Health Policy and Planning, 34, 2019, ii45–ii55
doi: 10.1093/heapol/czz109
Supplement Article

Diabetes epidemics: inequalities increase the burden on the healthcare system

Carolina Santamaría-Ulloa [1,*], Melina Montero-López [1] and Luis Rosero-Bixby [2]

[1]Instituto de Investigaciones en Salud, Universidad de Costa Rica, San José, Costa Rica, [2]Centro Centroamericano de Población, Universidad de Costa Rica, San José, Costa Rica

*Corresponding author. Instituto de Investigaciones en Salud, Universidad de Costa Rica, De la UNED carretera a Sabanilla, 200 m este y 125 m sur, San José, Costa Rica. E-mail: carolina.santamaria@ucr.ac.cr

Accepted on 5 September 2019

Abstract

Diabetes is a major cause of morbidity and mortality and represents a source of demands on already constrained healthcare systems in Latin America and the Caribbean. We estimate inequalities in diabetes incidence, prevalence and mortality and assess the economic burden on the healthcare system in Costa Rica. The main source of data is the Costa Rican Longevity and Healthy Aging Study, a longitudinal nationally representative survey of the elderly population ($n = 2827$). Data analyses include descriptive statistics, multiple regression models and survival analysis models. More than a fifth of Costa Rican elderly experience diabetes. Incidence is estimated at 5 per 1000 person-years in the population 30+. Gender and geographical inequalities were found. Men have a significantly lower prevalence (16.51% vs 24.02%, $P < 0.05$) and incidence (4.3 vs 6.0 per 1000 person-years, $P < 0.05$), but higher mortality (hazard ratio = 1.31, $P < 0.01$). Longer time to the closest facility translates into a lower probability of having the condition diagnosed [odds ratio (OR) = 0.77, $P < 0.05$]. The diabetic as compared to the non-diabetic population imposes a larger economic burden on the healthcare system with a higher probability of using outpatient care (OR = 3.08, $P < 0.01$), medications (OR = 3.44, $P < 0.01$) and hospitalizations (OR = 1.24, $P > 0.05$). Individuals living in the Metro Area have a significantly lower probability of being hospitalized (OR = 0.72, $P < 0.05$), which may be evidence of better access to primary care that prevents hospitalization. Along the same line, women have higher utilization rates of outpatient care (OR = 2.02, $P < 0.01$) and medications (OR = 1.73, $P < 0.01$), which may contribute to lower odds of hospitalization (OR = 0.61, $P < 0.01$). Aligned with the aim of attaining Sustainable Development Goals, this study highlights the importance of generating health policies focused on prevention of diabetes that take into consideration gender and geographical inequalities. Strategies should booster preventive healthcare utilization by men and aim to make healthcare services accessible to all, regardless of geographical location.

Keywords: Developing countries, diabetes, healthcare system, inequalities

Introduction

In virtually all populations, hyper-caloric diets and decreased physical activity have accompanied the benefits of modernization. These changes, which have led to an increasing prevalence of obesity, combined with increasing longevity have formed the basis for dramatic increases in the prevalence of type 2 diabetes (DM2) worldwide. Urbanization processes in developing countries play a role. To some extent, urbanization is a proxy for lifestyle changes, including a more sedentary lifestyle, and increased obesity (Shaw *et al.*, 2010). There is evidence that the principal, albeit not exclusive, driver of the DM2 epidemic is overweight and obesity, especially abdominal fat deposition (Hu *et al.*, 2001).

Diabetes is a major cause of both morbidity and mortality in the elderly. DM2 is a well-established risk factor for coronary heart

Key Messages

- Gender inequality was found in the context of the diabetes epidemic in the Costa Rican elderly. Although men have significantly lower prevalence and incidence of diabetes, they face a higher mortality than women.
- Geographical inequality was also described. The longer the time to the closest healthcare facility the lower the probability of having the condition diagnosed.
- The diabetic as compared to the non-diabetic population imposes a larger economic burden on the healthcare system with a higher probability of using outpatient care, medications and hospitalizations.
- Aligned with the aim of attaining Sustainable Development Goals, this study highlights the importance of generating health policies focused on prevention of diabetes that take into consideration gender and geographical inequalities.

disease, cardiovascular and cerebrovascular diseases. Furthermore, hypertension is more prevalent in the diabetic population (Grundy *et al.*, 1999; Barceló, 2000). This condition is therefore increasingly constraining the healthcare systems and imposing a high economic burden (Barceló *et al.*, 2003; Palloni *et al.*, 2006). Higher proportions of elderly combined with an increasing number of diabetic individuals—who have higher risk of premature mortality—have made diabetes a challenge for the medical care systems in Latin America (Barceló, 2000; Barceló *et al.*, 2006) and in developed regions (Sloan *et al.*, 2008; Solli *et al.*, 2010).

The population composition will play an important role in the impact the diabetes epidemic will have in the years to come. In Costa Rica, like in other Latin American countries, the population aging process is clearly on its way. In 1950, only 48 000 people (6%) were aged 60 or older. Currently, in 2019, there are already 650 000 people (13%) aged 60 or older. It is projected that in 2050 a total of 1.7 million will belong to this age group, which will represent nearly 30% of the total population (Figure 1).

As a consequence of demographic aging and the prevalence of diabetes risk factors, such as obesity, the elderly population with DM2 is expected to continue growing. Actions to reduce diabetes will therefore have noticeable results only in the medium or in the long term. Nonetheless, if the diabetes epidemic is left unaddressed, the burden on both the population and the healthcare system will increase to unsustainable proportions.

Costa Rican medicine is highly socialized (Rosero-Bixby, 1996). The health system includes a public and a private sector. The public sector is led by the Costa Rican Social Security Fund (CCSS, for its Spanish acronym) whose main functions are those of financing, purchasing and delivering most of the healthcare services. CCSS delivers healthcare in three levels with differential resolution capacity. The first level corresponds to Basic Teams for Comprehensive Healthcare (EBAIS, for its Spanish acronym) along with outpatient and peripheral clinics. The second level includes peripheral and regional hospitals. The third level includes national and specialized hospitals (Sáenz *et al.*, 2011). The private sector offers outpatient care and specialty services, and it is mainly financed by out-of-pocket payments.

A series of reforms have been under way since the 1980s (Villalobos and Piedra, 1998). This resulted in a better allocation of resources to the CCSS and has been associated with a reduction of inequalities and a strengthening of access to primary healthcare (Sáenz *et al.*, 2011). Currently, the Costa Rican healthcare system is focused on non-communicable diseases (Organización para la Cooperación y el Desarrollo Económicos (OCDE), 2017), which are complex and multi-causal (Sáenz *et al.*, 2011). Bolstering access to primary healthcare will be crucial to effectively reduce inequalities.

Little is known about diabetes epidemics among elderly populations in Latin America because most epidemiologic studies have focused on the general population or on younger population

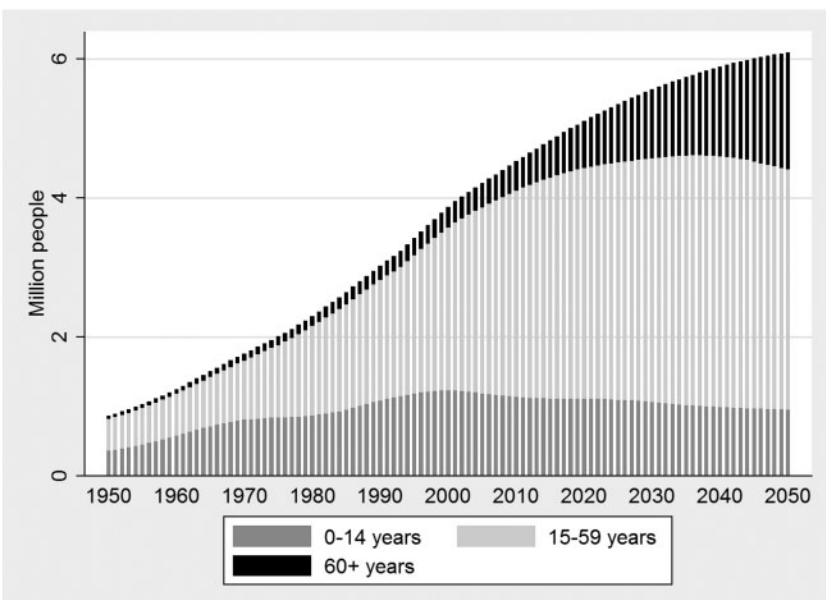

Figure 1 Population distribution in three large age groups. Costa Rica: 1950–2050.

segments (Barceló *et al.*, 2007). An estimation of the burden of diabetes in terms of healthcare will be an important input for the establishment of public policy that is relevant not only to Costa Rica but also to other developing countries facing similar scenarios.

In the search to meet the Sustainable Development Goals (SDGs), attempts to reduce inequalities are important. By providing evidence of inequalities that need to be addressed, this research contributes to SDG goal number 3: 'Ensure healthy lives and promote well-being for all at all ages'. As stated by Chaparro-Díaz (2016), efforts towards reducing inequalities are also related to SDG goal number 1: 'End poverty in all its forms everywhere'. Diabetes as well as many chronic diseases is related to poverty and increases costs to the healthcare system due to a higher demand of public healthcare services. Finally, by generating scientific knowledge that may be applicable to other developing countries, this research contributes to SDG goal 10: 'Reduce inequality within and among countries'.

The objective of this study is to estimate inequalities in diabetes incidence, prevalence and mortality, and to provide estimates of the elderly diabetes burden on the healthcare system. This research is an input for decision makers in terms of allocation and efficient use of resources. Although information alone does not translate into policymaking to reduce inequalities, this study provides evidence of the need for health promotion and prevention programmes aimed at reducing specific diabetes inequalities.

Methods

Data analyses and estimations were conducted with STATA computer software (StataCorp, 2013). The analyses include descriptive statistics, multiple regression models and survival analysis models depending on the nature of the phenomena to be described.

The main source of data is the Costa Rican Longevity and Healthy Aging Study (CRELES, for its Spanish acronym), a nationally representative longitudinal survey of health and life-course experiences of Costa Ricans ages 60 and over in 2005. As with any elderly survey, data are subject to selection bias since they refer solely to the population that had survived at least to the age of 60 in 2005 and was therefore eligible for the study. A baseline ($n = 2827$) and two subsequent 2-year follow-up interviews were conducted. Data collection occurred between 2004 and 2006 for the baseline, between 2006 and 2007 for the second wave and between 2008 and 2009 for the third wave. Loss to follow-up between baseline and wave 2 was 7% and between waves 2 and 3, it was 9% of the baseline sample.

The baseline sample was randomly drawn from Costa Rican residents in the 2000 population census who were born in 1945 or earlier, regardless of their nationality. It was stratified by 5-year age groups in order to have similar sample sizes in each age group. This strategy, that implied an over sampling of older people, assured a sufficiently large number of observations for advanced ages. Because of the use of sampling weights in the analyses conducted, oversampling of the oldest adults does not have an impact on the findings reported in this study. Details on the estimation of sampling weights for the CRELES survey have been previously published (Rosero-Bixby *et al.*, 2013).

This survey collected information on different health conditions, living conditions, health behaviours, healthcare utilization and socioeconomic status, among other variables. Baseline data, wave 2 and wave 3 were all used to follow individuals regarding diabetes diagnosis and mortality. Additionally, mortality was tracked by linking the CRELES dataset with the National Vital Registration System (Death Index). For the purpose of this study, mortality was tracked up to 31 October 2017.

Classification of individuals' diabetes status

Diabetes status was defined based on self-report of a diagnosis by a medical doctor. Self-reports have high specificity (ability to identify correctly those who 'do not have the diagnosis'), but lower sensitivity (ability to identify correctly those who 'have the disease'). Nonetheless, self-reports are still the easiest and most widely used way to measure health conditions in population studies.

Sociodemographic characteristics

Age and sex were used as sociodemographic characteristics in the prevalence, incidence and mortality models, and they were used as predisposing characteristics in the economic burden models. Age was used as a continuous variable. Sex was a dichotomous variable, with female as the reference category.

Education was used as a sociodemographic variable in the prevalence and mortality models and as a personal enabling resource in the economic burden models. It was a dichotomous variable that refers to incomplete or complete primary school (reference category).

Income was used as a sociodemographic variable in the prevalence model. It was a dichotomous variable that refers to low or high income. The cut-off point is 100 US dollars (USD) 2011 per elderly individual per month. That is the elder's own income if not married, or the average of the couple's monthly income if married. USD100 was considered the minimum income for an elderly person to cover his or her expenses over a 1-month period during the time period of the baseline survey. This cut-off point for income has also been used in similar studies with CRELES (Méndez-Chacón *et al.*, 2008; Brenes-Camacho and Rosero-Bixby, 2008b).

Diabetes risk factors

Two variables were used as diabetes risk factors in the prevalence model: family history of diabetes and a combined measure of waist circumference (WC) and body mass index (BMI).

Family history of diabetes was a dichotomous variable. It referred to whether or not (reference category) any of the individual's parents, siblings or grandparents had ever had the condition.

Obesity is known to be the main risk factor for diabetes. There are different indicators of obesity. BMI is an indicator of general obesity and WC of central obesity. According to BMI, individuals were classified as (1) underweight: <18.5, (2) normal: 18.5–24.9, (3) overweight: 25.0–29.9 or (4) obese: ≥ 30.0 (WHO, 2000). Participants were also classified in the following WC categories. For men: (1) normal: <94, (2) increased: 94–101 or (3) substantially increased: ≥ 102 cm. For women: (1) normal: <80, (2) increased: 80–87 or (3) substantially increased: ≥ 88 (WHO, 2000).

WC and BMI combined categories were combined into a more comprehensive measure of obesity and were used as follows: (1) normal WC, normal BMI; (2) normal WC, overweight or obese; (3) increased or substantially increased WC, normal BMI; (4) increased WC, overweight or obese; (5) substantially increased WC, overweight; and (6) substantially increased WC, obese.

Behavioural health risks

Three variables were used as behavioural health risks in the prevalence model: smoking, alcohol consumption and hyper-caloric diet.

Questions regarding active smoking behaviour in this study were asked only to those who had smoked 100 or more cigarettes or cigars during their lives. Those who were not current active smokers but lived with a smoking partner were classified as passive smokers. Individuals were categorized as: (1) never smoked (reference category), (2) former active or passive smoker, (3) current passive smoker and (4) current active smoker. Information on alcohol refers to alcoholic drinks ever consumed along individual's lives. Individuals were categorized into: (1) never (reference category), (2) former and (3) current alcohol drinker.

The estimation of calorie daily consumption was made from a tracer food consumption questionnaire that was part of the baseline interview. A cut-off point of 3000 kcal/day was used. This value is a standard cut point associated with differential risk of cardiovascular disease (Brown, 2008) and has been used in similar population studies (Méndez-Chacón *et al.*, 2008; Rosero-Bixby and Dow, 2009; Rehkopf *et al.*, 2010).

Chronic morbidity

Three comorbidities were included in the prevalence model: hypertension, elevated high-density lipoprotein (HDL)/low-density lipoprotein (LDL) cholesterol, and elevated triglycerides. Six chronic conditions were included in the mortality analysis: diabetes, cancer, lung disease, myocardial infarction, ischaemic heart disease (not infarction), and stroke.

Chronic morbidities were self-reported, they refer to whether or not the individual has ever been told by a medical doctor to have the condition and were defined as dichotomous variables, with not having the condition as the reference category.

Access to healthcare

Three variables related to healthcare access were included in the prevalence model: having a health insurance, living in the Great Metropolitan Area (GMA), and mean time to the nearest healthcare facility.

Following Gulliford *et al.* (2002), the choice of the aforementioned variables responds to access being measured in terms of utilization of available services, which depends on affordability, physical accessibility and acceptability of services. No measurements regarding acceptability were available. Access to healthcare was operationalized in terms of affordability (having a health insurance) and physical accessibility (living in the GMA and mean time to the nearest healthcare facility). Living in the GMA was used as a measure of physical accessibility because that is the geographical area where most important healthcare facilities are clustered in Costa Rica.

Determinants of healthcare services utilization

Variables used in the models of economic burden on the healthcare system are based on Andersen's theoretical model of healthcare use (Andersen, 1995), which is widely used and adjusts to the Costa Rican context (Brenes-Camacho and Rosero-Bixby, 2009; Llanos *et al.*, 2009). This model proposes that the use of healthcare services is mediated by the interaction of predisposing characteristics, enabling resources, and need (Andersen, 1995).

Predisposing characteristics included in the model are: age, sex, living in the GMA, married or in union, and retired. Age has been included as a continuous variable, the rest of predisposing characteristics were dichotomous variables.

Enabling factors refer to conditions that allow a greater availability and access to the services. They include individual (education and income) as well as contextual (mean time to the nearest healthcare facility) characteristics. Time has been included as a continuous variable, the rest of enabling factors were dichotomous variables.

Need is the most proximate determinant of utilization, and it varies as a function of the predisposing and enabling factors. Cultural factors can also influence need, but no measurement of such variables was available in the CRELES questionnaire. The following variables were included: having poor self-perceived health, having at least one limitation in activities of daily living (ADL), having at least one limitation in instrumental activities of daily living (IADL) and having been diagnosed with diabetes, cancer, lung disease, cardiovascular disease (myocardial infarction, ischaemic heart disease or stroke), hypertension, dyslipidaemia (hypercholesterolaemia or hypertriglyceridaemia), arthritis or osteoporosis. They were all treated as dichotomous variables.

Point prevalence rates of diabetes and their 95% confidence intervals were estimated by sex. Logistic regression models were used to analyse the relationship among individuals' diabetes status and sociodemographic characteristics (age, sex, education, income), diabetes risk factors (family history of diabetes, WC—BMI combined measure), behavioural health risks (smoking, alcohol drinking, hyper-caloric diet), access to healthcare (health insurance, living in the GMA, time to closest facility) and comorbidities (hypertension, HDL/LDL cholesterol, triglycerides).

The estimation of incidence relies on self-reporting on how old the subject was or what the date was when diabetes diagnosis occurred. When reporting a previous medical diagnosis, people will likely offer approximate rather than exact dates of the diagnosis of their condition. However, there is no way to attenuate this bias since no external sources of data, such as medical records, were used.

To avoid potential confounding with type 1 diabetes, only individuals reporting a diagnosis of diabetes at 30 years or older were included in incidence models. This criterion has been used in other population studies (Hu *et al.*, 2001, 2007; Suh *et al.*, 2008).

This estimation of adult population incidence is therefore a reconstruction that relies on both retrospective and prospective data on the timing of diabetes diagnosis. Prospective information comes from the three waves of the longitudinal study, and retrospective data come from participants' recall back to their age of 30. Because CRELES sampling weights were estimated to reproduce the structure of the Costa Rican elderly population in 2005 (Rosero-Bixby *et al.*, 2013), and this is rather a reconstruction of adult population rates, CRELES weights were not used for incidence estimates.

Incidence rates and their 95% confidence intervals were estimated for total population and by sex, no control variables were used for these estimates. The data weres set as survival time. Follow-up time starts at the date each individual was aged 30. Censoring occurs when individuals are lost to follow-up—either because of death or because of other reasons—or at the time of interview in the third wave. Starting at the age of 30, incidence rates were computed as the ratio of new diabetes diagnoses to the exact count of person-years.

Parametric survival models with a log-logistic distribution for the baseline hazard were used to model incidence. This distribution has a fairly flexible functional form (Hosmer and Lemeshow, 1999). Reason to select this distribution is that the incidence process does not grow monotonically. DM2 incidence increases from the age of 30 up to a certain point around the age of 60, and then starts going down at older ages. The log-logistic function can effectively represent a pattern of increasing incidence, followed by a decrease and was therefore selected for this analysis.

Because of the longitudinal nature of the data, parametric regression models were used to estimate the association between mortality and sociodemographic characteristics (sex and education) and chronic morbidity (diabetes, cancer, lung disease, myocardial infarction, ischaemic heart disease and stroke). The data were set as survival time. Follow-up time starts at the date each individual was 60. Respondent's vital status was assessed during the three waves of CRELES and it was also tracked by linking the CRELES dataset with the National Vital Registration System (the Death Index) up to 31 October 2017. Mortality rates were computed as the ratio of deaths to the exact count of person-years.

Parametric survival models with a Gompertz distribution for the baseline hazard were used to model mortality (Hosmer and Lemeshow, 1999). Costa Rican mortality rates have been shown to follow a Gompertz function, especially after the age of 45 (Rosero-Bixby and Antich, 2010).

Two-part models were used to analyse the factors that affect the propensity to use hospitalizations, outpatient consultations and medications and those that affect the volume of utilization once the person makes use of them. This is a common tool used in health economics applications in which the outcomes are measures of health-care utilization (Diehr *et al.*, 1999). It basically assumes that the probability of the outcome is >0 given a set of covariates is governed by a binary probability model. That is part 1, and is usually modelled as a logistic regression, as is the case in this study. It also assumes that the expected logarithm of the outcome given that the outcome is >0, and given the same covariates, is a linear function of those covariates. That is part 2, and has been modelled as a generalized linear model (GLM) for the three healthcare services analysed in this study.

The main characteristics of these data are that the outcomes are positive numeric values, there is an important fraction of zeros, and the non-zero outcomes are positively skewed (Manning and Mullahy, 2001). A gamma stochastic distribution with a log link has been used to estimate the parameters associated to each covariate in the part 2 of the models. Using the gamma distribution is common in models to explain healthcare services utilization and costs (Diehr *et al.*, 1999).

The expected levels of use of each of these three services were estimated by multiplying the estimates of part 1 and part 2 of the two-part models. Each individual's estimated utilization of health-care services is his probability of having any use multiplied by the expected volume of utilization conditional on being a user.

Economic cost is the dependent variable in each of the three models. Costs are inputted for each individual based on their volume of utilization of each of the following services: hospitalizations over a calendar year, outpatient visits over a calendar year and medications currently taken. Mean costs for these services as reported by the CCSS were used. Costs are reported in United States Dollars from the year 2011 (2011 USD).

Results

At least one-fifth (20.5%) of Costa Rican elderly is diabetic (Table 1). Gender inequalities in prevalence exist in this population. Diabetes prevalence in Costa Rican elderly is significantly higher among women [24.02%, 95% confidence interval (CI) 21.88–26.16] than men (16.51%, 95% CI 14.48–18.53). Diabetes prevalence is lowest in the oldest old (Table 1).

Out of 10 individuals, 7 have general or abdominal fat deposition that puts them at higher risk of diabetes. This elderly population seems to have good access to healthcare. The great majority of them have health insurance; more than half of them live in the GMA, where the urban conditions make healthcare facilities geographically more accessible (Table 1). Mean time to the nearest healthcare facility is half an hour across the country, but it is longer in rural as compared to urban areas (39 vs 27 min, $t = 2.86$, $P = 0.004$) and outside the GMA (38 vs 26 min, $t = 2.85$, $P = 0.004$).

Women have higher prevalence of general and central obesity as measured by BMI, WC and the combined measure of both variables. Obesity prevalence decreases with age. Smoking and especially alcohol drinking is higher in males, and both risk behaviours decrease with age (Table 1).

Chronic comorbidities are common in the elderly. Hypertension and hypertriglyceridaemia are highly prevalent in Costa Rican population. Hypertension is the most common cardiovascular disease and the most common comorbid condition for diabetic elderly: 82% of diabetic are hypertensive, as compared to 59% of non-diabetic who are hypertensive.

Diabetes incidence estimation according to CRELES is at least 5.2 per 1000 people aged 30 and above. As well as in prevalence, gender inequalities exist in incidence, with a significantly higher rate in the female adult population (Table 2).

Results of a longitudinal model of general mortality are shown in Table 3. When controlling for sociodemographic characteristics and other chronic morbidity as the most proximate determinants of mortality, diabetes is significantly associated with higher mortality. Men have higher mortality rates than women (hazard ratio = 1.31, $P < 0.01$).

Geographical inequalities translate into a lower probability of having the condition diagnosed. As time to the closest facility increases, the odds of having been diagnosed significantly decreases [odds ratio (OR) = 0.77, $P < 0.05$] (Table 4).

Following the Andersen's model of access to medical care, the economic burden of diabetes on the public healthcare system was estimated by modelling the probability and volume of utilization (Table 5) as well as the costs (Table 6) of outpatient care, hospitalizations and medications. CRELES data on healthcare utilization had high completeness rates, which allowed models to be estimated in the base of 2189 cases (77% of baseline sample). Because of the nature of data collected by the survey, both outpatient care and hospitalizations costs were estimated over one calendar year. Medications costs were estimated for those drugs that were currently being taken at baseline, rather than for one calendar year.

Outpatient consultation probability (OR = 3.08, $P < 0.01$) and its volume of use (OR = 1.11, $P < 0.01$) are significantly higher for diabetic individuals. Once diabetic individuals make use of outpatient care, they have an 11% higher volume of utilization than their non-diabetic counterparts (Table 5). Mean cost of outpatient care is ∼24% higher for the diabetic as compared to non-diabetic elderly (Table 6).

Hospitalization probability (OR = 1.24, $P > 0.05$) and its volume of use (OR = 1.09, $P > 0.05$) are higher for diabetic individuals, although not statistically significant (Table 5). Mean hospitalization costs are 50% higher for diabetic elderly (Table 6).

Medications probability of utilization (OR = 3.44, $P < 0.01$) and its volume of use (OR = 1.28, $P < 0.01$) are significantly higher for elderly, diabetic individuals. Once diabetic individuals make use of medications, they have a 28% higher volume of utilization than the non-diabetic elderly (Table 5). Mean cost of medications for the diabetic elderly is almost twice the cost for non-diabetic (Table 6). Costs presented in Table 6 are particularly low for medications because their estimation is based on the mean cost of a drug prescription, which is the way the CCSS registers and provides mean costs of drugs.

Once controlling for diabetes and other comorbidities, individuals living in the Metro Area have a significantly lower probability of being hospitalized (OR = 0.72, $P < 0.05$), which may be evidence of

Table 1 Descriptive information of the CRELES Costa Rican elderly at baseline: 2004–2006

Characteristics, $n = 2827$ unless otherwise noted	Total population	Sex		Age		
		Male	Female	60–69	70–79	80+
Sociodemographics						
Education: % with complete primary	49.0	48.8	52.4	58.6	40.0	33.5
Low income, 2799	40.6	38.1	42.8	36.8	42.9	49.4
Risk factors						
Waist circumference, 2632						
Normal	31.6	51.5	13.5	30.5	30.9	37.6
Increased	21.3	24.7	18.2	22.2	18.9	23.7
Substantially increased	47.0	23.8	68.3	47.4	50.2	38.7
Body mass index, 2698						
Underweight	13.3	12.3	14.1	9.4	13.0	28.9
Normal	39.6	41.4	37.9	38.2	40.1	43.9
Overweight	34.6	36.4	32.8	37.1	36.3	20.7
Obese	12.6	9.8	15.2	15.4	10.5	6.4
Waist circumference and BMI, 2627						
Normal WC and BMI	21.4	31.9	11.8	17.6	22.9	32.8
Normal WC, overweight or obese	10.3	19.7	1.8	12.7	8.8	4.6
Increased or substantially increased WC, normal weight	10.0	2.9	16.5	7.5	9.9	19.8
Increased WC, overweight or obese	17.0	23.8	10.8	19.0	15.3	13.3
Substantially increased WC, overweight	18.0	7.3	27.9	17.0	20.3	16.8
Substantially increased WC, obese	23.2	14.4	31.3	26.1	22.9	12.7
Behavioural health risks						
Smoking, 2810						
Never	10.0	29.42	41.09	36.68	34.12	34.5
Former active or passive smoker	33.1	51.0	17.0	31.5	33.5	37.8
Current passive smoker	21.4	2.9	38.1	19.5	24.2	22.2
Current active smoker	35.5	16.8	3.8	12.3	8.2	5.4
Alcohol						
Never	35.8	7.3	61.6	34.2	36.0	41.2
Former alcohol drinker	29.7	46.3	14.7	27.4	31.0	35.2
Current alcohol drinker	34.5	46.5	23.8	38.3	33.1	23.6
Calorie daily consumption ≥3000, 2819	12.3	16.0	9.0	13.9	11.6	7.9
Access to healthcare						
Having health insurance	94.6	92.9	96.1	92.9	96.5	96.5
Living in the Great Metropolitan Area	53	50.7	55.0	51.1	55.1	55.0
Mean time to the nearest health facility, 2401	31.0	32.3	29.8	29.9	30.4	37.3
Health condition						
Chronic morbidity						
Diabetes[a]	20.5	17.0	24.2	21.1	23.2	14.2
Hypertension, 2823	64.5	59.8	68.8	61.3	68.8	67.2
Dyslipidaemia,[b] 2656	51.2	50.8	51.6	54.8	47.6	45.9
Elevated total/HDL cholesterol ratio, 2654	28.5	32.7	24.6	31.8	24.7	24.0
Elevated triglycerides, 2573	44.9	42.0	47.4	47.6	42.5	39.7
Cardiovascular disease						
Myocardial infarction	4.6	5.6	3.7	3.0	6.3	6.8
Ischaemic heart attack (no infarction)	12	11.7	12.4	10.1	13.5	16.1
Stroke	3.8	3.5	4.1	2.1	4.7	8.2
Cancer	5.8	4.9	6.6	4.8	6.4	8.4
Lung disease	16.6	4.9	6.6	15.6	17.3	18.7

[a]Diabetes refers to self-report of MD diagnosis.

[b]Dyslipidaemia refers to any or both: hypercholesterolemia (total/HDL ratio) and hypertriglyceridaemia.

better access to primary care that prevents hospitalization. Along the same line, women have higher utilization rates of outpatient care (OR = 2.02, $P < 0.01$) and medications (OR = 1.73, $P < 0.01$), with a consequential lower odds of hospitalization (OR = 0.61, $P < 0.01$).

Discussion

Diabetes is highly prevalent. At least one-fifth of the Costa Rican elderly population has this condition. This is despite the fact that estimates from this study, based on self-reporting of diagnosis, can be taken as a conservative estimate of an even greater magnitude epidemic. Self-reports are known to underestimate true prevalence since there is a percentage of late-onset cases that go undiagnosed for a period of time. High prevalence also occurs in other Latin American and Caribbean (LAC) countries. In seven LAC cities, it is estimated to range from 12.4% in Buenos Aires, Argentina to 21.7% in Bridgetown, Barbados (Andrade, 2006). Compared to the LAC region, the prevalence of diabetes in Costa Rica is among the highest.

Table 2 Incidence[a] rate of diabetes by sex (rates per 1000 person-years)

Population	Incidence rate	95% CI
Total population	5.2	4.9–5.6
Female	6.0	5.5–6.6
Male	4.3	3.8–4.9
Incidence rate ratio[b]	1.4***	1.2–1.7

[a]Incidence estimated for adult ages 30 and above as reported by the subject.
[b]Mantel-Haenszel estimates of the rate ratio.
Significance level: ***$P < 0.01$.

Table 3 Hazard ratios and confidence intervals from Gompertz longitudinal regression models of general mortality at age 60 and above

Variables	Self-report	
	Hazard ratio	95% CI
Sociodemographics		
Male	1.35***	1.18–1.53
Complete primary school	1.14	0.99–1.31
Chronic morbidity		
Diabetes	1.57***	1.35–1.83
Cancer	1.03***	0.81–1.31
Lung disease	1.16***	0.99–1.36
Myocardial infarction	1.40**	1.09–1.82
Ischaemic heart disease (no infarction)	1.09***	0.94–1.31
Stroke	1.31**	1.03–1.67
Log pseudolikelihood	−1477.04	
Prob > Chi[2]	0.0000	

Significance levels: ***$P < 0.01$. **$P < 0.05$. *$P < 0.10$.

Table 4 Odds ratios and confidence intervals from logistic regression models of diabetes prevalence

Variables	OR	95% CI
Sociodemographics		
Age	0.99	0.98–1.01
Male	0.77*	0.56–1.05
Complete primary school	0.77**	0.60–0.98
Low income	1.06	0.84–1.35
Risk factors		
Family history of diabetes	2.57***	2.05–3.21
Normal WC and BMI	1.00	
Normal WC, overweight or obese	1.41	0.86–2.33
Increased or substantially increased WC, normal weight	1.64*	0.98–2.75
Increased WC, overweight or obese	2.10***	1.38–3.21
Substantially increased WC, overweight	2.11***	1.36–3.26
Substantially increased WC, obese	3.67***	2.45–5.48
Behavioural health risks		
Never smoker	1.00	
Former active or passive smoker	1.02	0.78–1.33
Current passive smoker	1.18	0.84–1.65
Current active smoker	2.24***	1.54–3.26
Never drinker	1.00	
Former drinker	0.82	0.59–1.13
Current drinker	1.06	0.78–1.43
Calorie daily consumption ≥3000	0.85	0.59–1.21
Access to healthcare		
Has health insurance	1.05	0.62–1.79
Living in the Great Metropolitan Area	0.89	0.71–1.12
Time to the closest facility (min)	0.77**	0.62–0.96
Comorbidities		
Hypertension	2.61***	1.99–3.43
Elevated HDL/LDL cholesterol	1.28*	0.99–1.67
Elevated triglycerides	0.76**	0.60–0.97
Pseudo R^2	0.1225	
Prob > Chi[2]	0.0000	

Significance levels: ***$P < 0.01$. **$P < 0.05$. *$P < 0.10$.

Metabolic conditions, hypertension and diabetes included, have common risk factors. Similar to what has been reported in other countries such as Mexico (Velázquez-Monroy *et al.*, 2003; Instituto Nacional de Salud Pública (INSP), 2012), in Costa Rica the odds of hypertension are higher in the diabetic elderly, which increases the burden both on individuals and on the healthcare system.

Smoking (Willi *et al.*, 2007; Kowall *et al.*, 2010; Zhang *et al.*, 2011) and alcohol consumption (Nakanishi *et al.*, 2003; Beulens *et al.*, 2005; Baliunas *et al.*, 2009; Pietraszek *et al.*, 2010) have been shown to be associated with diabetes. In this Costa Rican cohort, as it has also been reported by Velázquez-Monroy *et al.* (2003), the prevalence of diabetes increases as obesity and smoking increase.

Public policies should take into account diabetes risk factors, such as overweight, tobacco and alcohol consumption. Efforts to reduce risks while promoting health can contribute to reductions in inequalities surrounding the prevalence of diabetes, and promote a healthy life and universal well-being, as described in the SDGs.

The prevalence of diabetes among the elderly is higher at younger ages and decreases with age. This holds not only for Costa Rica but also for the Latin American population. The same age patterning of diabetes prevalence has been observed in many Latin American cities (Barceló *et al.*, 2006). Diabetes itself is associated with premature mortality, which contributes to lower prevalence at older ages.

Gender differences in the diabetes epidemic have not been consistent across the world (Ávila-Curiel *et al.*, 2007). While some studies show significant gender differences in prevalence, complications and mortality, those differences are not sufficiently explained (Sandín *et al.*, 2011). In the USA and some cities in LAC, diabetes prevalence has been reported to be higher in elderly men (Barceló *et al.*, 2007). In Costa Rica, however, it is lower for men in all 10-year age groups. After controlling for other sociodemographic characteristics, risk factors, behavioural health risks and access to healthcare, men are less likely to have a diabetes diagnosis in Costa Rica. Although this male advantage in terms of incidence may come in part from their lower prevalence of obesity; male disadvantage in mortality may come from late diagnoses that can be related to a lower utilization of outpatient care. The difficulty in understanding the sex differences that exist in the prevalence of diabetes has to do with the complexity of this disease. Obesity prevention, especially in women, and early detection, especially in men, are modifiable factors on which health policy should focus.

Having health insurance was not found to have a significant association with diabetes prevalence. This may be explained by the fact that Costa Rica has a universal healthcare system with no co-payments associated to the use of services, which makes healthcare affordable to the entire population. Access to healthcare is a complex concept. A population may have access if an adequate supply of services is available, but the extent to which a population actually gains access to healthcare depends on financial, organizational and

Table 5 Results from two-part regression models of cost of outpatient care, hospitalizations and medications at baseline: 2004–2006

Determinants	Outpatient care		Hospitalizations		Medications	
	Part 1—logistic	Part 2—GLM	Part 1—logistic	Part 2—GLM	Part 1—logistic	Part 2—GLM
	Odds ratios	Exp(β)	Odds ratios	Exp(β)	Odds ratios	Exp(β)
Predisposing characteristics						
Age	1.01	1.00	1.00	1.00	1.03	1.00
Female	2.02***	1.06**	0.61***	0.85	1.73***	1.10
Live in the Metro Area	1.29	1.00	0.72**	1.32	1.97	1.10
Married or in union	1.30	1.13***	0.84	0.48***	1.42	1.07***
Retired	2.13***	1.04	1.10	1.21	1.80***	1.05
Enabling resources						
Personal						
Complete primary school	1.18	1.07**	1.08	0.64**	1.39	1.06**
Low income	1.13	0.91***	0.79	1.40*	0.74	1.02***
Contextual						
Mean time to nearest health facility	1.06	1.01	1.05	1.06	1.00	1.01
Need						
Poor self-perceived health	1.37*	1.10***	1.90***	0.97	1.68*	1.13***
At least 1 ADL limitation	1.48**	1.05	1.51**	1.18	1.26**	1.09
At least 1 IADL limitation	0.89	1.08**	2.06***	1.17	1.47	1.12**
Diabetes	3.08***	1.11***	1.24	1.09	3.44***	1.28***
Hypertension	1.18	0.97	1.35*	1.39	3.42	1.42
Dyslipidaemia	0.64***	0.98	0.70**	1.03	0.85***	0.97
Cardiovascular disease	7.91***	1.16***	1.58***	0.96	3.52***	1.36***
Lung disease	2.99***	1.06*	0.84	1.01	1.96***	1.05*
Cancer	1.23	1.03	1.75**	1.01	0.70	1.01
Arthritis	1.46	1.09**	1.48**	0.85	1.75	1.15**
Osteoporosis	1.54	1.04	0.92	1.34	2.88	1.06
Pseudo R^2	0.1461		0.0841		0.2559	
Prob > Chi^2	0.0000		0.0000		0.0000	
AIC		27.43		29.69		21.31
BIC		−14 345.83		−1043.17		−12 381.65

$^{*}P<0.10$, $^{**}P<0.05$, $^{***}P<0.001$.

Table 6 Individual mean cost of outpatient care[a], hospitalizations[a] and medications[b]

Characteristics	Mean cost	95% confidence interval
Outpatient care[a]		
Total population	337	334–341
Non-diabetic	319	316–322
Diabetic	404	398–410
Hospitalizations[a]		
Total population	827	763–891
Non-diabetic	745	683–807
Diabetic	1.124	930–1318
Medications[b]		
Total population	20	20–20
Non-diabetic	17	16–17
Diabetic	31	31–32

Predicted mean costs from a two-part regression model (2011 USD).
[a]Estimated along one calendar year.
[b]Estimated for prescribed drugs currently taken at baseline.

social or cultural barriers. Access measured in terms of utilization of available services is therefore dependent on affordability, physical accessibility and acceptability of services (Gulliford *et al.*, 2002). Acceptability refers to the social and cultural influences that mediate access to healthcare. Leaving acceptability of healthcare services out of this study because of a lack of data results in a limitation to disentangle what portion of inequality is driven by cultural forces. This piece of information should be explored in future researches.

Longer mean times to the nearest healthcare facility were associated with a decreased probability of having a medical diagnose of diabetes. This is evidence of geographical barriers to healthcare that translate into a lower probability of diagnosis. A previous study by Brenes-Camacho and Rosero-Bixby (2008a) reported differential access to care in this same elderly population since individuals not living in the GMA had a lower probability of having their diabetes controlled. Inequalities in access to diabetes care can result from various factors including the geographical distribution of health services and therefore the distance needed to travel to have access to them (Whiting *et al.*, 2010).

Although most diabetes diagnoses occur during adulthood, the lack of an official population registry of incident cases prevents the direct estimation of incidence rates. An indirect estimation was therefore conducted based on the reconstruction of this elderly cohort back to age 30. Although subject to selection bias, this estimation can be used to project the impact of this condition on the healthcare system. Diabetes, as it has also been shown in other studies, is associated with increased risks of all-cause mortality (Hu *et al.*, 2007). The most highly effective interventions to reduce morbidity, premature mortality and the incidence of diabetes-related complications are both education for lifestyle change, and the creation of environments in which individual behavioural initiatives can succeed. As stated by Yach *et al.* (2006), overweight and obesity have become to diabetes what tobacco is to lung cancer. Acting on preventable risk factors for diabetes is therefore mandatory.

Diabetes costs are on the rise around the world (Zhang *et al.*, 2010). In Latin America, the increase in the prevalence of DM2 has already impacted healthcare systems. A 33% increase in economic spending for diabetes care between 2009 and 2011 has been reported in Mexico, and this figure is expected to rise (Arredondo and De Icaza, 2011). Countries such as Argentina have reported that deficiencies in programmes aimed at preventing complications in diabetic patients have increased the expected costs of diabetes care by a 23% (Gagliardino *et al.*, 2000).

In Costa Rica, diabetes is among the three highest-cost conditions for the healthcare system (Jiménez, 2018). Developing policies that prevent chronic non-communicable diseases prevention is an alternative to reducing costs in the healthcare system. Physiological changes related to DM2 begin in childhood or adolescence (Guerrero and Rodríguez, 2015) therefore creating policies to promote health as early as during childhood is critical.

A study to find out what prevention-focused actions can reduce costs in diabetes care has been carried out in Brazil, to analyse the relationship between physical activity and the expenditures in public healthcare on DM2 treatment. It was found that physical activity in diabetic populations was consistently associated with lower healthcare expenditures for the public healthcare system (Codogno *et al.*, 2011).

A challenge for policymakers is to develop policy and programmes aimed at reaching SDGs, as they respond to context needs and target inequity reduction. According to the Pan American Health Organization (2017) actions aimed at reaching SDGs and alleviating inequity must focus on policy that prioritizes actions to target structural determinants. Producing evidence of inequality related to diabetes will allow policy makers to identify policy targets.

To face the diabetes burden, health promotion aspects must be taken into consideration, specifically the action lines proposed in the Ottawa Charter for Health Promotion (1986), dealing with the implementation of public policy and healthy legislation, the creation and protection of healthy environments, the strengthening of communitarian action, individual and collective potentiality and the re-orientation of healthcare services.

Primary attention actions focused on the obesity and diabetes problem should be taken into account by decision makers. Araúz *et al.* (2001) propose to search for methodologies that deal with knowledge, perceptions, attitudes, fears and practices of patients both in the family and the community contexts. Health education may therefore prove to be a useful tool.

The universal access to primary healthcare can be crucial to effectively reduce inequalities, by preventing the onset of the disease. As stated by Aguilar *et al.* (2015), healthcare services should be re-oriented based on a Social Determinants of Health approach that considers equal access to preventive programmes, strengthening of primary healthcare and the development of human resources with adequate skills.

Conclusion

This study adds to the literature an estimation of the burden that DM2 has on a developing country that has already started the population aging process. Although the data are specific to Costa Rica, results may be applicable to other aging developing countries in the LAC region.

Besides the impact diabetes epidemic has on individuals lives, this condition clearly puts the public healthcare system under pressure. Caring for diabetic elderly is more expensive in terms of hospitalizations, outpatient care and medications. The costs of healthcare will increase because of the population aging process itself. But the impact of diabetes on these costs can be reduced if risk factors are attenuated in the population and earlier diagnoses of the condition are attained. Policies to reduce risk factors will not affect diabetes incidence in the short term but will do so in the medium and long terms. Programmes to promote health, to improve detection and management of diabetes would reduce the burden as a result of a slower progression to complications.

Directing public funds at treating diabetes and its complications is important. Nonetheless, the rapid escalation of expected numbers of elderly with diabetes in the near future demands urgent action on health promotion and prevention. Not doing so would have the adverse effect of increasing economic costs due to premature morbidity and mortality from diabetes that would absorb much of the healthcare budgets.

Strategies to tackle obesity might be incorporated into other existing health promotion programmes. But strategies should be framed in contexts that reduce obesogenic environments. Educational strategies may lead to a better diet in individuals, but sustainable changes occur in the population when supporting environments for these behavioural shifts are also part of the equation.

Acknowledgements

The CRELES project is a longitudinal study of the Universidad de Costa Rica, carried on by the Centro Centroamericano de Población in collaboration with the Instituto de Investigaciones en Salud, with the support of the Wellcome Trust Foundation (Grant No. 072406). Principal Investigator: Luis Rosero-Bixby. Co-principal investigators: Xinia Fernández and William H. Dow. Collaborating investigators: Ericka Méndez, Guido Pinto, Hannia Campos, Kenia Barrantes, Floribeth Fallas, Gilbert Brenes and Fernando Morales. Informatics and support staff: Daniel Antich, Aaron Ramírez, Jeisson Hidalgo, Juanita Araya, and Yamileth Hernández. Field workers: José Solano, Julio Palma, Jenny Méndez, Maritza Aráuz, Mabelyn Gómez, Marcela Rodríguez, Geovanni Salas, Jorge Vindas and Roberto Patiño. The following sources of funding were awarded to the corresponding author: Traineeship from the National Institutes of Health's (NIH) Fogarty International Center (FIC) training programme (5D43TW001586) at the Center for Demography and Ecology. Scholarships from the Costa Rican Ministry of Health and the Universidad de Costa Rica. The authors express their gratitude to Hazel Quesada-Leitón for her support in data management. They also thank the manuscript reviewers for their thoughtful comments.

Conflict of interest statement. None declared.

Ethical approval: The CRELES study was approved by the Ethical Science Committee of the University of Costa Rica (reference: VI-763-CEC-23 -04). All the databases of the study have been made anonymous (the name or identifier has been removed) to avoid risks to the privacy of the participants.

References

Aguilar C, Hernández S, García E, Barquera S, Reyes H. 2015. Chapter 15. Los sistemas de Salud en la Prevención y Control de la Diabetes. In: *Acciones para enfrentar a la diabetes*. México: Academia Nacional de Medicina. https://www.anmm.org.mx/publicaciones/CAnivANM150/L15-Acciones-para-enfrentar-a-la-diabetes.pdf, accessed 20 October 2018.

Andersen RM. 1995. Revisiting the behavioral model and access to medical care: does it matter? *Journal of Health and Social Behavior* **36**: 1–10.

Andrade FCD. 2006. Functional disability and health inequality among elderly Latinos: the diabetes mellitus burden. *Doctoral dissertation*, University of

Wisconsin-Madison. Available from ProQuest Dissertations and Thesis database (UMI No. 3245628).

Araúz A, Sánchez G, Padilla G, Fernández M, Roselló M, Guzmán S. 2001. Intervención educativa comunitaria sobre la diabetes en el ámbito de la atención primaria. *Revista Panamericana de Salud Pública* **9**: 145–53.

Arredondo A, De Icaza E. 2011. Costos de la Diabetes en América Latina: evidencias del Caso Mexicano. *Value in Health* **14**: S85.

Ávila-Curiel A, Shamah-Levy T, Galindo-Gómez C, Cuevas-Nasu L, Moreno-Macías H, Chávez-Villasana A. 2007. La diabetes mellitus en estratos socioeconómicos bajos de la ciudad de México. Un problema relevante. *Revista de Investigación Clínica* **59**: 246–55.

Baliunas DO, Taylor BJ, Irving H *et al*. 2009. Alcohol as a risk factor for type 2 diabetes. A systematic review and meta-analysis. *Diabetes Care* **32**: 2123–32.

Barceló A. 2000. Diabetes and hypertension in the Americas. *The West Indian Medical Journal* **49**: 262–5.

Barceló A, Aedo C, Rajpathak S, Robles S. 2003. The cost of diabetes in Latin America and the Caribbean. *Bulletin of the World Health Organization* **81**: 19–27.

Barceló A, Peláez M, Rodríguez-Wong L, Pastor-Valero M. 2006. The prevalence of diagnosed diabetes among the elderly of seven cities in Latin America and the Caribbean. *Journal of Aging and Health* **18**: 224–39.

Barceló A, Gregg E, Pastor-Valero M, Robles S. 2007. Waist circumference, BMI and the prevalence of self-reported diabetes among the elderly of the United States and six cities of Latin America and the Caribbean. *Diabetes Research and Clinical Practice* **78**: 418–27.

Beulens JWJ, Stolk RP, van der Schouw YT, Grobbee DE, Hendriks HFJ, Bots ML. 2005. Alcohol consumption and risk of type 2 diabetes among older women. *Diabetes Care* **28**: 2933–8.

Brenes-Camacho G, Rosero-Bixby L. 2008a. Diabetes mellitus en adultos mayores costarricenses. *Población y Salud En Mesoamérica* **5**: 1–7.

Brenes-Camacho G, Rosero-Bixby L. 2008b. Metabolic control in a nationally representative diabetic elderly sample in Costa Rica: patients at community health centers vs. patients at other health care settings. *BMC International Health and Human Rights* **8**: 5.

Brenes-Camacho G, Rosero-Bixby L. 2009. Differential by socioeconomic status and institutional characteristics in preventive service utilization by older persons in Costa Rica. *Journal of Aging and Health* **21**: 730–58.

Brown JE. 2008. *Nutrición en las diferentes etapas de la vida*. 3rd edn. México: McGraw Hill.

Chaparro-Díaz L. 2016. Objetivos de Desarrollo Sostenible y Enfermedad Crónica no Transmisible. *Revista Latino-Americana de Enfermagem* **24**: 1–2.

Charter for Health Promotion. 1986. *World Health Organization*. https://www.paho.org/hq/dmdocuments/2013/Carta-de-ottawa-para-la-apromocion-de-la-salud-1986-SP.pdf.

Codogno J, Fernandes R, Sarti F, Freitas I, Monteiro H. 2011. The burden of physical activity on type 2 diabetes public healthcare expenditures among adults: a retrospective study. *BMC Public Health* **11**: 1–7.

Diehr P, Yanez D, Ash A, Hornbrook M, Lin DY. 1999. Methods for analyzing health care utilization and costs. *Annual Review of Public Health* **20**: 125–44.

Gagliardino J, Olivera E, Etchegoyen G, Gonzalez C, Guidi M. 2000. Evaluación y costos del proceso de atención a pacietnes diabéticos. *Medicina (Buenos Aires)* **60**: 880–8.

Grundy SM, Benjamin IJ, Burke GL, Chait A, Eckel RH, Howard BV. 1999. Diabetes and cardiovascular disease: a statement for healthcare professionals from the. *Circulation* **100**: 1134–46.

Guerrero F, Rodríguez M. 2015· *Chapter 10*. Prevención de la Diabetes tipo 2: estrategias aplicables en México. In: *Acciones para enfrentar a la diabetes*. México: Academia Nacional de Medicina. https://www.anmm.org.mx/publicaciones/CAnivANM150/L15-Acciones-para-enfrentar-a-la-diabetes.pdf, accessed 3 November 2018.

Gulliford M, Figueroa-Munoz J, Morgan M *et al*. 2002. What does 'access to health care' mean? *Journal of Health Services Research & Policy* **7**: 186–8.

Hosmer DW, Lemeshow S. 1999. *Applied Survival Analysis*. New York: John Wiley & Sons.

Hu FB, Manson JE, Stampfer MJ *et al*. 2001. Diet, lifestyle and the risk of type 2 diabetes in women. *The New England Journal of Medicine* **345**: 790–7.

Hu FB, Stampfer MJ, Solomon CG *et al*. 2007. The impact of diabetes mellitus on mortality from all causes and coronary heart disease in women. 20 years of follow-up. *Archives of Internal Medicine* **161**: 1717–23.

Instituto Nacional de Salud Pública (INSP). 2012. *Encuesta Nacional de Salud y Nutrición 2012*. México: ENSANUT. http://ensanut.insp.mx/doctos/seminario/M0302.pdf36, accessed 7 November 2018.

Jiménez J. 2018. *Envejecimiento de la población y alto gasto en medicamentos retan la sostenibilidad de la Caja*. Noticias Universidad de Costa Rica. https://www.ucr.ac.cr/noticias/2018/12/21/envejecimiento-de-la-poblacion-y-alto-gasto-en-medicamentos-retan-la-sostenibilidad-de-la-caja.html, accessed 3 November 2018.

Kowall B, Rathmann W, Strassburger K *et al*. 2010. Association of passive and active smoking with incident type 2 diabetes mellitus in the elderly population: the KORA S4/F4 cohort study. *European Journal of Epidemiology* **25**: 393–402.

Llanos AA, Morera-Salas M, Barber-Pérez P, Hernández K, Xirinach-Salazar Y, Varga JR. 2009. Factores relacionados con la utilización de servicios de salud en Costa Rica. *Revista de Salud Pública* **11**: 323–35.

Manning W, Mullahy J. 2001. Estimating log models: to transform or not to transform? *Journal of Health Economics* **20**: 461–94.

Méndez-Chacón E, Santamaría-Ulloa C, Rosero-Bixby L. 2008. Factors associated with hypertension prevalence, unawareness and treatment among Costa Rican elderly. *BMC Public Health* **8**: 275.

Nakanishi N, Suzuki K, Tatara K. 2003. Alcohol consumption and risk for development of impaired fasting glucose or type 2 diabetes in middle-aged Japanese men. *Diabetes Care* **26**: 48–54.

Organización para la Cooperación y el Desarrollo Económicos (OCDE). 2017. *OECD Reviews of Health Systems: Costa Rica. Evaluación y Reocmedaciones*. Paris: OECD Publishing.

Palloni A, Wong R, Peláez M. 2006. The tide to come. Elderly health in Latin America and the Caribbean. *Journal of Aging and Health* **18**: 180–206.

Pan American Health Organization. 2017. *Hacia una Salud Sostenible*. https://www.paho.org/salud-en-las-americas-2017/?post_type=post_t_es&p=308&lang=es, accessed 28 October 2018.

Pietraszek A, Gregersen S, Hermansen K. 2010. Alcohol and type 2 diabetes: a review. *Nutrition, Metabolism, and Cardiovascular Diseases* **20**: 366–75.

Rehkopf D, Dow H, Rosero-Bixby L. 2010. Differences in the association of cardiovascular risk factors with education: a comparison of Costa Rica (CRELES) and the USA (NHANES). *Journal of Epidemiology & Community Health* **64**: 821–8.

Rosero-Bixby L. 1996. Adult mortality decline in Costa Rica. In: Timaeus IM, Chackiel J, Rusicka L (eds). *Adult Mortality in Latin America*. Chapter 9. Oxford: Clarendon Press, 33–42.

Rosero-Bixby L, Dow WH. 2009. Surprising SES gradients in mortality, health, and biomarkers in a Latin American population of adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* **64B**: 105–17.

Rosero-Bixby L, Antich D. 2010. Estudio longitudinal de mortalidad de adultos costarricenses 1984-2007. *Población y Salud En Mesoamérica* **7**: 1–24.

Rosero-Bixby L, Dow WH, Fernández X. 2013. *CRELES: Costa Rican Longevity and Healthy Aging Study. Methods, Wave 3*. Berkeley, CA: Department of Demography, University of California, Berkeley. Electronic Document http://www.creles.berkeley.edu, accessed 5 November 2018.

Sandín M, Espelt E, Escolar-Pujolar A, Arriola L, Larraña I. 2011. Desigualdades de género y diabetes mellitus tipo 2: la importancia de la diferencia. *Avances En Diabetología* **27**: 78.

Sáenz M, Acosta M, Muiser J, Bermúdez J. 2011. Sistema de Salud en Costa Rica. *Revista de Salud Pública de México* **53**: 156–67.

Shaw J, Sicree R, Zimmet P. 2010. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice* **87**: 4–14.

Sloan FA, Bethel MA, Ruiz D, Shea AH, Feinglos MN. 2008. The growing burden of diabetes mellitus in the US elderly population. *Archives of Internal Medicine* **168**: 192–9.

Solli O, Jenssen T, Kristiansen IS. 2010. Diabetes: cost of illness in Norway. *BMC Endocrine Disorders* **10**: 15.

StataCorp. 2013. *Stata Statistical Software: Release 13.0*. College Station, TX: Stata Corporation.

Suh DC, Kim CM, Choi IS, Plauschinat CA. 2008. Comorbid conditions and glycemic control in elderly patients with type2 diabetes mellitus, 1988 to 1994 to 1999 to 2004. *Journal of the American Geriatrics Society* **56**: 484–92.

Velázquez-Monroy Ó, Rosas-Peralta M, Lara-Esqueda A, Pastelín-Hernández G;Grupo ENSA 2000, Sánchez-Castillo C. 2003. Prevalencia e interrelación de enfermedades crónicas no transmisibles y factores de riesgo cardiovascular en México: resultados finales de la Encuesta Nacional de Salud (ENSA) 2000. *Archivos de Cardiología de México* **73**: 62–77.

Villalobos L, Piedra M. 1998. Reforma en la salud en Costa Rica: implicaciones en la gestión municipal. *Revistas de Ciencias Administrativas y Financieras de la Seguridad Social* **6**: 43–51.

Whiting D, Unwin N, Roglic G. 2010. Diabetes: equity and social determinants. In: Blas E, Sivasankara Kurup A (eds). *Equity, Social Determinants and Public Health Programmes*. Switzerland: World Health Organization, 77–94.

World Health Organization. 2000. *Obesity: preventing and managing the global epidemic: Report of a WHO consultation*. Geneva, Switzerland. 2000. Technical Report Series no. 894.

Willi C, Bodenmann P, Ghali WA, Faris PD, Cornuz J. 2007. Active smoking and the risk of type 2 diabetes. A systematic review and meta-analysis. *JAMA* **298**: 2654–64.

Yach D, Stuckler D, Brownell KD. 2006. Epidemiologic and economic consequences of the global epidemics of obesity and diabetes. *Nature Medicine* **12**: 62–6.

Zhang L, Curhan GC, Hu FB, Rimm EB, Forman JP. 2011. Association between passive and active smoking and incident type 2 diabetes in women. *Diabetes Care* **34**: 892–7.

Zhang P, Zhang X, Brown J, Vistisen D, Sicree R, Shaw J, Nuchols G. 2010. Global healthcare expenditure on diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice* **87**: 293–301.