

## Burden of disease from lower limb amputations attributable to diabetes mellitus in Santa Catarina State, Brazil, 2008-2013

Carga da doença para as amputações de membros inferiores atribuíveis ao diabetes mellitus no Estado de Santa Catarina, Brasil, 2008-2013

Carga de enfermedad para las amputaciones de miembros inferiores, atribuibles a la diabetes mellitus en el Estado de Santa Catarina, Brasil, 2008-2013

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doi: 10.1590/0102-311X00013116

### Abstract

*The objective was to estimate the burden of disease from lower limb amputations attributable to diabetes mellitus in Santa Catarina State, Brazil, from 2008 to 2013. A descriptive epidemiological study was performed by calculating disability-adjusted life years (DALY). Burden of disease was high, more than 8,000 DALY in men and women. Disability accounted for 93% of DALY and mortality for 7.5%. The burden in men was 5,580.6 DALY, almost double that in women (2,894.8), and the share of the years lost due to disability (YLD) component in men pushed this rate to 67.6% of total DALY. Men live longer following amputation, so they lose more years of healthy life (65.8%), while mortality is higher in women (61%). DALY rates were not distributed homogeneously across the state. The intensification of evaluation, planning, and development of cost-effective strategies for prevention and health education for diabetic foot should be oriented according to higher male vulnerability.*

*Amputation; Diabetes Mellitus; Potential Years of Life Lost; Global Burden of Disease*

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## Introduction

Lower limb amputation is twice as frequent in diabetic individuals as in non-diabetics, accounting for 70% of non-traumatic lower limb amputations, and 85% of these amputations occur after the emergence of ulcers, which affect 25% of diabetics. Diabetes mellitus affect 30% of persons over 40 years of age, and its costs increase significantly when the diabetic patient undergoes limb amputation <sup>1</sup>.

In 2001, the incidence of amputations in Brazil was 13.9 per 100,000 inhabitants per year. There were 80,900 amputations due to diabetes mellitus, of which 21,700 evolved to death <sup>2</sup>. From 2011 to 2016, 102,056 amputation surgeries were performed in the Brazilian Unified National Health System (SUS), of which 70% were in individuals with diabetes mellitus and the majority (94%) were lower amputations <sup>3,4</sup>. In Santa Catarina State, during this same period, there were 11,041 lower limb amputations (Secretaria de Estado da Saúde de Santa Catarina. <http://www.saude.sc.gov.br>, accessed on Feb/2015).

The last Global Burden of Disease (GBD) study calls attention to the increase in healthy life years lost. The study <sup>5</sup> emphasizes the concern with the years of life lost over the next two decades, especially related to diabetes mellitus and associated complications, such as diabetic retinopathy, diabetic neuropathy, amputations, and chronic kidney disease. According to projections by the GBD study, persons with chronic diseases live longer, but with complications from stroke, amputations due to diabetes, and dialysis <sup>5</sup>. Further related to life expectancy, the tendency is towards more years lived with disability <sup>6</sup>; importantly, such disabilities can be extremely burdensome for patients, their families, and the health system <sup>7,8</sup>.

Based on the above, what is the burden from lower limb amputations due to diabetes mellitus in Santa Catarina State? Estimating the burden based on knowledge of disability-adjusted life years can assist health policymakers and professionals in the organization of resources for this large contingent of patients. The current study thus aimed to estimate burden of disease from lower limb amputations attributable to diabetes mellitus in Santa Catarina from 2008 to 2013 by calculating disability-adjusted life years (DALY).

## Materials and methods

This was a hospital-based descriptive epidemiological study using DALY <sup>7,9,10,11</sup>. From 2008 to 2013, lower limb amputations in individuals with diabetes residing Santa Catarina were identified in the database of the Hospital Information System of the SUS (SIH/SUS). The study included amputations due to all types of diabetes mellitus, unilateral or bilateral lower limb amputations in both sexes, for all levels of amputation, and in all age brackets.

Following approval of the research project by the Institutional Review Board (case review CAEE 32282213.1.0000.0118), the sample was selected from the database of the SIH/SUS, which includes Authorizations for Hospital Admissions (AIH) of patients undergoing amputation surgery covered by the SUS in Santa Catarina State from 2008 to 2013.

The period available for consulting incidence of lower limb amputations was 2008 to 2013, the time interval for which the data were digitized and available in the Santa Catarina State Health Secretariat (SEC/SC). Based on the period available for consultation, the investigators determined that the investigation of mortality from diabetes mellitus would also use this same period for the search in the Mortality Information System (SIM) in Santa Catarina.

The first step was to collect the data from the AIH database on lower limb amputations. We verified the existence of codes for the surgical procedures, and the search for those specifically related to lower limb amputations, identified in the table of procedures in the SUS. In addition to the variables sex, age, type of diabetes mellitus, and micro-region, we searched for the codes for surgical procedures corresponding to lower limb amputations to identify the amputation levels. It was necessary to calculate DALY by micro-region: surgical codes, date of amputation, age, sex, municipality, and type of diabetes mellitus. Data in the DATASUS system (<http://datasus.saude.gov.br>) are distributed by health micro-regions, and the study adopted the standard geographic distribution used by the SEC/SC.

Thus, the location of the study population was described by macro-regions and health micro-regions, as shown in the results.

### Calculation of DALY due to limb amputations

We used the internationally known terminology recommended by the GBD study for the components and study methods on burden of disease. Use of this standard ensures the results' comparability with those of other countries <sup>5,10</sup>.

DALY simultaneously estimates the impacts of mortality and morbidity from lower limb amputations, using as the common metric the period from 2008 to 2013 in Santa Catarina State. One DALY represents one year of healthy life lost, calculated by adding two sub-indicators: mortality (YLL – years of life lost), or years of life lost due to premature death; and morbidity (YLD – years lost due to disability), or years of healthy life lost due to disability. Figure 1 depicts the methodological algorithm for calculating DALY.

YLL was based on the number of deaths from diabetes mellitus and estimated life expectancy for the mean age at time of death. Considering gender, calculation of YLL for cause *c*, age *i*, and sex *s*, with  $N(c, i, s)$  as the number of deaths due to diabetes mellitus, with cause *c*, mean age *i*, and sex *s*, defined according to Equation 1:

$$YLL(c, i, s) = N(c, i, s) \times E(i, s) \quad (1)$$

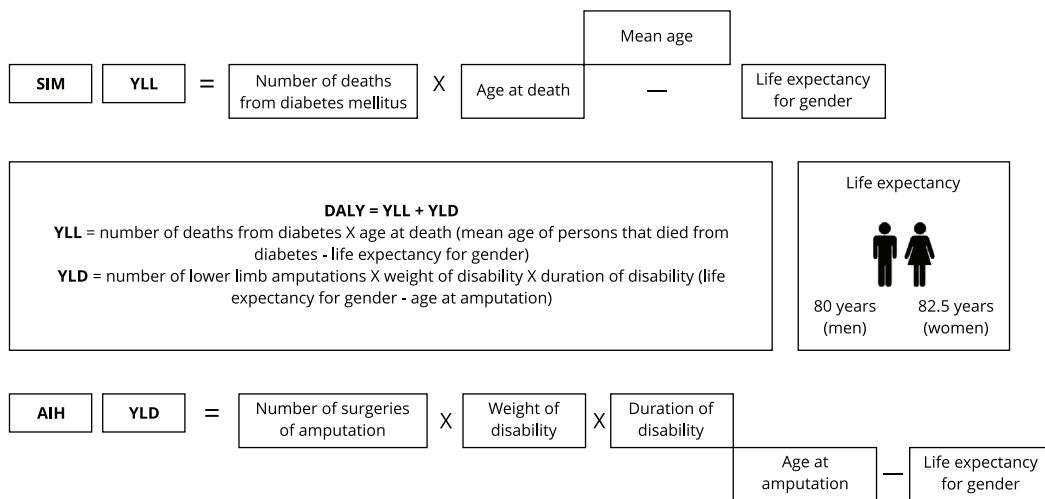
The study followed the Murray & Lopez method closely <sup>5</sup>. According to GBD recommendations, we used the life expectancy from Japan, or 80 years for men and 82.5 years for women and YLL, since this procedure allows comparison with other countries.

Murray & Lopez assigned weights to quantify the loss of health during the time lived with disease/disability, varying from 0 for full health status to 1 for the worst possible health. YLD was calculated with the weight of amputation estimated as 0.36 <sup>12,13,14,15</sup>. In its simplified form, calculation of YLD for cause *c*, age *i*, and sex *s* follows Equation 2:

$$YLD(c, i, s) = I(c, i, s) \times D(c, i, s) \times P(c, i, s) \quad (2)$$

**Figure 1**

Methodological algorithm for calculation of DALY (disability-adjusted life years).



AIH: Authorizations for Hospital Admissions; SIM: Mortality Information System; YLD: years lost due to disability; YLL: years of life lost. Source: Santos <sup>25</sup>.

Thus,  $I(c, i, s)$  is the number of cases of amputation surgeries  $c$ , for age  $i$  and sex  $s$ ;  $D(c, i, s)$  refers to the mean duration of disability  $c$ , for age  $i$  and sex  $s$ ; and  $P(c, i, s)$  represents the weight of disability for amputation  $c$ , for age  $i$  and sex  $s$ .

DALY represents the burden of disease obtained from the sum of the two health sub-indicators (YLL and YLD). Based on equations 1 and 2, which determine YLL and YLD, DALY is calculated as shown in Equation 3:

$$DALY = YLL + YLD \quad (3)$$

Statistical analysis used the SPSS version 20.0 (IBM Corp., Armonk, USA). Confidence intervals (95%CI) were calculated for the variables sex, age, YLL, YLD, and DALY. Descriptive analysis was performed for YLL, YLD, and DALY per 100,000 inhabitants, presenting the absolute values and absolute frequency distribution considering sex, age bracket, and micro-regions of Santa Catarina State.

## Results

### Epidemiological profile of morbidity and mortality from diabetes mellitus in Santa Catarina State

The results represent the epidemiological profile, mortality and morbidity, determinants of burden of disease from lower limb amputations due to diabetes mellitus in Santa Catarina. The data showed that for six years (2008-2013) there were 1,183 cases of amputation surgeries in public hospitals in the state, distributed in 20 micro-regions.

Table 1 shows the epidemiological profile of lower limb amputations attributable to diabetes mellitus in 2008-2013 according to sex and micro-region of Santa Catarina with the highest DALY. All the data showed normal distribution according to the Kolmogorov-Smirnov ( $p < 0.004$ ) and Shapiro-Wilk ( $p < 0.000$ ) tests. Diabetic men (66.2%) underwent more amputations than diabetic women (33.8%). In addition, mean age of women was 66 years (95%CI: 44-86), compared to mean age of 61 years in men (95%CI: 43-80). For both sexes, the highest percentage of amputations was attributed to type 1 diabetes mellitus, and the most frequent surgical level was toe amputation.

Table 2 shows the distribution of deaths from diabetes mellitus in Santa Catarina State in the last six years, according to sex, age bracket, and macro-region. The mortality rate due to diabetes mellitus was estimated at 133.93/100,000 inhabitants for the period, and the mortality in men (121.31) was lower than in women (171.56). The majority of deaths in women (58.9%) were in patients over 80 years of age, while a large share of men (41%) were over 70 years of age. Among the macro-regions of Santa Catarina, the Southern region of the state showed the highest mortality (18.2%), followed by Vale do Itajaí (16.7%) and Grande Oeste (11.33%).

### Estimated DALY from amputations

From 2008 to 2013, Santa Catarina showed an estimated 8,475.46 DALY in 1,183 persons (1,242 DALY/100,000 inhabitants) that underwent limb amputations due to diabetes mellitus, including 638.5 YLL and 7,910.44 YLD. Comparing burden of disease from limb amputations according to gender (Table 3), men showed higher DALY (5,580.6) than women (2,984.8 DALY) and also higher YLD (5,344) than women (2,566.4). Distribution of DALY varied between the sexes: men had almost twice as many DALY as women. Only YLL in women (388) was higher than in men (250.5), indicating longer time lived with the disability in men and higher mortality in women. Morbidity accounted for 93% of DALY and mortality for 7.5%.

Table 3 shows the proportional distribution of YLL, YLD, and DALY according to gender and micro-regions of Santa Catarina State. The highest DALY rates were in Joinville (2,328.3), Florianópolis (1,404), and Itajaí (1,021.1) for both sexes. These micro-regions represent 56% of the burden of disease from lower limb amputations attributable to diabetes mellitus in Santa Catarina State, with the highest share from the Joinville micro-region (27.5%), followed by the micro-regions of Florianópolis (17%) and Itajaí (12%). The highest absolute DALY was in Joinville and the lowest in Tabuleiro (30.6), considering the number of cases for each micro-region.

**Table 1**

Epidemiological profile of amputees according to sex, micro-region, type of diabetes mellitus, and level of amputation. Santa Catarina State, Brazil, 2008-2013.

Sex	Female		Male	
	n	%	n	%
Amputations (n = 1,183)	400	33.8	783	66.2
Micro-region				
Joinville	97	24.2	235	30.0
Florianópolis	70	17.5	121	15.4
Itajaí	42	10.5	89	11.3
Type 1 diabetes mellitus	166	41.5	295	37.7
Type 2 diabetes mellitus	83	20.8	167	21.3
Level of amputation				
Lower limb	152	38.0	267	34.1
Foot	71	17.8	154	19.7
Toes	177	44.2	362	46.2

Source: database of the Hospital Information System/SUS, Santa Catarina State, Brazil.

**Table 2**

Distribution of deaths from diabetes mellitus (per 100,000 inhabitants) according to sex and macro-region. Santa Catarina State, Brazil, 2008-2013.

Sex	Female		Male	
	n	%	n	%
Deaths from diabetes (n = 9,133)	5,402	58.9	3,762	41.1
Macro-region				
Foz do Rio Itajaí	508	9.4	404	10.7
Florianópolis	559	10.3	399	10.6
Grande Oeste	647	11.9	382	10.1
Meio Oeste	509	9.4	373	9.9
Nordeste	564	10.4	399	10.6
Planalto Norte	324	6.0	242	6.4
Serra Catarinense	350	6.4	290	7.7
Sul	1,008	18.6	680	18.0
Vale do Itajaí	933	17.2	593	15.7

Source: database of the Hospital Information System/SUS, Santa Catarina State, Brazil.

As shown in Table 4, the Joinville micro-region recorded 75.2 YLL, 1,581 YLD, and 1,653.7 DALY in men. The Florianópolis micro-region recorded 38.7 YLL, 871.6 YLD, and 908.5 DALY and the Itajaí micro-region 28.4 YLL, 643.5 YLD, and 672.4 DALY. Comparing the burden of disease in men and women, the male burden also predominated in the micro-regions with the highest DALY. The highest DALY, YLL, and YLD in women occurred in these micro-regions: Joinville with 674.6 DALY, 94 YLL, and 595.9 YLD; Florianópolis with 67.9 YLL, 438.1 YLD, 495.5 DALY; and Itajaí with 40.7 YLL, 316 YLD, and 348.7 DALY.

In the burden of disease for lower limb amputations attributable to diabetes mellitus according to sex, age bracket, and micro-regions with the highest DALY (4,753.4), men had 3,234.6 DALY in the 60-69-year age bracket, and women had 1,518.8 DALY in the 50-59-year bracket. The male

**Table 3**

Distribution of YLL (years of life lost), YLD (years lost due to disability), and DALY (disability-adjusted life years) from amputations attributable to diabetes mellitus according to sex and micro-regions. Santa Catarina State, Brazil, 2008-2013.

Micro-region (n = 1,183)	YLL	%	YLD	%	DALY	%
Araranguá						
Men	2.5	0.4	63.9	0.8	66.0	0.8
Women	8.7	1.4	44.4	0.6	51.2	0.6
Total	11.2	1.8	108.3	1.4	117.2	1.4
Blumenau						
Men	22.4	3.5	527.9	6.7	549.7	6.5
Women	32.1	5.0	255.0	3.2	282.1	3.3
Total	54.4	8.5	782.9	9.9	831.8	9.8
Campos de Lages						
Men	3.8	0.6	81.7	1.0	85.6	1.0
Women	5.8	0.9	48.6	0.6	54.4	0.6
Total	9.6	1.5	130.3	1.6	140.0	1.7
Canoinhas						
Men	5.7	0.9	129.2	1.6	134.1	1.6
Women	8.3	1.3	51.3	0.6	58.0	0.7
Total	14.4	2.3	180.5	2.3	192.2	2.3
Chapecó						
Men	9.6	1.5	147.5	1.9	155.7	1.8
Women	16.4	2.6	95.5	1.2	106.3	1.3
Total	26.0	4.1	243.0	3.1	262.1	3.1
Concórdia						
Men	8.0	1.3	160.2	0.6	168.3	2.0
Women	9.7	1.5	47.8	2.0	53.8	0.6
Total	17.7	2.8	208.0	2.6	222.2	2.6
Criciúma						
Men	19.8	3.1	445.9	5.6	465.0	5.5
Women	28.1	4.4	156.7	2.0	183.4	2.2
Total	47.9	7.5	602.2	7.6	648.4	7.7
Curitibanos						
Men	4.1	0.6	81.0	1.0	84.6	1.0
Women	9.7	1.5	78.4	1.0	88.1	1.0
Total	13.8	2.2	159.4	2.0	172.7	2.0
Florianópolis						
Men	38.7	6.1	871.6	11.0	908.5	10.7
Women	67.9	10.6	438.1	5.5	495.5	5.8
Total	106.6	16.7	1.309.7	16.6	1.404.0	16.6
Itajaí						
Men	28.4	4.4	643.5	8.1	672.4	7.9
Women	40.7	6.4	316.0	4.0	348.7	4.1
Total	69.2	10.8	959.5	12.1	1.021.1	12.0
Ituporanga						
Men	1.2	0.2	32.8	0.4	33.4	0.4
Women	4.8	0.8	18.9	0.2	23.7	0.3
Total	6.1	1.0	51.7	0.7	57.1	0.7

(continues)

**Table 3 (continued)**

Micro-region (n = 1,183)	YLL	%	YLD	%	DALY	%
Joaçaba						
Men	10.5	1.6	220.6	2.8	230.8	2.7
Women	7.7	1.2	74.1	0.9	81.9	1.0
Total	18.3	2.9	294.7	3.7	312.7	3.7
Joinville						
Men	75.2	11.8	1.581.0	20.0	1.653.75	19.5
Women	94.0	14.7	595.9	7.5	674.6	8.0
Total	169.2	26.5	2.176.98	27.5	2.328.36	27.5
Rio do Sul						
Men	4.4	0.7	84.4	1.1	86.8	1.0
Women	8.7	1.4	68.2	0.9	75.0	0.9
Total	13.2	2.1	152.6	1.9	161.8	1.9
São Bento do Sul						
Men	3.5	0.3	53.4	0.7	55.5	0.7
Women	6.7	1.0	48.4	0.6	53.2	0.6
Total	10.3	1.6	101.8	1.3	108.8	1.3
São Miguel do Oeste						
Men	2.2	0.3	25.1	0.3	27.4	0.3
Women	13.5	0.3	88.2	1.1	99.8	1.2
Total	15.8	0.3	113.3	1.4	127.3	1.5
Tabuleiro						
Men	0.6	0.1	24.8	0.3	25.4	0.3
Women	0.9	0.1	4.14	0.1	5.11	0.1
Total	1.6	0.3	28.9	0.4	30.6	0.4
Tijucas						
Men	3.2	1.8	65.8	0.8	68.5	0.8
Women	4.8	0.8	26.1	0.3	30.9	0.4
Total	8.0	1.3	91.9	1.2	99.4	1.2
Tubarão						
Men	2.8	0.4	49.7	0.6	51.9	0.6
Women	8.7	1.4	38.7	0.5	47.4	0.6
Total	11.6	1.8	88.4	1.1	99.4	1.2
Xanxerê						
Men	3.2	0.5	54.0	0.7	56.6	0.7
Women	9.7	1.5	71.2	0.9	80.9	1.0
Total	12.9	2.0	125.2	32.4	137.6	1.6
Total						
Men	250.5	39.2	5.344.0	67.6	5.580.6	65.8
Women	388.0	60.7	2.566.4	32.4	2.894.8	34.2
Total	638.5	7.5	7.910.4	92.5	8.475.4	100.0

Source: database of the Hospital Information System/SUS, Santa Catarina State, Brazil.

burden (1,653.7 DALY) from amputations in the Joinville micro-region exceeded that in women (674.6 DALY). The burden of disease from amputations prevails starting at 50 years of age in the micro-regions with the highest DALY, independently of the distribution of number of cases.

**Table 4**

Distribution of burden of disease from lower limb amputations attributable to diabetes, according to sex and the most affected micro-regions. Santa Catarina State, Brazil, 2008-2013.

DALY (n = 1,183)	Female			Male		
	n	DALY	%	n	DALY	%
Age bracket (50-69 years)	89	978.5	35.1	277	1,813.1	64.9
Micro-region						
Joinville	97	674.6	44.4	235	1,653.7	51.1
Florianópolis	70	495.5	32.6	121	908.5	28.1
Itajaí	42	348.7	23.0	89	672.4	20.8
Total	209	1,518.8	100.0	445	3,234.6	100.0

DALY: disability-adjusted life years.

Source: database of the Hospital Information System/SUS, Santa Catarina State, Brazil.

## Discussion

From 2008 to 2013, Santa Catarina recorded some 8,500 DALY in approximately 1,200 persons that underwent limb amputations due diabetes mellitus, revealing the high burden of disease and suggesting that diabetes mellitus is one of the principal causes of amputation in Brazil <sup>2</sup> and specifically in Santa Catarina.

Does amputation accelerate death? From 2010 to 2016, according to data on hospital admissions (AIH) in public hospitals in Santa Catarina, there were some 1,200 cases of lower limb amputations distributed across 20 micro-regions of Santa Catarina, and the majority were distal, such as toe amputations. It was not possible to track the deaths of persons with diabetes mellitus that had already undergone amputations, but Brazilian studies <sup>16,17,18</sup> have already highlighted the high number of both amputations and amputations followed by death in individuals hospitalized in the SUS with diabetes mellitus and foot ulcers. Concerning hospitalization in the last two decades, considering 7.1 million persons with type 2 diabetes, there were an estimated 169,600 hospital admissions and 80,900 amputations, of which 21,700 evolved to death <sup>18</sup>. Estimating the direct cost of hospitalizations for individuals with diabetes mellitus and ulcers, Rezende et al. <sup>19</sup> showed that 12.8% of the patients died during the index hospitalization. The study <sup>19</sup> estimated the burden of disease with an approach to amputations, calculated the YLL component for all complications of diabetes, and did not show a specific concern with attributing death as closely as possible to YLD. Meanwhile, another study has estimated the fraction of the burden of disease attributable to overweight and obesity <sup>20</sup>, calculating YLL based on overall mortality in the group of chronic non-communicable diseases. Another approach to the calculation of YLL was in the study on burden of disease from oral conditions <sup>21</sup>. The authors <sup>21</sup> estimated YLD from these conditions and also calculated premature death due to all its oral complications, including in the calculation of deaths all the underlying causes related to oral conditions for YLL, and thus obtained the overall burden of diseases from these conditions.

The current study's outcomes revealed that hospitalizations occurred in persons of both sexes with type 1 diabetes mellitus submitted to toe amputations. In the last 5 years, in Brazil as a whole, 102,056 amputations were performed in the SUS alone, 70% of them in individuals with diabetes mellitus, and the majority (94%) were lower limb amputations <sup>3,4</sup>. Meanwhile, a study <sup>19</sup> in the SUS network in Sergipe State found that of 109 hospital admissions for diabetic patients in a five-month period, more than half of the amputations (56.1%) were at higher levels. Concerning amputation level, the current Brazilian pattern shows that some 80% of amputations in diabetic patients occurred at the transtibial level and that such patients were more prone to re-amputation <sup>2</sup>. Worldwide, diabetic foot is the most common etiology in hospitalizations, accounting for 25% of hospital admissions in the United States <sup>21</sup>.



According to data from 2011, mortality from diabetes mellitus is higher in women than in men, and this difference is greatest over 60 years of age<sup>22</sup>. Life expectancy for men and women increased as did the number of deaths in persons over 70 years of age. The increase in mortality from 1990 to 2013 was attributed to the higher mean population age. The last GBD study<sup>13</sup> pointed to a reduction in mortality from cardiovascular diseases and an increase in disability from their complications.

Concerning DALY estimates for Santa Catarina State disaggregated by sex, diabetic men suffered more amputations than diabetic women. Tabuleiro, the micro-region with the lowest DALY, also had the highest concentration in males. Men lost more years of healthy life from amputations in the micro-regions with the lowest DALY. The influence of gender is evidenced in the latest study on global burden from diabetes mellitus in Brazil, since the DALY rates were higher in men (208 DALY/1,000) than in women (183 DALY/1,000). Diabetes mellitus ranks third in the female population and the sixth in males in burden of all diseases, which are divided into 21 subgroups of diseases and 107 diseases<sup>23</sup>, and the first in projections of global burden of disease in Brazil<sup>19</sup>.

Concerning the influence of age, one of the guidelines of the Brazilian Society of Diabetes emphasizes a 2.7% increase in prevalence of diabetes mellitus in the age bracket from 30 to 59 years and a 17.4% increase in prevalence in the 60-69-year bracket. There has been a 6.4-fold increase in prevalence, a consequence of Brazil's demographic transition, reaching 21.6% in individuals over 65 years of age<sup>2</sup>.

Premature death (YLL) in the burden of disease study was not the main component accounting for the absolute amount of DALY. Most of the burden was concentrated in YLD (93%), particularly in the southern macro-region of Santa Catarina. Burden of disease according to causes of disease or conditions in Brazil and regions did not show a difference in the DALY rates between men and women for diabetes mellitus<sup>23</sup>. In this DALY<sup>23</sup>, men had higher YLL than women, expressing male over-mortality in all regions of the country, since the mortality component (YLL) accounted for 61.5% of total DALY and chronic non-communicable diseases recorded the highest DALY in the country (77.2%)<sup>23</sup>.

Morbidity from diabetes mellitus was higher in men in Santa Catarina. YLD in diabetic men and amputees pushed the male DALY rate upwards. The DALY outcome based on the YLL and YLD components was double the DALY in women. Thus, male amputees lose more years of life from amputation and live longer after amputation than women, since the YLL component represents female over-mortality. Two explanations can be proposed for this observation. Considering all types of diabetes mellitus, women in Santa Catarina die younger than men and live less time with the disability generated by amputation. Diabetic women that underwent amputation were older than men in the same conditions, meaning that when they undergo amputation they are closer to reaching their life expectancy. Meanwhile, men carry the burden of disability longer as they approach life expectancy. DALY in men confirms that as more men are amputated from 50 years upward, they live more years with disability and lose more years of healthy life. The higher burden of disability in men does not appear in the study<sup>19</sup> on burden from diabetes mellitus and complications in the year 1998, even indicating that DALY from this disability was higher in women.

Our study revealed the occurrence of amputation surgeries in younger individuals. Since life expectancy is undergoing a transition, we estimated both potential years of life lost and years lived with disability. This suggests that young amputees will age with an irreversible physical disability, in addition to the limitations caused by the aging process itself.

The micro-regions of Joinville, Florianópolis, and Itajaí (with one-third of the population of Santa Catarina State) have the highest accumulated number of years lost due to amputation in both sexes, and women with diabetes that underwent amputations have about half the years lost when compared to men in the same conditions. These micro-regions represent 56.1% of the burden of disease from lower limb amputations attributable to diabetes mellitus, with the highest share in the Joinville micro-region (27.5%), showing approximately 276 DALY/100,000 inhabitants, compared to the micro-regions of Florianópolis (16.6%) with 159 DALY/100,000 inhabitants and Itajaí (12%) with 178 DALY/100,000 inhabitants. In these micro-regions, male mortality is concentrated in a younger age bracket than mortality in women. Premature death was not the largest component of DALY, since the majority of the burden is concentrated in YLD, which calls greater attention in this micro-region to years lived with the disability. This emphasizes the importance of evaluating effective prevention, that is, more effective in primary prevention of diabetes and secondary prevention of its

complications. It also emphasizes more practical short and long-term health promotion through education of persons with diabetes mellitus <sup>2</sup>.

The burden of disease from diabetes mellitus varies between the micro-regions of Santa Catarina State. This regional variation is similar to the variation in global burden of disease between regions of Brazil, highlighting the predominance of chronic non-communicable diseases in all these regions, particularly cardiovascular diseases. The comparative epidemiological profile between micro-regions indicates greater concentration of the burden in the Joinville micro-region, expressing early mortality and greater burden of disability. Based on the distribution of burden, it is important to note that Joinville is the micro-region with the largest population in the state. Like Florianópolis and Itajaí, the Joinville micro-region has a high concentration of hospitals and other healthcare resources. Even so, it is still important to call attention to the need for early treatment of diseases and their disabling complications.

Leite et al. <sup>23</sup> suggest that high DALY rates may be reflected in worse living conditions, difficulty in access to healthcare services, and the need for better control of risk factors, because they are determinants of premature death and disability, as well as the need for evaluation and reinforcement of strategies for the prevention of diabetic foot, since mortality in patients with amputations is increasingly higher and earlier, mainly among diabetics <sup>24</sup>.

The study's results agree with the projections <sup>19</sup> made up to 2013. In 1998, diabetic neuropathy accounted for 12.8% of DALY in the burden from complications of the disease, and its occurrence increased to 30%, in other words doubled, by the year 2013. The increase was projected for men and for a greater share of the YLD component in total DALY from diabetes mellitus in the age brackets from 45 to 59 years <sup>19</sup>. Considering that the estimate in 1998 of 7,494 DALY from all complications of diabetes mellitus in Brazil, in six years Santa Catarina State showed an important amount of years of healthy life lost due to one of the main complications of diabetes, namely lower limb amputations.

It is necessary to assess trends in the distribution of burden of disease in all the micro-regions, since it involves a growing burden of disability and an epidemiological transition, challenging the public health system in Santa Catarina. Based on this information, it is necessary to step up planning and development of cost-effective strategies for prevention and health education by the multidisciplinary team, actions in services in a network format, and healthcare for diabetics. Studies are needed on burden of disease from limb amputations in other states of Brazil, since the estimated years of healthy life lost due to complications of diabetes are worrisome in terms of the Brazilian population's health.

Protective sensitivity testing in the feet of diabetic patients allows determining the degree of functional impairment and implements the practice of comprehensive care for diabetic patients when prevention and health education are used to meet this population's specific needs.

The work by the multidisciplinary team should be preventive and health-promoting. In addition to foot sensitivity testing, health professionals need to orient patients and family members, taking into account social, economic, cultural, and environmental factors that can affect the health/disease process. The team should be capable of helping to motivate patients with diabetic foot, whether following amputation or not, as a way of encouraging patients to take responsibility for their own control and/or treatment, through collaboration rather than merely prescriptive approaches.

The use of data exclusively from the SUS limits the study's conclusions, since we only evaluated the sample reported by the SIM and the AIH in Santa Catarina, and there was no correction for under-reporting of deaths or by region. Thus, the number of amputations may have been underreported. Importantly, the lack of records from specific databases for deaths in diabetic individuals with lower limb amputation did not invalidate the study. The available mortality data for diabetes in the SIM were satisfactory, since they refer to mortality in the population with diabetes mellitus, the majority of which evolve to death after undergoing amputation. Nevertheless, we emphasize the sample's representativeness in relation to the population of Santa Catarina State and the study's internal validity, since we estimated the burden of disease in Santa Catarina State in all persons recorded in the SUS that underwent amputations due to diabetes mellitus from 2008 to 2013, distributed across all the state's 20 micro-regions.

Considering the National Policy for Comprehensive Healthcare for Men, which promotes specific healthcare measures aimed at increasing life expectancy and reducing morbidity and mortality rates from preventable and avoidable causes, the current study offers indicators of morbidity and mortality from diabetes mellitus that are essential for implementing adequate public health policies. The study shows that men with diabetes in Santa Catarina are aging as amputees.

## Contributors

K. P. B. Santos contributed to the study design and conception, writing, data analysis, and revision of the article. S. C. T. Luz contributed to the study design, writing, data analysis, and revision of the article. L. Mochizuki collaborated in assembling the database, analysis of the results, and revision of the article. E. d'Orsi participated in the study design, writing, and revision of the article.

## Acknowledgments

The authors wish to thank the Santa Catarina State Health Secretariat, especially the staff of the Division of Planning, Control, and Evaluation of the Brazilian Unified National Health System (SUS), for their support during the research project, and the Brazilian Graduate Coordinating Board (Capes) and the Brazilian National Research Council (CNPq) for funding the study.

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## Resumo

O objetivo foi estimar a carga da doença para as amputações de membros inferiores atribuíveis ao diabetes mellitus no Estado de Santa Catarina, Brasil, no período de 2008 a 2013. Realizou-se um estudo epidemiológico descritivo, utilizando-se o cálculo de anos de vida perdidos ajustados por incapacidade (DALY – disability-adjusted life years). A carga da doença foi alta, mais de 8 mil DALY, distribuídos entre homens e mulheres. A incapacidade respondeu por 93% do DALY e a mortalidade por 7,5%. A carga dos homens foi 5.580,6 DALY, praticamente o dobro das mulheres (2.894,8), sendo que a participação do componente anos de vida saudável perdidos em virtude de incapacidade (YLD – years lost due to disability) dos homens impulsionou esta taxa para 67,6% do total do DALY. Os homens vivem mais tempo com a amputação, por isto perdem mais anos de vida sadia (65,8%), e a mortalidade é maior entre as mulheres (61%). As distribuições das taxas de DALY no estado não mostraram distribuição homogênea. A intensificação de avaliação, planejamento e desenvolvimento de estratégias custo-efetivas para a prevenção e educação em saúde para o pé diabético deve ser considerada a partir da maior vulnerabilidade masculina.

*Amputação; Diabetes Mellitus; Anos Potenciais de Vida Perdidos; Carga Global de Doença*

## Resumen

El objetivo fue estimar la carga de enfermedad para las amputaciones de miembros inferiores, atribuibles a la diabetes mellitus en el Estado de Santa Catarina, Brasil, durante el período de 2008 a 2013. Se realizó un estudio epidemiológico descriptivo, utilizándose el cálculo de años de vida ajustados por discapacidad (DALY – disability-adjusted life years). La carga de la enfermedad fue alta, más de 8 mil DALY distribuidos entre hombres y mujeres. La incapacidad supuso un 93% del DALY y la mortalidad un 7,5%. La carga de los hombres fue 5.580,6 DALY, prácticamente el doble de las mujeres (2.894,8), siendo que la participación del componente años de vida saludable perdidos por discapacidad (YLD – years lost due to disability) de los hombres impulsó esta tasa hacia un 67,6% del total del DALY. Los hombres viven más tiempo con la amputación, por ello pierden más años de vida sana (65,8%), y la mortalidad es mayor entre las mujeres (61%). Las distribuciones de las tasas de DALY en el estado no mostraron distribución homogénea. La intensificación de evaluación, planificación y desarrollo de estrategias costo-efectivas para la prevención y educación en salud para el pie diabético debe ser considerada a partir de la mayor vulnerabilidad masculina.

*Amputación; Diabetes Mellitus; Años Potenciales de Vida Perdidos; Carga Global de Enfermedades*

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Submitted on 25/Jan/2016

Final version resubmitted on 02/Jan/2017

Approved on 25/Apr/2017