Title: "Uncovering the Indirect Costs of Diabetes in the Small Island Developing State of Barbados"

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Abstract: Type II Diabetes Mellitus (T2DM) is one of the leading causes of death in the world. Lack of exercise and poor nutrition form the roots for both the development of hypertension and T2DM. Barbados, and the majority of the Small Island Developing States (SIDS), post world high numbers for overweight and obesity metrics. Thereby, the prevalence of diabetes is likewise elevated. The indirect cost burden is estimated to be much larger than the direct costs. Indirect costs are computed by calculating the costs from premature mortality and productivity impairment caused by diabetes, utilizing local income data and estimates from the World Health Organization Global Health Estimates.

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Introduction

Non-communicable diseases (NCDs) are the world's most deadly diseases, killing 41 million persons per year with 77 percent of these deaths in low- and middle-income countries (WHO, 2022a). According to the World Bank Country and Lending Groups (2024), 73 percent of the available country indicators for Small Island Developing States (SIDS) are classified as low- or middle income. SIDS are particularly vulnerable to NCDs due the elevated prevalence of risk factors such as their world-high obesity rates (World Population Review, 2024). Barbados, a nation of the SIDS and Caribbean, has declared to halve its numbers of new NCD cases by 2030 according to Mission Barbados (Carrington, 2023). If current epidemiological trends were to continue without intervention, NCD deaths would rise from present 83 percent to 86.3 percent of all deaths in Barbados by 2030 – substantially higher than the global average (WHO, 2022b; Springer, 2019).

Ischaemic heart disease and strokes are the largest killers, causing 16 percent and 11.2 percent of deaths globally, respectively (World Health Organization Global Health Estimates – WHOGHE, 2019). Diabetes mellitus and kidney diseases are the 9th and 10th highest cause of death in the world, accounting for a cumulative 5.2 percent of global deaths. Within the WHO Region of the Americas, ischaemic heart disease and stroke retain their top positions as the leaders of cause of death while diabetes and kidney diseases move up to the 6th and 8th position respectively; accounting for 7.6 percent of deaths in the region (WHOGHE, 2019). Clearly, these four causes of death should be monitored as literature shows demonstrably that these illnesses share a common risk profile and/or comorbidity of obesity, diabetes, and hypertension (Akil & Ahmad, 2011; Ghaderian & Beladi-Mousavi, 2014; Agarwal et al., 2003; Akmal, 2001; CDC, 2022; Verma et al., 2016).

In Barbados, the prevalence of diabetes and hypertension are high, boasting 19 percent and 41 percent prevalence rates for the population aged over 25, respectively (Barbados Health of the Nation Study – Unwin et al., 2015). Therefore, the risks of elevating these causes of death are high. The Government of Barbados provides free comprehensive healthcare through the island's polyclinics and its main hospital, the Queen Elizabeth Hospital (QEH). The Barbados Drug Benefit service allows citizens to access free medication (Bartholomew et al., 2022). Meaning, the direct costs of national healthcare provision hinge on the government's fiscal budget.

However, costs can go unrecorded by focusing on a purely direct costs analysis of a fiscal budget. The indirect costs through morbidity and mortality are substantial and should be considered in a holistic cost analysis (World Obesity Federation, 2022; Abdulkadri, 2009). The World Health Organization Global Health Estimates provide a standardized methodology and dataset for years lived with disability and cause of death data, which could be utilized to assign costs to morbidity and mortality.

This paper seeks to contribute an economic costing model to display indirect costs of diabetes to Barbados. To start, previous literature is reviewed to establish precedence of mortality and morbidity cost methodologies as well as establish footing for development of an augmented model, then data collection was initiated and analysed to produce results that would be discussed relative to the indirect cost results for diabetes and its co-morbidity with ischaemic heart disease and strokes.

Literature Review

Indirect costs from diabetes flow through the economy by reducing the productivity and earnings potential of living workers (morbidity of disease) as well as reducing the potential years lived and economic stimulus provided by human capital (mortality from disease).

Morbidity costs generally stem from reduced employment, reduced productivity if employed and resultant lowered wages; largely corroborated by literature. In the broad category of disability, the US Bureau of Labour Statistics (2024) found that the disabled population had a much lower employment-population ratio, higher unemployment rates across all educational attainment groups, and more likely to be out of the labour force as compared to persons with no disabilities. Continuing in the US, the Office of Disability Employment Policy (2023) found that the employment and unemployment rates of disabled persons at 37.2 percent and 7.7 percent where much worse off than the non-disabled which recorded employment at 75 percent and unemployment at 3.5 percent. Following on, the Office of Disability Employment Policy (2023) stated that the labour force participation rate of the disabled population was 40.3 percent as compared to the 77.7 percent of their able-bodied counterparts; with Blacks posting the most extreme shifts between disabled and non-disabled across race categories. Across 51 states in the United States of America, it was found that the average disabled person earned 67 percent of the wages of their able-bodied counterparts between the period of 2016-2020 (Office of Disability Employment Policy, 2022). Another study conducted by American Institutes for Research (Yin, 2014) found that disabled earn 37 percent less than able-bodied counterparts, with notable disparities across educational attainment. The World Health World Report on Disability (2011) confirmed that when disabled persons are employed they tend to earn less than able-bodied persons.

The incidence of diabetes has shown to follow the trend of the disabled population, with deleterious effects to earning capacity and employability. Ng, Jacobs & Johnson (2007) recorded a general one-third decline in yearly earnings for diabetics as well as a reduced participation rate in the labour force. Due to diabetics being more likely to have health-related work limitations, they are less likely to work with diabetes (Tunceli et al., 2005). When compared with non-diabetic persons, diabetics had poorer labour outcomes in unemployment and lower income (Rodríguez-Sánchez & Cantarero-Prieto, 2017). However, it should be noted that as the severity of the impact from diabetes changes over the course of the disease as its progression could lead towards more productivity impairment as time goes on, although, there is a negative average effect of diabetes and both male and females are estimated to earn less than their healthy complements (Minor, 2013).

Abdulkadri (2009) conducted a direct and indirect cost estimate of diabetes and hypertension within four English-speaking CARICOM (Caribbean Community) Island States: Jamaica, Trinidad & Tobago, Bahamas, and Barbados. Years of productive life lost (up to the retirement age of 65) was estimated using data from local Ministries of Health, and the cost of morbidity was costed utilizing the per capita GDP and a 3 percent discount rate for mortality. The estimates derived for 2001 displayed total indirect costs of $5.8 million in Barbados, with the larger portion ($3.5 million) stemming from mortality while morbidity accounted for $2.3 million. This forward-thinking paper noted the presence of unnoticed indirect costs that could detrimentally impact the economy through the impairment of its most valuable resource, humans.

Having examined literature encompassing the fallout costs of diabetes, the possible preventative actions to obviate costly poor health outcomes will be explored. Primarily, diabetes could be inhibited

by a diabetes reversal/remission intervention program. Type 2 Diabetics would be initiated into this program upon positive albuminuria screening results. Early detection of albuminuria allows for interventions that prevent development of diabetic kidney disease (DKD) and ESRD (Kam et al., 2022). According to the American Diabetes Association (ADA) Standards of Care (2022), annual albuminuria screening is advocated for type 2 diabetics, with interventions seen to be cost-effective. Regarding the identification testing tools itself, a spot urine albumin-to-creatinine ratio (UACR) is recommended for its ease of test timing and low cost (Kam et al., 2022). Upon DKD risk identification, immediate enrolment in the diabetes reversal program (DRP) should ensue. The goal of the DRP is to restore normal glucose and insulin metabolism to diabetic participants (Bynoe et al., 2019). This goal is achieved through a rigorous 2-3-month very-low calorie diet program (VLCD) followed by 6-month-period of structured diet monitoring to ensure diabetic remission endures (Bartholomew et al., 2022). Continuing, the VLCD comprised of four shakes per day (Glucerna), three litres of water, and 250g of high fibre low carbohydrate vegetables daily. Nonetheless, DRP does come with its limitations. Bartholomew et al. (2022), acknowledged a variety of issues that could lead to diet noncompliance including: monotonicity of starch foods consumed, relative expense of vegetables, inefficient meal tracking technology, and social gathering peer pressure. Although, each of these issues encountered have a correlative remedy: meal preparation handbooks (to provide new/creative ways of cooking starches and vegetables), growing kitchen gardens (to promote self-sufficiency and food security whilst remediating financial and caloric constraints), development of a Caribbean-styled meal tracking technology (to accurately display ranges for caloric intake of our unique food products), and use of social media participant chat forums (to support participants and have benevolent peer pressure to maintaining diet).

Essentially, diet and exercise are major risk factors to T2DM incidence. Thus, the best course of action is to eat well, get regular check-ups (including blood sugar and blood pressure tests), and exercise frequently to remain healthy (Adams & Carter, 2011). Following on, a healthy diet excludes overconsumption of sugar-sweetened beverages (SSB), as intake of SSB is reliably linked to obesity, type 2 diabetes, cardiovascular disease, and kidney disease (Malik & Hu, 2022). Notably, SSB taxation has been gaining prevalence worldwide (85 countries as of 2022) with the WHO releasing its first-ever global tax manual. To this point, the WHO stated "taxes on SSB cane be a powerful tool to promote health", this is because a reduction in SSB consumption could save lives and prevent disease (WHO, 2022c); promoting health equity and global health convergence. Sugar-sweetened beverages contain added sweeteners such as sucrose, high fructose corn syrup, or fruit juice concentrates which all have similar metabolic effects (Brownell et al., 2009). In 2015, Barbados became the second country to implement an SSB tax policy. The excise was instituted at 10 percent, on a population that has an average consumption of two 8oz servings per day – ranked amongst the highest in the world (Mangera & Adams, 2020). Countries introduce this excise as a means of reducing intake of these beverages and thereby lowering healthcare costs whilst simultaneously generating government revenue that could be channelled to health programs (Brownell et al., 2009). Referencing Alvarado et al. (2019), SSB sales declined by 4.3 percent compared to expected sales without the 10 percent tax, and sales of non-SSBs increased by 5.2 percent with bottled water sales growing by 7.5 percent. Effective April 1st 2022, SSB excise was instituted at 20 percent in Barbados; PAHO (2021) implies that a 20 percent excise tax would decrease demand for SSB in a nation by approximately 24 percent.

Markedly, awareness campaigns to enlighten the public to the dangers of poor dietary health, infrequent exercise, and infrequent doctor check-ups could substantially improve health outcomes, with events such as World Kidney Day positively impacting awareness and control of CKD risk factors

(Chin et al., 2009). Therefore, to have a successful screening program and intervention program, nations must administer a successful educational outreach program to reach a higher health literacy level (Nutbeam, 2000). The utilization of social media advertising to promote healthier lifestyle adoption (consumption modification) and disease awareness manifests a low-cost operation with extensive outreach capabilities (Te et al., 2019).

Data and Methodology

Data Description

To construct the model for estimating indirect costs, the key data sourced included health estimates for diseases, macroeconomic variables, and labour market information for Barbados. Years lived with Disability (YLD) and cause of death data was sourced from the World Health Organization Global Health Estimates (WHOGHE) over the period 2000-2019 in an annual format, disaggregated by 5-year age categories and sex. The specific diseases extracted included Chronic Kidney Disease due to Diabetes, Diabetes, Ischaemic Heart Disease, and Stroke. The Barbados National Registry Report (2020) provided the known parameters for stroke and heart attack patients in 2020 which shared the trait of diabetes. The Barbados Survey of Living Conditions (2016) informed the labour income data as well as diabetes in the labour force. The unemployment rates by 5-year age categories and sex were sourced from the 2018 & 2019 Labour Force Surveys conducted by the Barbados Statistical Service (BSS). The Retail Price Index (BSS) was utilized for monthly 12-month moving average inflation rates in Barbados (January 2003 – December 2023). The monthly treasury bill rates were sourced from the Central Bank of Barbados (January 2000 - April 2024).

Methodology

The estimate for productivity impairment is constructed by multiplying the number of years lived with disability in each age category by the expected wage to be earned by the normal population versus one with diabetes. The years lived with disability were taken exactly from the WHOGHE, representing the number of years that would be worked by "the disability". Under this assumption, the number of years by age category and sex can be juxtaposed to its average income as well as expected participation and employment within that age category and sex. This first estimate shows the total income expected to be earned if all years with disability did not impact the productivity or work life of the disabled. The second estimate uses a new wage that has been adjusted in line with literature to be 66% of the average wage (around one third removed), and new labour market indicators (unemployment and participation sourced from the average of 2018 & 2019) that have been augmented in line with known data on labour market conditions of solely diabetics (calculated from BSLC). This second estimate of expected total labour income of the disabled population represents what is expected to be earned if the disability impacts productivity in line with known effects on labour conditions as well as an estimate based on international literature for pay differentials due to disability.

$$Premature\ Mortality_{tisa} = (YLD_{tisa} * Average\ Wage_{tsa} * PR_{sa} * (1 - UR_{sa})) - (YLD_{tisa} * (0.66 * Average\ Wage_{tsa}) * NPR_{sa} * (1 - NUR_{sa}))$$

i – type of illness/disease t – year s – sex a – age bracket

Average wage – age and sex average labour income from the BSLC 2016

PR – Participation rate sourced as the average from 2018 and 2019 annual labour force statistics

UR – Unemployment rate sourced as the average from 2018 and 2019 annual labour force statistics

NPR – new participation rate calculated by adjusting the PR according to labour conditions within the diabetic population from the BSLC

NUR – new unemployment rate calculated by adjusting the UR according to labour conditions within the diabetic population from the BSLC

The average wage was calculated under age and sex stratification, and the point estimate from 2016 was indexed to the average nominal inflation rate (3.5%) to be backdated to 2000 and brought forward. The methodology of an indexation scheme adjusts wages in response to movements in the average price level in the economy (Horton, Kanbur & Mazumdar,1994). Complete indexation is suitable in an economy subject to solely nominal shocks (Gray, 1976). This nominal wage indexation forms a key part of the labour market assumptions that are utilized within the model.

Premature mortality costs were calculated by utilizing the cause of death data by 5-year age breakout and gender, and imputing the midpoint as the date of death. Interval censorship was necessary given that the exact time of death between the 5-year age category was unknown, utilizing midpoint imputation can inflate the possibility of type 1 errors (Sridhara, Mandrekar, & Dodd, 2013). The life expectancy was set at 75 years for both males and females and was held constant throughout the time period under analysis. The time elapsed between the date of death and life expectancy was counted (years of life lost) and the wage expected to be earned throughout that period was accounted for according to the average income expected for that age category and sex. Treasury bills (T-bills) are commonly used as the risk-free rate of return (Zaimović & Mrkonja, 2010), and can be utilized in the calculation of discount rates (Booth, 2015). The interest rate chosen for the discounting factor to create a present value estimate for premature mortality was the risk-free rate of return i.e. the average T-bill rate of 2.82%. For the purposes of estimating premature mortality, the entirety of the loss of income across the life years not lived is encapsulated into the year of death in the present value of that year.

$$Premature\ Mortality_{tisa} = YLL_{tisa} * PV(Average\ Wage_{tsa} * UR_{sa})$$

PV – Present Value of the expected average wage for that age bracket and sex, adjusted by the 2.82% discounting factor

YLL – Years of Life Lost using midpoint imputation and a life-expectancy cut-off point of 75 years

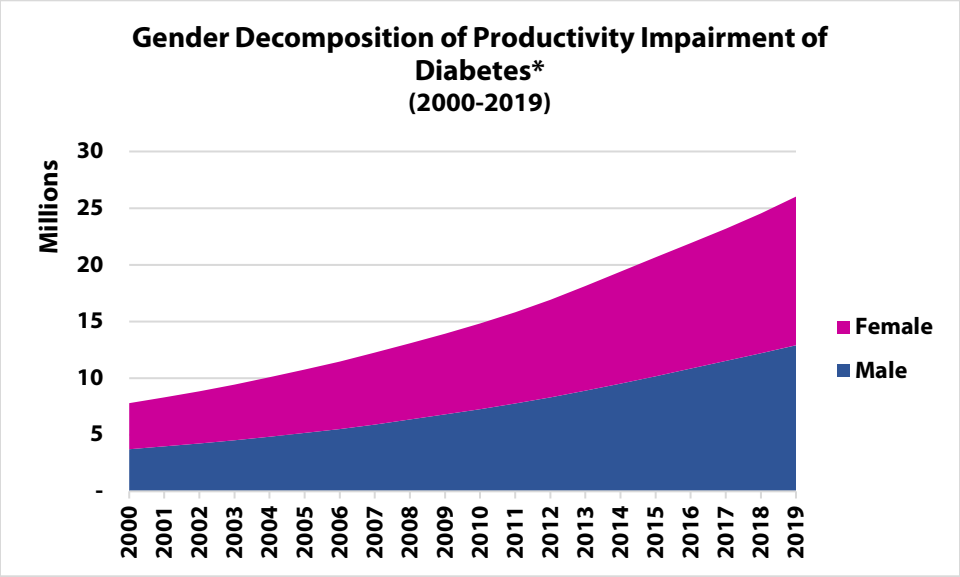
The timeframe under analysis (t) spanned from 2000-2019. The illnesses under consideration include the WHOGHE causes of Chronic Kidney Disease due to Diabetes (K1b), Diabetes (C), Ischaemic Heart Disease (H3), and Stroke (H4). The summation of CKD and Diabetes gives the total of costs directly associated with diabetes (referenced as Diabetes*). There is a larger indirect cost burden which extends to the co-morbidity associated with diabetics experiencing ischaemic heart disease and stroke. The proportion of heart attack and stroke patients with co-morbidity of diabetes (co-morbidity adjustment labelled CM_{iHD} & CM_S) was applied to the overall burden of H3 and H4, to determine the indirect costs attributable to co-morbidity of diabetes. Therefore, the total indirect costs attributable to diabetes is considered as the sum of Diabetes* and the co-morbidity associated with diabetics experiencing heart & stroke events ($K1b + C + CM_{iHD}*H3 + CM_S*H4$).

Results

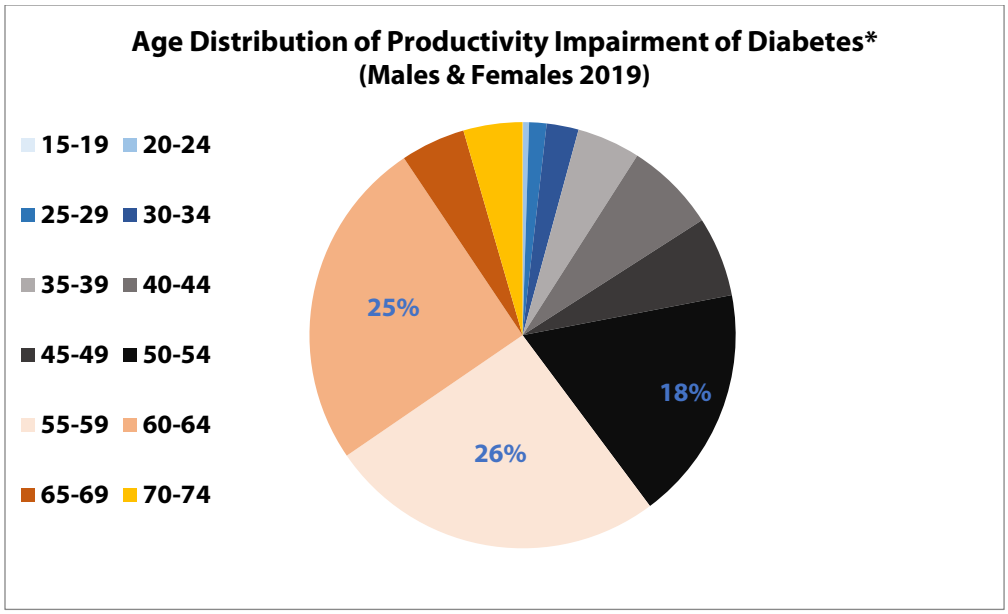
Productivity Impairment

The total productivity impairment from Chronic Kidney Disease amounted to $404,798 in 2000, and increased to $1,224,631 in 2019. The productivity losses from this disease grew at an average rate of 6 percent from 2001 to 2019. The underlying metric of years lived with disability grew by 2.7 percent in this same timeframe, with the distribution between genders relatively equal at 50.3 percent for males and 49.7 percent in females. However, males accounted on average 54.4 percent of the productivity cost burden (2000-2019) with the gender decomposition remaining flat throughout the time.

The total productivity impairment from Diabetes Mellitus totalled $7,383,928 in 2020 increasing to $24,793,302 in 2019, with an average growth rate of 6.6 percent across the timeframe of analysis. Females accounted for 56 percent of the years lived with disability across the timeline, and accounted for 48.3 percent of the concomitant cost burden. When considering the sum of C and Kb1, the productivity impairment of the overall diabetes burden totalled over $26 million in 2019. The productivity impairment for Barbados from diabetes is most impactful in the 50-64 age range, representing around 69 percent of the overall burden.



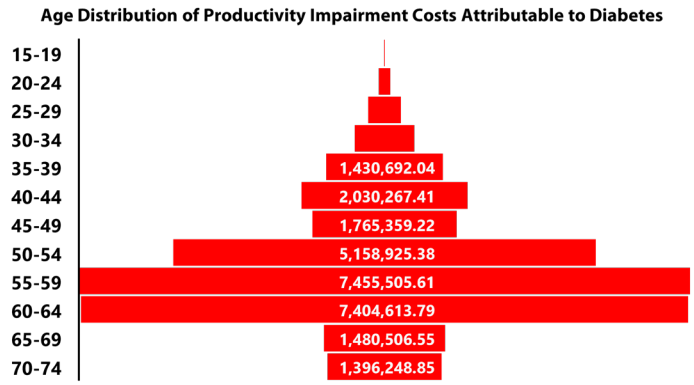
Source: Author's Calculations

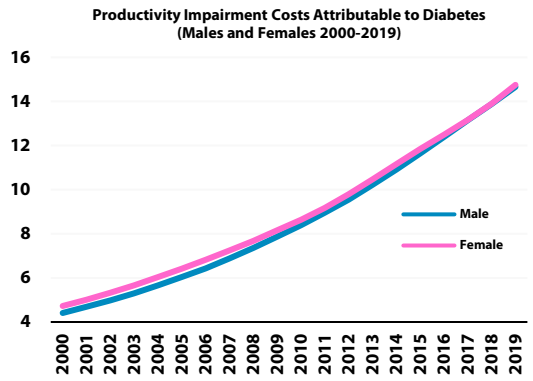


Source: Author's Calculations

Turning to the co-morbidity associated with diabetes, the productivity impairment losses were seen to be less severe than the prior categories, likely due to the differences in morbidity and mortality of broad diabetes complications and cardiovascular diseases. The BNR (2020) displayed that 75% of heart attacks were associated with comorbidity of diabetes, while 77% of stroke events were associated with diabetes. Strokes with co-morbidity of diabetes caused $1 million more productivity impairment than ischaemic heart disease in 2019 ($2.2 million versus $1.2 million). Males significantly contributed more to the productivity impairment from ischaemic heart disease, accounting for on average 67.8% of costs. On the other hand, productivity impairment costs stemming from strokes were more concentrated in the female population (43.8% average). Overall, co-morbidity costs associated with productivity impairment were skewed slightly to males at 51.9%.

The total productivity costs attributable to diabetes, combining both direct and co-morbidity considerations, totalled $29.4 million in 2019; representing an increase of $20.3 million or 222% since the year 2000. These costs were higher in the female category, representing 50.9% of the total burden. The age structure distribution of productivity impairment costs follows the dominant diabetes costs, with the age range of 50-64 contributing the most to the outturn.





Source: Author's Calculations

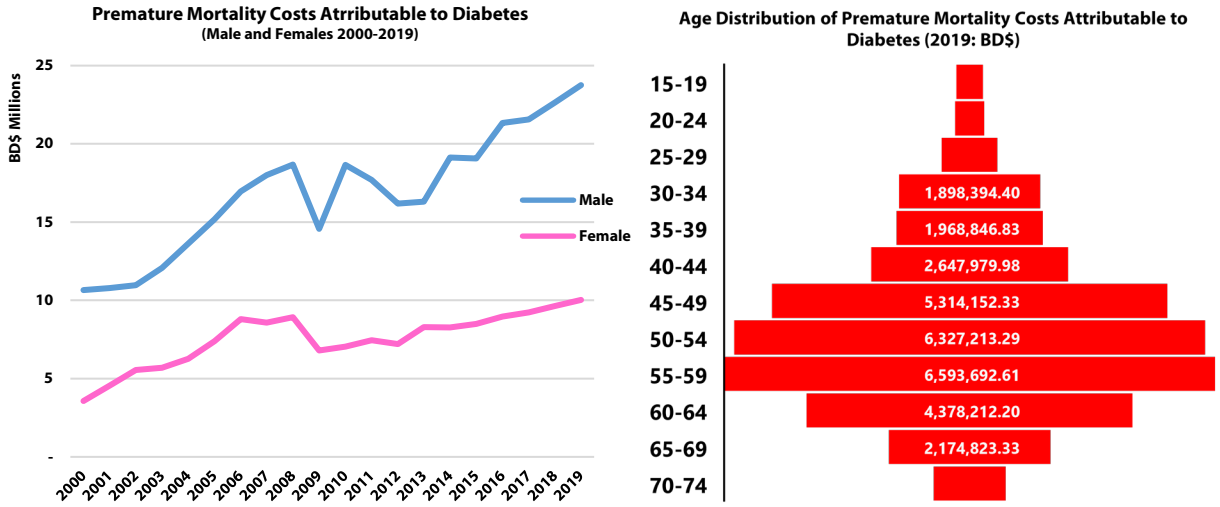
Premature Mortality

The premature mortality cost stemming from CKD totalled $1.6 million in 2019, 31% higher than the corresponding productivity impairment for the category. These costs have increased by 7.3% annually since 2001, but with much more fluctuations than exhibited in the productivity impairment estimates. The first ten years of analysis (2000-2009) displayed a significantly higher burden stemming from males at an average of 65% while the following ten years displayed a lower, but still significant, 57% of the total costs. This movement is due to the cost burden stemming from females enlarging over the 2010-2019 period by 52.7% when compared to the 2000-2009 period.

The premature mortality costs of Diabetes Mellitus (C) amounted to just over $8 million in 2019, which is 67% lower than the corresponding productivity impairment. The number of deaths from diabetes majorly stemmed from females at 55.4%, however, males accounted for 57.6% of the premature mortality costs due to higher wages and an overall higher labour force participation and employment metrics. Total diabetes premature mortality costs (C + K1b) summed to $3.7 million in 2000, growing 162% to reach $9.6 million in 2019, which is $16.4 million lower than the relevant productivity impairment costs.

The co-morbidity estimates for premature mortality displayed the reverse of the productivity impairment structure, with ischaemic heart diseases accounting for a higher proportion than strokes at 63% of the total. Both diseases showcased significantly higher average costs for males (73% of the total co-morbidity) in relation to females (27% of the total co-morbidity). This is likely due to the higher wages earned by males, especially in the 70-74 category as well as employment and participation rates being higher in the male population.

The overall premature mortality costs attributable to diabetes totalled $33.8 million in 2019, more than doubling from the initial $14.2 million recorded in 2000. Majority of these costs fell into the 45-59 age categories. The co-morbidity cost components dominated this field, representing 72% of the total premature mortality costs.



Source: Author's Calculations

Total indirect costs (productivity losses + premature mortality costs) amounted to $63.2 million in 2019. This represents an estimated increase of nearly $40 million from the turn of the decade. When considering the $5.8 million indirect cost result for 2001 stated by Abdulkadri (2009), the results from this paper are 4.3 times higher for that time period. The largest differences would stem from the inclusion of co-morbidity analysis of heart attack and stroke, yet solely diabetes* remains more than double that initial estimate by Abdulkadri (2009). Granted, that previous study employed an earnings estimate based on GDP per capita, with no consideration for the labour market conditions within the economy. There was also a lower age cut-off used (retirement age of 65) compared to this study which cuts off at the life expectancy of 75, and allows the labour market statistics to augment retirement through the labour force participation rate. The average indirect costs from 2015-2019 stood at $57 million per annum (see Appendix 1).

There are a few notable limitations to the study. The normal population unemployment & participation rates used in the productivity impairment and premature mortality has an unknown presence of disease, which could be considered as underestimating the impact of diabetes on productivity impairment; disease impacts are already present and entangled within present labour market conditions. Inherently, the unadjusted labour force conditions have the potential to display downward bias in estimates as both participation and unemployment are implicitly affected by health as age increases. This study utilized a uniform penalty for diabetes, ignoring the possibility of the impact of diabetes changing over the course of the disease.

While deaths remained within a similar band for the most part between sexes, the premature mortality costs were higher due to the varying structures of the labour force as employment*participation was 9.4% higher for males than females. Also, women earned less than males in 2016 when utilizing the weighted-average across ages for labour income in the Barbados Survey of Living Conditions: males earned $32,543.69 while females earned $30,153.91. Labour income was grown with the same distribution as at 2016 which means that the gender gap calculated of 0.073 will perpetuate into the future. Moreover, the participation rate would be held constant, which does not align with literature of the gap of wages and participation closing in the future due to bettered technologies and the

percentage of women employed growing fastest in Latin America & the Caribbean (Bando, 2019). The inclusion of a time series dataset for average wages across 5-year age category and sex could better inform the wage variable used within the study. Less of a limitation, but more of a future research consideration, is to include estimates for unpaid labour (caregiving and keeping house) which has the potential to account for missing costs and raise the indirect costs further. The indirect cost burden should be considered when considering the cost effectiveness of diabetes controls.

Conclusion

The indirect cost of diabetes was found to be substantial, with the most recent annual cost of $63.2 million from 2019. Premature mortality costs were found to be the highest burden at over $33 million dollars, followed closely by morbidity considerations for the labour force at over $29 million. Diabetes was the highest cost category to the productivity of the work force while ischaemic heart disease and strokes constituted the largest burden within premature mortality.

The costs analysed within this paper could be furthered by including an estimate for unpaid labour such as caregiving and keeping of house. The utilization of a time series wage dataset could help improve the accuracy of datapoints across years.

This study adds to the body of literature that showcases diabetes as a costly threat to the world population. Focussing efforts on screening, prevention, and intervention before the disease develops more health complications is essential to reduce costs…both hidden (indirect) and seen (direct).

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Appendix

Table 1: Indirect Cost Decomposition - Average 2015-19 (BD$)

	Productivity Impairment			Premature Mortality			Indirect Costs		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
*Diabetes**	*11,523,077*	*11,739,161*	*23,262,237*	*4,839,505*	*3,953,194*	*8,792,699*	*16,362,582*	*15,692,355*	*32,054,937*
CKD	611,932	505,533	1,117,466	835,685	648,375	1,484,060	1,447,617	1,153,909	2,601,526
Diabetes	10,911,144	11,233,627	11,233,627	4,003,820	3,304,819	3,304,819	14,914,964	14,538,446	14,538,446
*Co-Morbidity**	*1,623,168*	*1,495,724*	*3,118,892*	*16,831,396*	*5,322,467*	*22,153,864*	*18,454,564*	*6,818,192*	*25,272,755*
Heart Disease	747,723	347,927	1,095,650	9,143,848	2,102,100	11,245,948	9,891,571	2,450,027	12,341,598
Stroke	875,444	1,147,798	2,023,242	7,687,549	3,220,367	10,907,916	8,562,993	4,368,165	12,931,158
Attribution to Diabetes	**13,146,244**	**13,234,885**	**26,381,129**	**21,670,901**	**9,275,661**	**30,946,563**	**34,817,146**	**22,510,547**	**57,327,692**

Source: Author's Calculations