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Original Research

Valuing preventable deaths from major non-communicable diseases and all causes associated with sedentary behavior in Argentina

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ABSTRACT

Objective: This study estimated the population attributable fractions, preventable deaths, and indirect economic costs from major non-communicable diseases (NCDs) and all causes associated with excessive sitting time in Argentina in 2019.
Methods: Population attributable fractions were used to calculate preventable deaths from NCDs and all causes associated with prolonged sitting time (≥6 h/d). Then, the human capital approach was used to quantify the present value of lifetime earnings, which was subsequently used to calculate indirect costs due to lost productivity. A Monte Carlo simulation was performed in three counterfactual scenarios to evaluate the sensitivity of the results.
Results: In Argentinian men and women, respectively, approximately 11.3% (381) [10% (290)] of deaths from colon cancer, 4.4% (250) from breast cancer (women only), 4.6% (588) [4.4% (402)] from coronary heart disease, 30.5% (1390) [27% (1047)] from diabetes, and 14.9% (24,686) [13.7% (21,418)] from all causes could have been avoided annually by eliminating excessive sitting time. The indirect economic costs of excessive sitting time reached 0.025% (0.019%–0.032%) and 0.37% (0.25–0.58%) of GDP for major NCDs and all causes, respectively. High levels of heterogeneity were found at the regional level.
Conclusion: Prolonged sitting time generates substantial societal costs. Public policies aimed at reducing excessive sedentary behavior in the overall population, especially in the most affected regions, would represent considerable savings for society as a whole. Such initiatives should address the complex and multifactorial causes of sedentary behavior, the clear gender and age differences in this behavior, and the factors underlying these differences.

Introduction

Non-communicable diseases (NCDs) generate a large social cost globally. Each year, worldwide deaths from NCDs account for nearly 15 million people aged between 30 and 69 years, 85% of which occur in low-income and middle-income countries.[1] In addition, projections indicate that the worldwide economic burden of lives lost due to NCDs will increase to US$43.4 billion by 2030 (from a 2010 baseline of US$6.7 million).[2] For the Latin American region (Argentina, Brazil, Colombia, and Mexico), the cumulative loss of GDP due to cardiovascular diseases and diabetes has been estimated at approximately US$13.54 billion.[3]

Physical inactivity is a well-known risk factor associated with an increased burden of NCDs and all-cause mortality. It has been estimated that if World Health Organization recommendations (<600 METs min/wk) are achieved in Argentina, between 2813 and 3111 potential deaths could be avoided, approximately 80 fewer years of life would be lost (per 100,000 inhabitants), and average life expectancy could increase by 0.23 years.[4] In addition, it has been estimated that annual economic losses due to cardiovascular deaths associated with physical inactivity reached 1197 million international dollars in 2014.[5]

Sedentary behavior—defined as low energy expenditure activities equivalent to ≤1.5 METs while in a sitting, reclining, or lying position—[6] has been identified as an independent risk factor for a large burden of premature deaths from NCDs (e.g. colon and breast cancer, cardiovascular disease, and type 2 diabetes) and all causes.[7,8] Notably, even individuals who meet public health

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recommendations for physical activity may still spend a considerable amount of time engaging in sedentary behaviors. Therefore, sedentary behavior has gained attention from the scientific community and has been incorporated into global health guidelines for over a decade.[9]

The most common subcomponent of sedentary behavior is sitting time (hereinafter, both terms are used interchangeably), which can be spent on various activities, such as traveling, attending school, working, or watching TV.[10] Epidemiological evidence indicates that sitting time (>3 h/d) accounts for 3.8% of all-cause mortality (approximately 433,000 deaths per year) worldwide.[11] In turn, sitting time not only increases global mortality but also represents a significant economic burden. In Finland, the direct costs of major NCDs attributable to high levels of sedentary behavior (>7 h/d) were quantified at €469 million, and the indirect costs were estimated at €1034 million.[12] Meanwhile, in the United Kingdom, the total direct costs attributable to prolonged sedentary behavior (≥6h/d) were quantified at £800 million, including £424 million for cardiovascular disease, £281 for type 2 diabetes, £30 for colon cancer, £19 for lung cancer, and £7 for endometrial cancer.[8]

To date, there has been no comprehensive assessment of the heterogeneity of mortality-related productivity losses attributable to excessive sitting time. Because many physical activity–related health policy decisions are made at a regional or national level, focusing on the most vulnerable populations, detailed information on the preventable deaths and economic costs of sitting time at both levels, and identifying target populations can be useful for public health planners and policymakers. As the evidence at both scales is limited, this study fills this evidence gap by estimating four indicators of the burden of prolonged sitting time on public health due to NCDs and all-cause deaths. First, population attributable fractions (PAFs) were calculated from the prevalence of sitting time, which was measured through a national survey, and the relative risks (RRs) of each NCD and all-cause mortality. From this, preventable deaths (PDs) were quantified for each health outcome. Then, the valuation of PDs was conducted using the human capital approach, which is widely used for the monetary assessment of mortality risk and plays a key role in cost–benefit evaluations of public health policies.[13] Finally, economic costs were computed, and a sensitivity analysis was performed.

Methods

Data

Population-level sedentary behavior data

Data from the 2018 National Risk Factor Survey (NRFS; $n = 29{,}224$) were used for the present analysis (for open access, visit https://www.indec.gob.ar/bases-de-datos.asp). This is a face-to-face survey administered nationally using a multistage probability sample and the national urban sampling framework. The target population comprises persons aged ≥18 years living in urban areas with at least 5000 inhabitants. The NRFS contains a specific module in which the International Physical Activity Questionnaire-Short Form (IPAQ-SF) is used to collect information on the amount of time an individual spends sitting, which was used as a proxy for sedentary behavior. The survey includes the following question: "How much time per day do you usually spend sitting, for example at home, at work, or at school? [In minutes per day]". To ensure consistency with the other data resources, only the data of adults aged 20 to >74 years who responded to the IPAQ-SF were used for the present analysis. Following IPAQ-SF recommendations, observations of sitting times greater than 960 min (16 h/d) were eliminated, as this length of sitting time implies that an individual spends an average of 8 h/d sleeping.[14] Then, the prevalence of sitting for <6 h/d and ≥6 h/d were computed. These cutoffs were based on the RR estimates used hereinafter. To ensure that the sampling distribution was nationally representative, the prevalence of sitting time was weighted by the expansion factor provided by the NRFS.

RR data

RRs for colon and breast cancer,[8,15] coronary heart disease,[16] type 2 diabetes, and all causes[8] (Supplementary Table S1) were retrieved from different dose–response meta-analyses of prospective cohort studies. All these data were classified under two cutoff points of sitting time: <6 h/d and ≥6 h/d. The <6 h/d category was selected as the benchmark for the theoretical minimum risk exposure levels, which assume that there are no additional benefits of reducing exposure to the risk factor.

Death data

Data on observed deaths (20 to >74 years of age) from 2018 were collected from the vital statistics database developed by the National Directorate of Health Statistics and Information, and these data were classified according to underlying cause, age, gender, and region.[17] The 10th revision of the International Statistical Classification of Diseases (ICD-10) was used to classify PDs according to the following underlying causes: CHD (ICD I20–I25), breast cancer (ICD C50) for women, colon cancer (ICD C18), type 2 diabetes (ICD E11 and E14), and all causes (ICD A00–Y89). Data consistency was assessed by cross-checking the number of deaths with the official statistics aggregated at the region–age level.[18] No statistically significant differences were found.

Population data

Population data were obtained from the 2001 and 2010 censuses.[19,20] Linear interpolation was used to obtain the data for 2018 by assuming a constant intraperiod annual population growth rate.

Income data

Income data were extracted from the Permanent Household Survey for 2019, the most important survey to collect socio-economic information in Argentina at the national level. This survey retrieves information quarterly through a stratified probabilistic sample. The main variable extracted for the present analysis was monthly income from labor sources for all occupations. Only positive income was taken into account for men aged 20–64 years and women aged 20–60 years (retirement age cutoff). In computing the mean annual income by age and sex, the expansion factors provided by the Permanent Household Survey were used to minimize the effect of income non-response.

Statistical analysis

Estimation of PAFs and PDs

Adjusted PAFs were calculated with the following equation:

$$PAF^{i}_{a,g,r} = \frac{(P_{a,g,r})\left[\left(RR^{i}_{adj}\right) - 1\right]}{\left(RR^{i}_{adj}\right)} \quad (1)$$

where $P_{a,g,r}$ denotes the proportion of sitting time for the exposure analyzed (≥6 h/d of sitting time) among cases within a particular age group (a), gender (g), and region (r). Meanwhile, RR^{i}_{adj} indicates the adjusted RR for each NCD of interest (i) when comparing people with different exposure levels.[21] Given that the PAF equation requires the prevalence of sitting time between cases (i.e. deaths) and not the population of origin (i.e. the prevalence from the NRFS), each population prevalence obtained from the NRFS was corrected for an adjustment factor (Supplementary Table S1), which was derived from previous studies and multiplied by the prevalence of sitting time.[8,22] Then, PDs were calculated with the following equation:

$$PD^{i}_{a,g,r} = \left(PAF^{i}_{a,g,r}\right)\left(D^{i}_{a,g,r}\right) \quad (2)$$

where $D^{i}_{a,g,r}$ is the number of observed deaths. All specific $PAF^{i}_{a,g,r}$ and $PD^{i}_{a,g,r}$ values were computed by age group (a), gender (g), region (r), and cause (i).

Present value of lifetime earnings and economic costs

The human capital approach was used to convert lives that could be saved through reduced sitting time by estimating the present value of lifetime earnings (PVLE). This approach is based on the valuation of life in terms of lost productivity using market

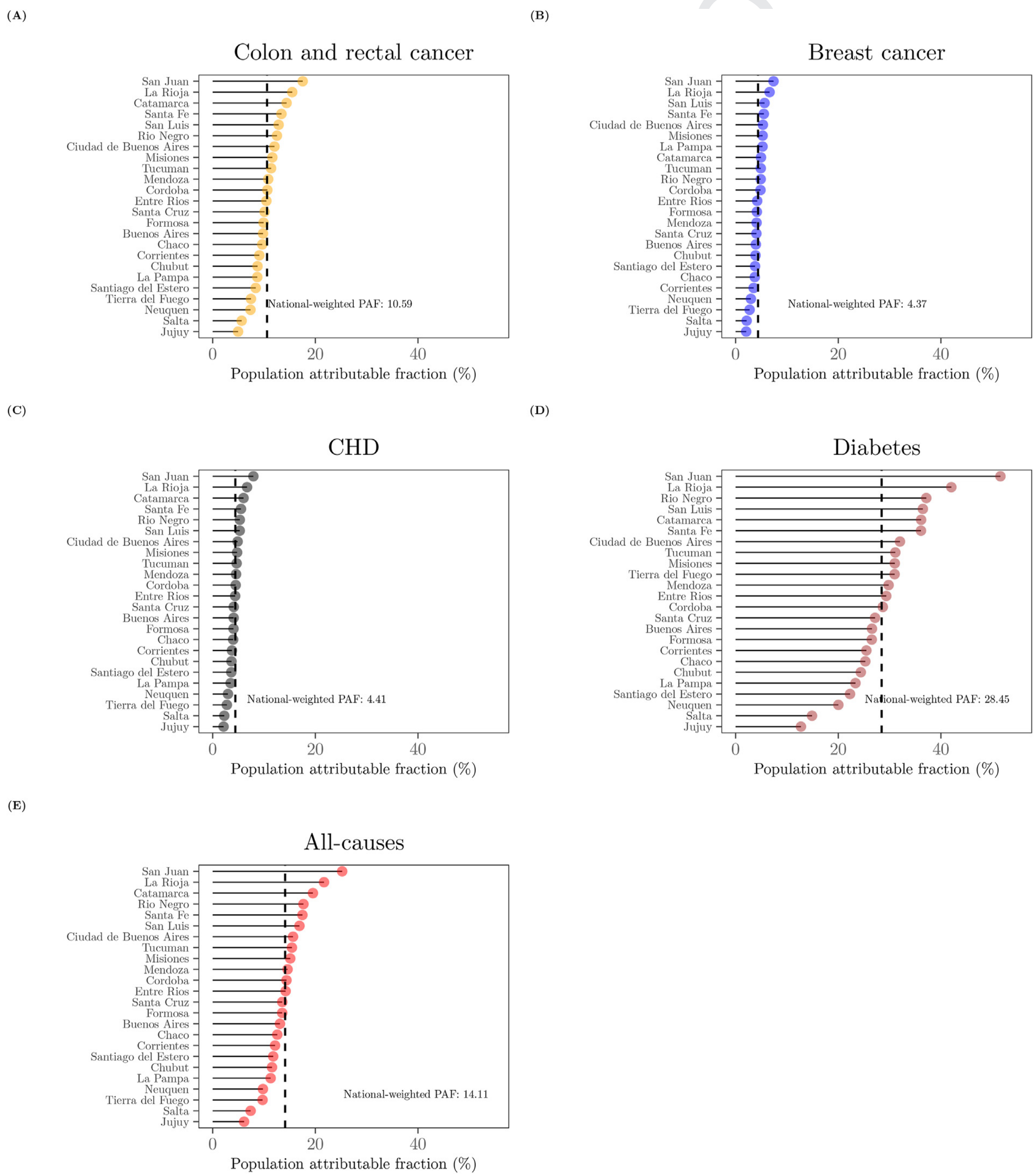

Fig. 1. Population attributable fractions for excessive sitting time associated with NCDs and all causes of mortality across regions. Breast cancer was considered only for women (Panel B). Types of NCDs shown: colon cancer (yellow), breast cancer (women only; violet), CHD (gray), diabetes (light brown), and all causes (light red). CHD, coronary heart disease; NCDs, non-communicable diseases. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

income. As such, the value of life is measured as a stream of future income discounted to the present and can be computed with the following equation:

$$PVLE_{j,g,(c)} = \sum_{j=n}^{64} p(alive)^{j}_{n,g} \cdot income_{j,g} \cdot \left(1+g_{(c)}\right)^{j-n} \cdot \left(\frac{1}{1+r_{(c)}}\right)^{j-n} \quad (3)$$

where $p(alive)^{j}_{n,g}$ is the probability that a person of age (n) will be alive at age (j), which was estimated using Grushka's actuarial tables.[23] The variable $income_{j,g}$ is the mean annual labor income of persons at age (j), g is the mean income growth rate, and r is the discount rate. The growth rate of mean labor source income was calculated as the average value of GDP per capita growth from 1983 (return to democracy) to 2020. An average discount rate of 3% was chosen, as it was considered moderate. Once all PVLEs were computed, they were aggregated at the age group level, weighted by the population for each age and sex.

Then, a sensitivity analysis was performed in three counterfactual scenarios (c) to evaluate how the output (PVLE) changed when the inputs were varied. To carry out this analysis, a Monte Carlo simulation was performed with 25,000 iterations and a triangular distribution reflecting different scenarios regarding the variability of the chosen values. Regarding the inputs, a lower limit of 1% and a maximum of 5% were set for the growth rate of mean labor income and the discount rate, as recommended for sensitivity analyses in studies with the same approach.[24] Finally, the economic costs were calculated as follows:

$$EC^{i}_{a,g,r,(c)} = PD^{i}_{a,g,r} \cdot PVLE_{a,g,(c)} \quad (4)$$

where $EC^{i}_{a,g,r,(c)}$ is the indirect economic cost due to PDs associated with lost productivity attributable to sitting time for each cause of death. To assess heterogeneity at the regional level, economic costs per death were calculated by dividing economic costs by observed deaths for each cause. All analyses were performed using Stata (version 15.0; StataCorpLP, College Station, TX) and RStudio (version 1.4.1106; RStudio Inc., Boston, MA).

Results

In 2018, approximately one-fifth (22.08%) and slightly more than one-third (36.13%) of Argentina's adult population displayed excessive sedentary behavior. In this cohort, men (31.47%) outnumbered women (26.33%;Supplementary Table S2).

Among Argentinian men and women, respectively, approximately 11.3% (381) [10% (290)] of deaths from colon cancer, 4.4% (250) from breast cancer (women only), 4.6% (588) [4.4% (402)] from CHD, 30.5% (1390) [27% (1047)] from diabetes, and 14.9% (24,686) [13.7% (21,418)] from all causes could have been avoided annually by eliminating excessive sitting time. When disaggregated by age, the greatest PD savings were projected to occur in those over 60 years of age (Supplementary Table S3), as expected. At the regional level, high levels of heterogeneity in the burden of potentially PDs were observed. Fig. 1 shows that, for both sexes, potentially PDs ranged from approximately 5%–18% (colon cancer), 2%–7% (breast cancer, women only), 2%–8% (CHD), 13%–52% (diabetes), and 6%–26% (all causes).(Table 1)

Table 2 shows that the PDs of individuals aged 20–24 years were the most costly (I$1023 [I$506–2178] thousand). Beyond this age range, PVLEs decreased, especially in older adults because they had fewer years of life remaining and also because their probability of survival decreased along with their expected income. When stratified by sex, this trend was the same, although PVLEs were substantially higher among men than among women. On average, the computed PVLE was I$660 (I$403–1155) thousand for both sexes, I$728 (I$446–1269) thousand for men, and I$481 (I$311–784) thousand for women.

The results regarding economic costs are presented in Table 3, which shows the interaction between RRs, the prevalence of sitting time, and PVLEs, which varied from higher to lower among younger individuals and older adults. For men, economic costs for the mean, minimum, and maximum scenarios peaked highest in the 50–54 age group (colon cancer: I$6.38 [I$5.17–7.95] million; CHD: I$10.13 [I$8.21–12.62] million; diabetes: I$21.74 [I$17.21–27.08] million). For women, the highest costs appeared in the 40–44 years age group for breast cancer (I$4.56 [I$3.42–3.99] million) and in the 45–49 years age group for the remaining NCDs (colon cancer: I$2.48 [I$2.01–3.08] million, CHD: I$1.28 [I$1.04–1.60] million, diabetes: I$5.48 [I$4.44–6.82] million). Finally, for all causes, the highest costs appeared in the youngest age group (men: I$454.94 [I$226.69–961.43] million; women: I$127.18 [I$68.19–247.22] million). In relative values, the economic costs of excessive sitting time associated with major NCDs and all causes, respectively, reached 0.025% (0.019–0.032%) and 0.37% (0.25–0.58%) of purchasing power parity (PPP)-adjusted GDP.

At the regional level (Fig. 2), high levels of heterogeneity were found. For men and women, respectively, economic costs per death ranged from I$38–418 (I$0–282) for colon cancer, I$40–390 for breast cancer (women only), I$64–756 (I$0–204) for CHD, I$114–3246 (I$0–878) for diabetes, and I$12,675–31,275 (I$3411–12,540) for all causes.

Table 1
Preventable deaths from NCDs and all causes attributable to sitting time by gender in Argentina (among individuals aged 20 to >74 years).

Outcome	Men			Women		
	Deaths (*n*)	PAF (%)	Preventable deaths (*n*)	Deaths (*n*)	PAF (%)	Preventable deaths (*n*)
Colon cancer[a]	3348	11.38	381	2902	10.01	290
Breast cancer[b]	NA	NA	NA	5717	4.37	250
CHD[c]	12,702	4.63	588	9173	4.38	402
Diabetes[d]	4551	30.54	1390	3869	27.07	1047
Total	20,601	11.45	2359	21,661	9.18	1988
All-cause mortality[e]	165,675	14.90	24,686	156,793	13.66	21,418

CHD, coronary heart disease; NCDs, non-communicable diseases; PAF, population attributable fraction.
The tenth revision of the International Statistical Classification of Diseases (ICD-10) was used to classify preventable deaths.
[a] Colon cancer (ICD C18).
[b] Breast cancer (ICD C50).
[c] CHD (ICD I20–I25).
[d] Diabetes (ICD E11, E14).
[e] All-cause mortality (ICD A00-Y89).

Table 2
Sensitivity analysis of the value of a statistical life by age group and gender in Argentina (among individuals aged 20–64 years).

Group age	Both			Men			Women		
	Minimum[a] (I$)	Mean (I$)	Maximum (I$)	Minimum (I$)	Mean (I$)	Maximum (I$)	Minimum (I$)	Mean (I$)	Maximum (I$)
20–24	506.47	1022.60	2177.60	561.45	1126.80	2,381,20	405.67	756.57	1470.70
25–29	516.87	944.34	1813.10	574.67	1041.70	1982.90	407.40	689.10	1209.60
30–34	504.64	847.25	1483.30	559.40	932.34	1619.00	391.26	607.53	972.36
35–39	467.99	729.31	1172.30	518.05	801.03	1276.90	351.40	506.27	744.84
40–44	422.86	610.99	902.47	467.46	669.57	980.47	302.19	403.66	546.50
45–49	364.17	487.32	661.64	396.79	527.42	711.26	241.85	298.51	371.38
50–54	287.40	357.03	447.37	309.88	382.54	476.40	158.07	181.31	208.81
55–59	191.89	222.07	257.94	198.94	229.52	265.81	61.03	65.57	70.54
60–64[b]	85.33	91.72	98.72	84.90	91.27	98.24	NA	NA	NA
Population-weighted average (%)	403.08	660.07	1154.85	445.92	728.07	1268.62	310.64	480.80	783.82
Total	3347.63	5312.67	9014.38	3671.54	5802.13	9792.18	2318.87	3508.52	5594.68

[a] Amounts are presented in thousands of international dollars (I$). For the conversion from Argentine pesos to international dollars, the 2019 purchasing power parity conversion factor was used.
[b] In this age group, the value of a statistical life was computed for both sexes by taking the average annual income for men. The parameters of the minimum, mean, and maximum values of the growth rate and discount rate were set at 0.01, 0.0219, and 0.05 and 0.01, 0.03, and 0.05, respectively.

Table 3
Economic costs from major NCDs and all causes of sitting time by age group and gender in Argentina (among individuals aged 20–64 years).

Scenario/outcome	Colon cancer[a]		Breast cancer[b]		CHD[c]		Diabetes[d]		All-cause mortality[e]	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Panel A. Minimum (g = 1%, r = 1%)										
20–24	0.28[f]	0.22	NA	0.08	0.48	0.23	1.14	0.91	226.69	68.19
25–29	0.56	0.40	NA	0.52	0.63	0.31	2.02	1.68	187.84	56.44
30–34	1.15	0.74	NA	1.10	1.51	0.26	5.81	1.53	213.70	56.00
35–39	2.84	0.97	NA	2.41	2.81	0.49	6.25	1.59	239.30	65.88
40–44	2.65	1.49	NA	3.42	4.30	0.90	9.57	3.19	253.36	84.06
45–49	4.08	2.01	NA	3.13	7.11	1.04	13.52	4.44	274.52	82.18
50–54	5.17	1.68	NA	2.47	8.21	0.87	17.61	4.24	285.08	67.02
55–59	3.97	0.91	NA	1.25	6.07	0.57	14.81	3.03	196.43	38.81
60–64	3.53	NA	NA	NA	4.93	NA	13.71	NA	170.45	NA
Total	24.24	8.44	NA	14.37	36.05	4.66	84.44	20.60	2047.38	518.58
‰ of GDP[g]	0.024	0.008	NA	0.014	0.036	0.005	0.083	0.020	2.023	0.512
Panel B. Mean (g = 2.19%, r = 3%)										
20–24	0.57	0.42	NA	0.15	0.97	0.42	2.28	1.69	454.94	127.18
25–29	1.02	0.68	NA	0.87	1.14	0.52	3.67	2.84	340.50	95.46
30–34	1.92	1.15	NA	1.71	2.52	0.40	9.69	2.37	356.17	86.95
35–39	4.39	1.40	NA	3.47	4.34	0.70	9.66	2.29	370.02	94.92
40–44	3.80	2.00	NA	4.56	6.16	1.20	13.71	4.26	362.91	112.29
45–49	5.42	2.48	NA	3.87	9.45	1.28	17.96	5.48	364.90	101.44
50–54	6.39	1.92	NA	2.84	10.13	1.00	21.74	4.87	351.93	76.87
55–59	4.58	0.98	NA	1.34	7.00	0.62	17.09	3.26	226.62	41.70
60–64	3.80	NA	NA	NA	5.31	NA	14.73	NA	183.23	NA
Total	31.87	11.03	NA	18.81	47.02	6.14	110.54	27.05	3011.21	736.80
‰ of GDP	0.031	0.011	NA	0.019	0.046	0.006	0.109	0.027	2.976	0.728
Panel C. Maximum (g = 5%, r = 5%)										
20–24	1.19	0.81	NA	0.18	2.05	0.82	4.83	3.28	961.43	247.22
25–29	1.95	1.19	NA	0.99	2.18	0.91	6.98	4.99	648.16	167.56
30–34	3.33	1.85	NA	1.77	4.37	0.64	16.82	3.79	618.49	139.16
35–39	6.99	2.06	NA	3.31	6.92	1.03	15.40	3.36	589.84	139.64
40–44	5.56	2.70	NA	3.99	9.02	1.62	20.07	5.76	531.41	152.03
45–49	7.31	3.08	NA	3.11	12.75	1.60	24.23	6.82	492.09	126.20
50–54	7.95	2.22	NA	2.12	12.62	1.15	27.08	5.60	438.28	88.53
55–59	5.30	1.06	NA	0.93	8.11	0.66	19.79	3.51	262.45	44.86
60–64	4.09	NA	NA	NA	5.71	NA	15.86	NA	197.23	NA
Total	43.68	14.97	NA	16.41	63.72	8.43	151.06	37.12	4739.37	1105.20
‰ of GDP	0.043	0.015	NA	0.025	0.043	0.008	0.149	0.037	4.683	1.092

CHD, coronary heart disease; NCDs, non-communicable diseases.
The tenth revision of the International Statistical Classification of Diseases (ICD-10) was used to classify preventable deaths.
[a] Colon cancer (ICD C18).
[b] Breast cancer (ICD C50).
[c] CHD (ICD I20–I25).
[d] Diabetes (ICD E11, E14).
[e] All-cause mortality (ICD A00-Y89).
[f] Amounts are presented in millions of international dollars (I$).
[g] Purchasing power parity–adjusted GDP at constant (2011) international prices for 2019.

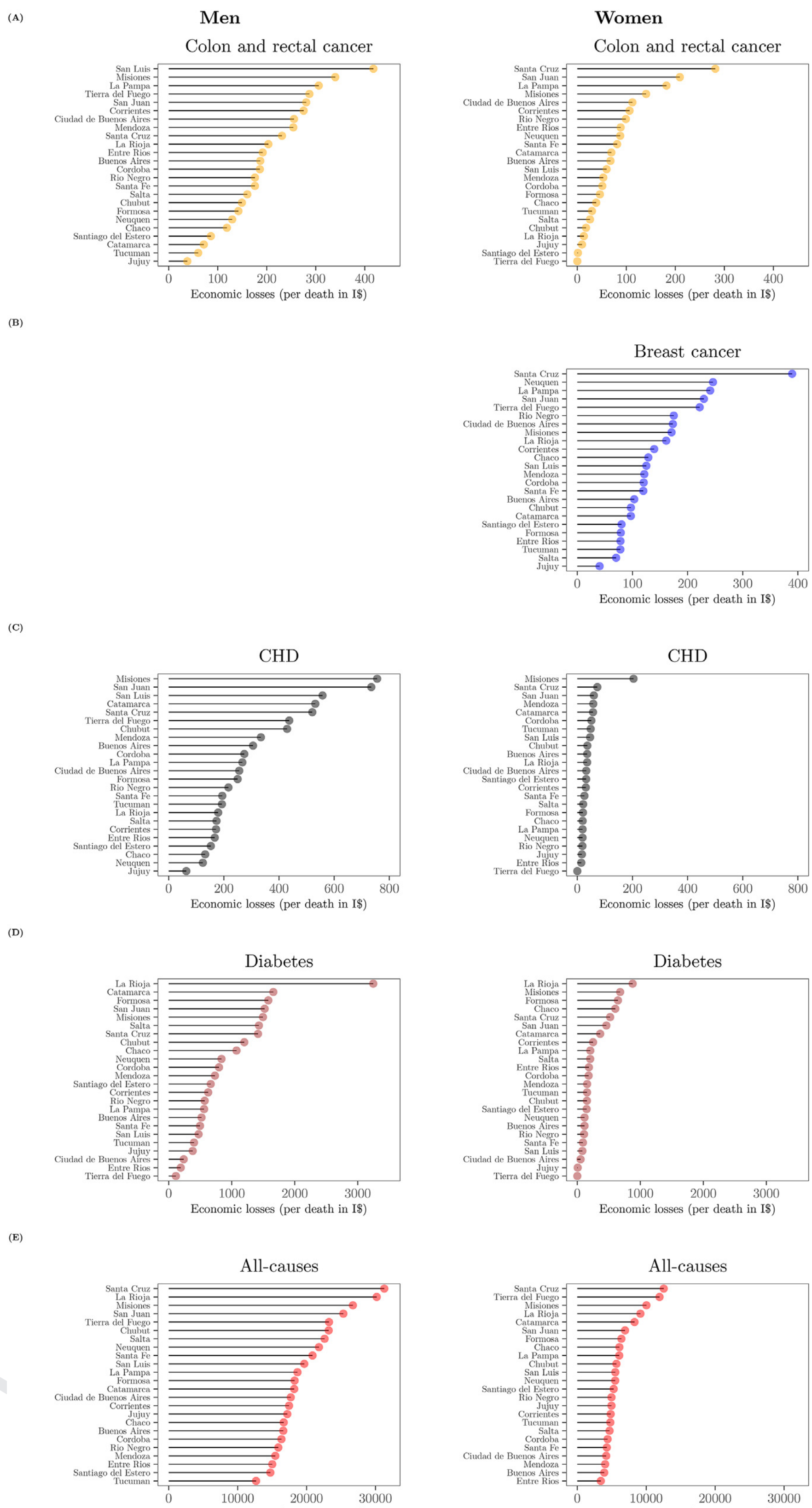

Fig. 2. Economic losses per death from NCDs and all causes associated with excessive sitting time across regions. Breast cancer was considered only for women (Panel B). Types of NCDs shown: colon cancer (yellow), breast cancer (women only; violet), CHD (gray), diabetes (light brown), and all causes (light red). CHD, coronary heart disease; NCDs, non-communicable diseases. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Discussion

From a societal perspective, this article is the first to quantify the public health burden due to deaths from NCDs (colon and breast cancer, CHD, and diabetes) and all causes attributable to sedentary behavior in Argentina. In addition, the results were disaggregated jointly by region, age, and gender. This approach allowed us to explore the heterogeneity of our results to better understand the patterns of this complex relationship, which are especially useful for setting priorities in stratified health planning by identifying the most vulnerable target populations. Likewise, a Monte Carlo simulation was performed in three counterfactual scenarios to evaluate the sensitivity of the results.

Notably, PAFs provide a useful theoretical measure of the impact of a risk factor of interest on one or multiple outcomes. The present results were comparable to previous estimates in multiple countries. In the United States,[25] England,[8,26] and Australia,[27] respectively, sedentary behavior has been estimated to account for 19%–27% (TV watching and sitting time), ≈8%–11%, and ≈7% of all-cause deaths (vs ≈14% reported earlier). For the other outcomes, the present estimates fell within a fairly reasonable range: ≈5% (vs ≈4%, England) for CHD,[8,26] 5%–9% (vs ≈10%, England and Canada) for colon cancer,[8,26,28] ≈3% (vs ≈4%, Canada) for breast cancer,[28] and 17%–29% (vs ≈28%, England) for diabetes.[8,26] However, there were slight differences in these estimates, likely due to multiple factors, such as differences in definitions of sedentary behavior (e.g. sitting time or TV viewing), PAF equations, sitting time cutoffs, and RR estimates.

This article used the human capital approach to quantify the PVLEs, which was subsequently used to calculate the indirect costs of lost productivity. This measure has been used as a basic tool for public health decision-making, as it allows for the measurement of social benefits derived from investments in public policy programs aimed at disease prevention. From a social perspective, this approach can capture substantial economic losses, as it considers people of working age, who provide the largest proportion of fiscal resources (especially in Argentina, where society pays for all public education). However, the present estimates should be interpreted as equivalent to lower bounds on the full cost of sedentary behavior, as only mortality-related productivity losses were considered. Even so, the results showed substantial costs of excessive sedentary behavior in Argentina, amounting to 0.025% (0.019–0.032%) of PPP-adjusted GDP for deaths from major NCDs and 0.37% (0.25–0.58%) of PPP-adjusted GDP for all-cause deaths by 2019. Therefore, public policies aimed at reducing excessive sedentary behavior would be cost-beneficial, for example, by allowing for higher income tax revenues. Nevertheless, the challenge of reducing sedentary behavior in the general population is not easy to address. In contemporary society, where the use of technology has negatively impacted the way people move, excessive sitting is commonplace. This problem has been exacerbated by the COVID-19 pandemic, during which many people have stopped commuting to and from work.[29,30]

This study had some limitations that warrant mentioning. First, PAFs were calculated from self-reports of sitting time—which are considered subjective and associated with measurement bias—[31] and from RRs taken from cohort studies in developed countries and thus do not necessarily reflect external validity for Argentina. Second, PVLEs were differentiated by gender, which provides valuable information for calculating economic costs. However, this strategy generates a marked difference between men's and women's remunerations, as it does not consider implicit household production, which translates to lower participation in the labor market and lower average salaries among women. Nevertheless, this measure is useful for describing the marginal rate of substitution (or trade-off) between mortality risk and a given monetary value over a given period[32] and has been widely used as the main economic parameter in the struggle to reduce mortality risk.[33] This has made it possible to compare results obtained on an international scale. Finally, we considered high levels of sedentary behavior—regardless of compliance with physical activity recommendations—as an independent risk factor that impacts health outcomes. However, new scientific evidence has indicated that high levels of moderate-intensity physical activity appear to eliminate the increased risk of death associated with high levels of sitting time,[33] possibly resulting in overestimations of the indirect costs of excessive sitting time.

In conclusion, the PDs and indirect costs attributable to NCDs and all causes associated with high levels of sedentary behavior are considerable. Accordingly, public policies aimed at reducing excessive sedentary behavior in the overall population, especially in the most affected regions, would represent considerable savings for society as a whole. For example, the present results suggest that eliminating excessive sitting time in Argentina could annually prevent 4347 deaths from major NCDs and 46,104 deaths from all causes, generating annual savings of approximately I$252.5 million and I$3748 million, respectively. However, these estimates reflect a theoretical minimum risk exposure level scenario that lacks external validity in relation to the current distribution of the risk factor and should therefore be considered as upper bounds of the indirect costs that could potentially be avoided. Based on these results, it appears that public health initiatives aimed at reducing sedentary behavior in the general population are crucial to reducing NCD-related and all-cause deaths in Argentina. Such initiatives should address the complex, multifactorial causes of sedentary behavior, the clear gender and age differences in this behavior, and the underlying factors of these differences, such as contextual factors and differences in the ability to adopt a healthier lifestyle.

Author statements

Ethical approval

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Competing interests

The author declares no conflicts of interest.

Data availability

Codes and data are available on reasonable request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2023.02.011.

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