many LMICs and so their public health priorities may be quite different to those of the high-income countries. It is important to know the probable impact of measures to address dementia risk factors in order to develop the most effective policies and strategies for each context. This study therefore aimed to investigate the potential for dementia incidence reduction in Brazil, Mozambique, and Portugal by using existing data to estimate the population-attributable risk (PAR) of dementia for seven potentially modifiable risk factors in each of these countries.

## METHODS

We replicated the methodology of Barnes and Yaffe [8] and Norton et al. [2] for our estimates and the same seven main risk factors, which were based on a systematic review and meta-analyses of the most prevalent modifiable risk factors for Alzheimer's disease. Although the study considered only the modifiable risk factors for Alzheimer's disease while we in our study consider the prevalence of dementia in general, it is generally accepted that the seven risk factors can be applied to the most common forms of dementia in the older populations as they are mixed in nature [3]. We selected Mozambique, Brazil, and Portugal for our estimates, to reflect low, middle, and high-income countries that are culturally related. The prevalence of each of the seven risk factors in Brazil, Mozambique, and Portugal were taken from various population-derived sources, including the National

Table 1  
Relative risks for dementia and shared variance between risk factors

Risk Factor	Definition used	Relative risk (95% CI)	Communality
Diabetes mellitus	Adult prevalence of diagnosed diabetes mellitus between the ages of 20 years and 79 years	1.46 (1.20–1.77)	50.9%
Midlife hypertension	Adult midlife prevalence of hypertension between the ages of 35 years and 64 years	1.61 (1.16–2.24)	65.0%
Midlife obesity	Adult midlife prevalence of body-mass index greater than 30 kg/m <sup>2</sup> between the ages of 35 years and 64 years	1.60 (1.34–1.92)	43.7%
Physical inactivity	Proportion of adults who do not do either 20 min of vigorous activity on 3 or more days or 30 min of moderate activity on 5 or more days per week	1.82 (1.19–2.78)	49.0%
Depression	Lifetime prevalence of major depressive disorder using Diagnostic and Statistical Manual of Mental Disorders or International Classification of Diseases criteria	1.65 (1.42–1.92)	37.4%
Smoking	The proportion of adult smokers	1.59 (1.15–2.20)	58.1%
Low educational attainment	The proportion of adults with an International Standard Classification of Education 15 level of 2 or less (pre-primary, primary, and lower secondary education)	1.59 (1.35–1.86)	45.6%

Based on Norton et al. [2].

118 Sample Household Survey (PNAD) and the National  
119 Health Survey (PNAS) in Brazil [5], as well as pub-  
120 lished epidemiological studies from Mozambique  
121 [9–14] and Portugal [7, 15–19]. Table 1 lists the inves-  
122 tigated risk factors, their relative risks and shared  
123 variance.

### 124 Statistical analysis

125 To estimate the proportion of cases of dementia  
126 that can be attributable to each risk factor, we cal-  
127 culated the PAR based on previous publications [8,  
128 19]. Using the same methods as Barnes and Yaffe [8]  
129 and Norton et al. [2], the PAR for each of the risk  
130 factors was calculated using the formula presented  
131 in (a), and then combined to obtain the PAR<sub>combined</sub>,  
132 using the formula in (b), which shows the proportion  
133 of cases of dementia attributable to the seven risk fac-  
134 tors. However, the PAR<sub>combined</sub> formula assumes the  
135 independence of each risk factor. This is not represen-  
136 tative for people with dementia, since one individual  
137 may present with more than one risk factor at the  
138 same time (e.g., hypertension and diabetes mellitus).  
139 To account for the non-independence of the risk fac-  
140 tors, the PAR<sub>AdjustedCombined</sub> formula (c) weights the  
PAR for each risk factor by using communality [2].

(a)  $PAR = (\text{prevalence of risk factor} \times (RR - 1)) / (1 + \text{prevalence of risk factor} \times (RR - 1))$

(b)  $PAR_{\text{combined}} = 1 - \Pi$  1 - PAR, where  $\Pi$  implies subtraction of one minus the risk factor, and then multiply each of the results

(c)  $PAR_{\text{AdjustedCombined}} = 1 - \Pi$  1 - (w × PAR), where the weight (w) was computed using the estimate of 1 minus the proportion of the variance shared with the other risk factors, which is the communality.

141 The communalities were obtained via principal  
142 components analysis of the inter-risk-factor tetra-  
143 choric correlation matrix of data derived from data of  
144 surveys containing measurements for each risk factor.  
145 In our analysis, we used the same communality scores  
146 from Norton et al. [2]. The total number of demen-  
147 tia cases was obtained through multiplying the total  
148 number of persons aged 65 years old or above (num-  
149 bers available in <http://www.worldometers.info>) by  
150 the prevalence of dementia in each country: 3.5% in  
151 Mozambique, 7.0% in Brazil, and 9.2% in Portugal  
152 [1, 20, 21]. The number of dementia cases attributable  
153 to each risk factor was then estimated by multiplying  
154 the PAR estimates by the present number of demen-  
155 tia cases in each country. To estimate the potential  
156 reduction of dementia cases in the future by reducing  
157 the prevalence of risk factors, we calculated a 10% or  
158 20% reduction of the relative prevalence of each risk

Table 2  
Estimates for population-attributable risk and number of attributable cases

Country	Prevalence	PAR (95% CI)	Number of attributable cases in 2010 (95% CI) in thousands
<b>Mozambique</b>			
Diabetes mellitus	2.9%	1.3% (0.6–2.2)	0.344 (0.159–0.582)
Midlife hypertension	10.6%	6.1% (1.7–11.6)	1.614 (0.450–3.070)
Midlife obesity	1.5%	0.9% (0.5–1.4)	0.238 (0.132–0.371)
Physical inactivity	9.3%	7.1% (1.7–14.2)	1.879 (0.450–3.758)
Depression	10.7%	6.5% (4.3–9.0)	1.720 (1.138–2.382)
Smoking	21.4%	11.2% (3.1–20.4)	2.964 (0.820–5.399)
Low educational attainment	44.9%	20.9% (13.6–27.9)	5.532 (3.600–7.384)
Combined		44.0% (23.4–61.8)	11.645 (6.193–16.357)
Adjusted combined		24.4% (12.9–36.1)	6.458 (3.414–9.555)
<b>Brazil</b>			
Diabetes mellitus	6.2%	2.8% (1.2–4.6)	25.976 (11.133–42.675)
Midlife hypertension	7.4%	4.3% (1.2–8.4)	39.892 (11.133–77.928)
Midlife obesity	7.5%	4.3% (2.5–6.4)	39.892 (23.193–59.374)
Physical inactivity	46.0%	27.4% (8.0–45.0)	254.193 (74.217–417.470)
Depression	7.6%	4.7% (3.1–6.5)	43.602 (28.759–60.301)
Smoking	15.0%	8.1% (2.2–15.3)	75.145 (20.410–141.940)
Low educational attainment	45.1%	21% (13.6–27.9)	194.819 (126.169–258.831)
Combined		55.3% (28.3–74.3)	513.024 (262.542–689.289)
Adjusted combined		32.3% (15.8–46.3)	299.651 (146.578–429.530)
<b>Portugal</b>			
Diabetes mellitus	9.8%	4.3% (1.9–7.0)	7.844 (3.466–12.770)
Midlife hypertension	19.8%	10.8% (3.1–19.7)	19.702 (5.655–35.938)
Midlife obesity	15.7%	8.6% (5.1–12.6)	15.689 (9.304–22.986)
Physical inactivity	53.9%	30.7% (9.3–49.0)	56.005 (16.966–89.390)
Depression	16.7%	9.8% (6.6–13.3)	17.878 (12.040–24.263)
Smoking	20.0%	10.6% (2.9–19.4)	19.337 (5.290–35.391)
Low educational attainment	46.4%	21.5% (14.0–28.5)	39.222 (25.540–51.992)
Combined		65.8% (36.2–83.4)	120.038 (66.039–152.145)
Adjusted combined		40.1% (20.7–55.4)	73.154 (37.763–101.065)

factor per decade and multiplied this by the number of dementia cases for that year. We used the same proportion of risk factor reduction and same timeline for projections as Norton et al., 2014 [2] to allow comparisons.

## RESULTS

Table 2 shows estimates of the PAR for dementia for each risk factor and the proportion of attributable cases in Portugal, Brazil, and Mozambique in 2010. As low educational attainment was similarly highly prevalent in the three countries, it was estimated that 2 in 10 cases of dementia were attributable to this risk factor. While physical inactivity was responsible for almost 3 in 10 cases of dementia in Portugal and Brazil, this was attributable to less than 1 in 10 cases in Mozambique. Midlife hypertension was more prevalent in Portugal (19.8%) than in Brazil (7.4%) and Mozambique (10.6%), contributing to about 1 in 10 cases of dementia in Portugal, but less than 1 in 10 in Brazil and Portugal.

Midlife obesity accounted for 8.6% and 4.3% of cases of dementia in Portugal and Brazil, respectively, while this estimate was as low as 0.9% in Mozambique due to a much lower prevalence of this risk factor in that country. Smoking accounted for around 10% of the cases of dementia in the three countries, while depression accounted for almost 10% of cases in Portugal, but for only 4.7% of cases in Brazil and 6.5% in Mozambique. Diabetes was among the least prevalent risk factor in all three countries, contributing to 1.3%, 2.8%, and 4.3% of cases of dementia in Mozambique, Brazil, and Portugal, respectively. If we consider that each risk factor contributes to dementia prevalence independently, the seven risk factors accounted for 44.0% of dementia cases in Mozambique, 55.3% in Brazil, and 65.8% in Portugal. The communality scores for risk factor attribution in the three countries were high (from 37.4% to 65.0%, Table 1) and so the non-independent attributable number of cases was much lower in all the three countries (24.4% in Mozambique, 32.3% in Brazil, and 40.1% in Portugal).

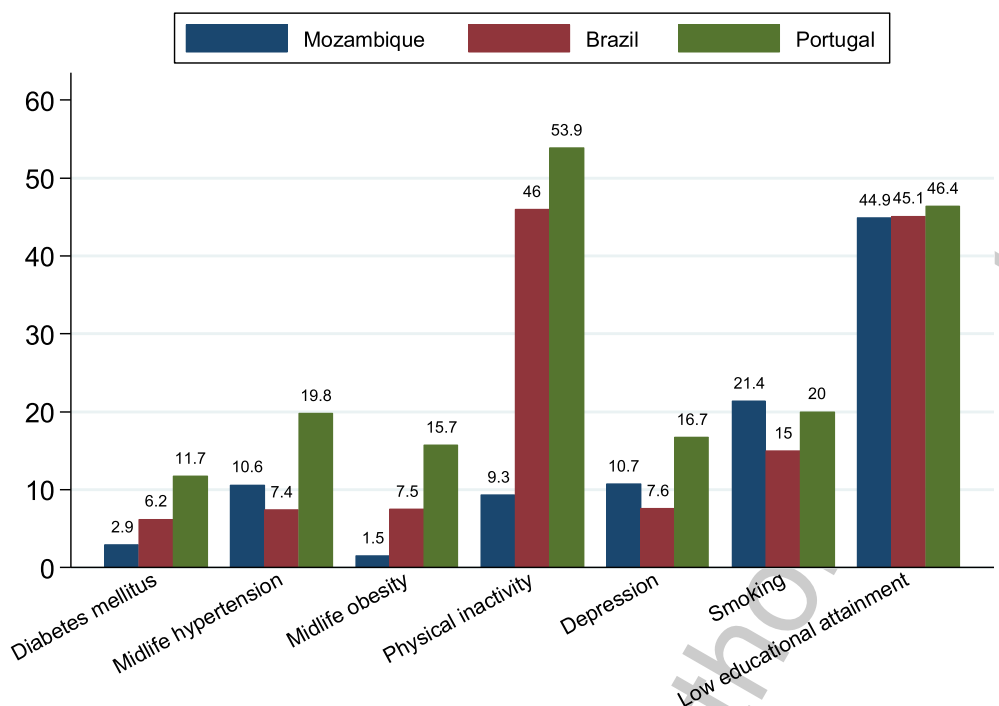


Fig. 1. Prevalence of risk factors for dementia in each country.

201 Considering a reduction of 10% in the prevalence  
 202 of these seven risk factors by 2020, combined with  
 203 the projections of population ageing in each country,  
 204 there could be a reduction in the number of cases  
 205 of dementia in Mozambique, Brazil, and Portugal  
 206 of 1.9%, 2.3%, and 2.7%, respectively (Supplemen-  
 207 tary Table 1 and Fig. 2). By 2050, the prevalence  
 208 of dementia could be reduced by 7.0%, 8.7%, and  
 209 10.2% in the three countries. If the reduction in the  
 210 prevalence of these risk factors was as high as 20%,  
 211 there would be a reduction of 12.9% of dementia in  
 212 Mozambique, 18.1% in Brazil, and 20.9% in Portu-  
 213 gal. Considering that the number of people with  
 214 dementia is estimated to increase from 1.14 to 4.13  
 215 million by 2050 in these three countries combined,  
 216 around 676 thousand cases could be prevented with a  
 217 20% reduction in the prevalence of these risk factors  
 218 by 2050.

## 219 DISCUSSION

220 This is the first study to investigate the potential  
 221 for dementia incidence reduction in Mozambique,  
 222 Brazil, and Portugal by estimating the population-  
 223 attributable risk for seven potentially modifiable risk  
 224 factors (low educational attainment, physical inactiv-

ity, midlife hypertension, midlife obesity, depression,  
 225 smoking, and diabetes mellitus). After adjusting for  
 226 the non-independence of risk factors, the findings  
 227 suggest that 24.4%, 32.3%, and 40.1% of dementia  
 228 cases can be explained by seven potentially  
 229 modifiable risk factors in Mozambique, Brazil, and  
 230 Portugal, respectively. Reducing the prevalence of  
 231 each risk factor by 10% or 20% per decade could  
 232 potentially reduce the prevalence of dementia in 2050  
 233 by 7.0 or 12.9% in Portugal, 8.7 or 16.2% in Brazil,  
 234 and 10.2 or 19.5% in Portugal. This has impor-  
 235 tant implications for public health preventive actions,  
 236 which could use this information to focus resources  
 237 on the clinical and life style risk factors most respon-  
 238 sible for potential increased numbers of people with  
 239 dementia locally.

240 Given the equally high prevalence of low educa-  
 241 tional attainment in Mozambique, Brazil, and Portugal  
 242 (about 45%), this risk factor accounted similarly for  
 243 a large proportion of cases of dementia in all three  
 244 countries (about 20%). There was, however, a clear  
 245 difference between them regarding the other risk fac-  
 246 tors and after adjusting for non-independence of risk  
 247 factors 24.4%, 32.3%, and 40.1% of dementia cases  
 248 could be explained by seven potentially modifiable  
 249 risk factors in Mozambique, Brazil, and Portugal  
 250 respectively. The adjusted PAR we found for Portugal  
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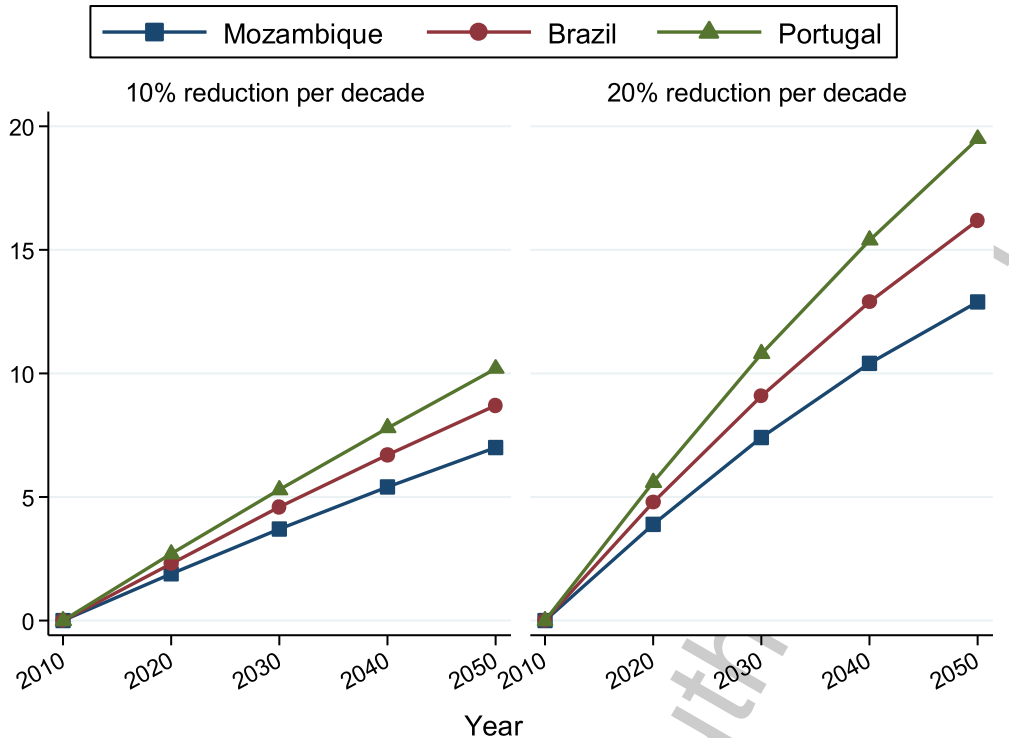


Fig. 2. Differences in estimated reduction of numbers of cases of dementia with 10% or 20% reduction per decade in the relative prevalence of the seven risk factors.

(40.1%) appears to be overall higher when compared to two other high-income countries, using similar risk factors (UK: 30% and USA: 30.6%) [2], but closer to what was found for Australia (48.4%) [22] with a similar profile of risk factors contributing the most to current cases (physical inactivity and midlife hypertension). Low educational attainment was the only risk factor with similar prevalence and dementia population-attributable risk in the three countries, and it is a social determinant of many health-related behaviors and outcomes, including physical inactivity. Comparing previous studies using a similar methodology [2, 22], with the same seven risk factors considered, physical inactivity had the highest PAR in the USA (21%), followed by the UK (20%), and Australia (17.9%). This was also the case in this study for Portugal (PAR = 30.7%) and Brazil (PAR = 27.4%) but not for Mozambique (PAR = 7.1). Considering the gradual increases in income levels in Mozambique (low-income), Brazil (middle-income), and Portugal (high-income), it is interesting to note a parallel shift in the respective epidemiological profiles towards an increase in the prevalence of chronic conditions and physical inactivity. Overall, countries with lower incomes have less access to transport and technolog-

ical resources, as well as industrialized food; these countries' populations may also have more agricultural activities or other jobs relying on physical effort; which might explain their lower prevalences of chronic diseases and higher levels of physical activity. On the other hand, such countries also have lower life expectancy and so we do not know for certain whether individuals would develop or would be exposed to some of the risk factors considered in this study and whether these would lead to dementia were their populations to live longer. Nonetheless, there is a 'window of opportunity' for lower-income countries to plan and implement actions that might interrupt this pattern by preventing people becoming less physically active, more obese, and of having hypertension and diabetes in the future. Increasing physical inactivity is likely to reduce obesity, hypertension, depression, and diabetes [23], contributing to large scale dementia risk reduction.

The strengths and limitations of the methods used to estimate the number of cases of dementia attributable to potentially modifiable risk factors in this study have been pointed out previously [2]. For example, the relative risk estimates are based on secondary data and the causes for several of the risk

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factors analyzed are unclear. There is also the fact that the prevalence of many of the dementia risk factors results from life-long experiences and the exact impact of improving each of these risk factors in different age groups is unclear. A longitudinal approach to these estimates accounting for several other interacting variables is needed. The prevalence estimates of the seven risk factors was taken from published studies, which have some limitations, including country representativeness. Dementia in LMICs is still under researched and underdiagnosed [24] so the prevalences used in the calculations might not represent the true number of people living with the condition in these areas, which might have affected the estimates provided. Although the adjusted combined estimates are robust, further research is needed to confirm these findings and the low-, middle-, and high-income countries comparisons could be expanded by gathering data from more countries. This study used the number of people living with all types of dementia in Portugal, Brazil, and Mozambique, so conclusions cannot be drawn about the impact of the seven investigated risk factors on each cause of dementia (e.g., vascular versus Alzheimer's disease). However, it has been argued that such risk factors are likely to contribute to more than one type of dementia and previous studies have shown that multi-domain approaches to dementia prevention are more likely to reduce the prevalence of the condition [25]. Such interventions may benefit cognition regardless of individual sociodemographic characteristics and vascular risk and can be implemented in large populations. This suggests that estimating the impact of risk factors on the prevalence of all types of dementia together might provide valuable predictions to inform public health actions aimed at reducing the number of people living with any type of dementia. This study did not consider other potential modifiable risk factors which may also contribute to dementia risk, such as diet, social isolation, sensory loss, air pollution, and sleep quality.

Our findings highlight the need for policy makers and public health services to understand and consider windows of opportunity to reduce different risk factors throughout lifespan globally and within diverse cultural and economic contexts. Most of the modifiable risk factors contributing to the highest rates of dementia in low-, middle-, and high-income countries are partly dependent on behavior change and policies are needed to strengthen public health actions. Global actions are needed to tackle the increasing prevalence of dementia worldwide and there is currently

little research on the potentially modifiable risk factors for dementia in low- middle-income countries, where the number of people living with dementia are the highest.

The biological, environmental, social, and psychological interplay between the numerous risk factors and dementia onset is complex. The socioeconomic situation of many LMICs can be a limiting factor for dementia prevention as education and lifestyle are ultimately linked. Working towards dementia risk reduction is likely to help prevent several other chronic diseases and so there is a large potential for collaboration across and within health and social sectors which may optimize resources and effectiveness. Future research should focus on exploring the effects of such risk factors on dementia across lifespan and on the relationships among these different factors in respect of dementia onset in LMICs. Economic evaluations of dementia risk reduction in such countries are also likely to contribute to the development of affordable preventive practices for dementia [26].

### Conclusions

The proportion of cases potentially preventable by acting upon the seven risk factors studied was greater in Portugal than in Brazil, and in Brazil was greater than in Mozambique. This finding might have been a reflection of the gradient found in the proportion of current cases attributable to the seven risk factors studied and of the substantial differences found in the prevalence of each risk factor in each country. Our findings partially reflect the demographic and epidemiological transition stage of the countries studied, with a gradual parallel increase in the prevalence of the chronic conditions and unhealthy behaviors associated with dementia. All three countries need to improve the education levels of their populations, and higher-income countries need an urgent approach to improving physical activity. Different countries and regions may need to pursue different strategies for dementia risk reduction based on their unique demographic and risk factor profiles.

Future research should focus on exploring the effects and impact of such risk factors on dementia across lifespan and on the relationships among these several factors in respect of dementia onset in LMICs. Also, larger study of groups from low-, medium-, and high-income countries, using good quality data from local well conducted studies on the national prevalence of each risk factor are required to explore these relationships in more detail.

## ACKNOWLEDGMENTS

JL is supported by the Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro (FAPERJ) and by Conselho Nacional de Pesquisa (CNPq) and CF by the Conselho Nacional de Pesquisa (CNPq) and Associação Fundo de Incentivo a Pesquisa (AFIP).

Authors' disclosures available online (<https://www.j-alz.com/manuscript-disclosures/18-0636r1>).

## SUPPLEMENTARY MATERIAL

The supplementary material is available in the electronic version of this article: <http://dx.doi.org/10.3233/JAD-180636>.

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