DETERMINANTS OF TYPE 2 DIABETES MELLITUS BASED ON GENDER AND ITS IMPACT ON LABOUR PRODUCTIVITY IN MALAYSIA

By

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This study was conducted with the aim to evaluate the determinants of Type 2 Diabetes Mellitus (T2DM) based on gender and its impact on labour productivity in Malaysia. The study employed time series data in Malaysia from 1990-2019. The data were analysed using quantitative methods including descriptive statistics and Autoregressive Distributed Lag (ARDL) approach. There are less studies conducted on T2DM even though it is currently one of the major risk factors that are associated with cardiovascular diseases. Besides, studies have shown that diabetes death is often caused by complications such as cardiovascular disease. Diabetes caused high blood sugar which is a major risk factor for cardiovascular disease, the current leading cause of death in Malaysia. This study will provide information that can help policymakers and practitioners to decide on supplying better health services that would reduce diabetes mortality rate whilst the population gain awareness of the danger of diabetes as a silent killer after identifying the determinants of T2DM in Malaysia. Therefore, the first objective of the study examined the social determinants of T2DM according to gender in Malaysia from 1990 to 2019 using the ARDL approach to co-integration. The second objective investigated the impact of T2DM on Malaysia's labour productivity from 1990 to 2019 using the same data analysis approaches. Overall, in the long run, the result revealed a strong association between GDP per capita, health expenditure per capita and primary school attainment as the social determinants of T2DM in Malaysia for both male and female. It is observed that obesity is a primary determinant for T2DM among Men but not Female. As for the second objective, all the variables except the current Incidence of diabetes (ID) have an impact on labour productivity in the short run. Even though the incidence of diabetes does not directly affect labour productivity in Malaysia, still, it is undeniable that diabetes has left high death statistics in Malaysia. Therefore, care and prevention must be taken before the overwhelming burden of diabetes prevalence and mortality rate hike becomes the main culprit for an economic downturn.

Keywords: Gender, Social Determinants, Labour Productivity, Type 2 Diabetes Mellitus,

SDG: GOAL 3: Good Health and Well-Being, GOAL 5: Gender Equality, GOAL 11: Sustainable Cities and Communities

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENENTU DIABETES MELLITUS JENIS 2 BERDASARKAN JANTINA DAN KESANNYA TERHADAP PRODUKTIVITI BURUH DI MALAYSIA

Oleh

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Pengerusi : Profesor Madya Norashidah binti Mohamed Nor, PhD
Sekolah : Perniagaan dan Ekonomi

Objektif kertas ini adalah untuk menyiasat penentu sosial Diabetes Mellitus Jenis 2 (T2DM) berdasarkan jantina dan mengkaji kesan T2DM terhadap produktiviti buruh di Malaysia. Untuk menilai kedua-dua objektif, kajian ini akan menggunakan pendekatan “Autoregressive Distributed Lag (ARDL)” bagi siri masa tahunan dari 1990 hingga 2019 di Malaysia. Kaedah kualitatif yang digunakan ialah statistik deskriptif. Terdapat kekurangan kajian yang dijalankan ke atas T2DM walaupun pada masa ini ia merupakan salah satu faktor risiko utama yang dikaitkan dengan penyakit kardiovaskular Selain itu, kajian menunjukkan bahawa kematian diabetes selalunya disebabkan oleh komplikasi seperti penyakit kardiovaskular. Diabetes menyebabkan gula darah tinggi yang juga merupakan faktor risiko utama penyakit kardiovaskular, punca utama kematian semasa di Malaysia. Kajian ini akan menyediakan maklumat yang boleh membantu penggubal dasar dan pengamal untuk membekalkan perkhidmatan kesihatan yang lebih baik yang akan mengurangkan kadar kematian diabetes sementara penduduk mendapat kesedaran tentang bahaya diabetes sebagai pembunuh senyap selepas mengenal pasti faktor penentu T2DM di Malaysia. Oleh itu, objektif pertama kajian mengkaji penentu sosial T2DM mengikut jantina di Malaysia menggunakan pendekatan ARDL untuk integrasi bersama. Objektif kedua menyiasat kesan T2DM terhadap produktiviti buruh Malaysia menggunakan pendekatan analisis data yang sama. Secara keseluruhan, dalam jangka masa panjang, keputusannya menunjukkan perkaitan yang kukuh antara KDNK per kapita, perbelanjaan kesihatan per kapita dan sekolah rendah sebagai penentu social untuk lelaki dan wanita. Adalah diperhatikan bahawa obesiti merupakan penentu utama T2DM di kalangan lelaki tetapi bukan wanita. Bagi objektif kedua, semua pembolehubah kecuali Insiden Diabetes (ID) mempunyai kesan ke atas produktiviti buruh dalam jangka pendek. Walaupun kejadian diabetes tidak secara langsung menjejaskan produktiviti buruh di Malaysia, masih tidak dapat dinafikan bahawa diabetes telah meninggalkan statistik kematian yang tinggi di Malaysia. Oleh itu, penjagaan dan pencegahan mesti diambil sebelum beban kenaikan diabetes dan kenaikan kadar kematian menjadi punca utama kegawatan ekonomi.

Kata Kunci: Jantina, Diabetes Mellitus Jenis 2, Penuntu Diabetes, Produktiviti Buruh

SDG: MATLAMAT 3: Kesihatan yang Baik dan Sejahtera, MATLAMAT 5: Kesamarataan Gender, MATLAMAT 11: Bandar dan Komuniti Mampan

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LIST OF ABBREVIATIONS

T2DM	Type 2 Diabetes Mellitus
CUSUM	Cumulative sum of recursive residuals Test
CUSUMSQ	Cumulative sum of square of recursive residuals Test
DRM	Male Death Rate
DRF	Female Death Rate
LP	Labour Productivity
GDPC	Gross Domestic Product (GDP) per capita
HEXPC	Health Expenditure per capita
CP	Gross Capital Formation
OPN	Trade Openness
PG	Population Growth
URB	Urbanization
EDUC	Education
PM	Male Primary School Attainment
PF	Female Primary School Attainment
BMIM	Male Prevalence of Body Mass Index (BMI) $\geq 30 kg/m^2$
BMIF	Female Prevalence of BMI$\geq 30 kg/m^2$
ID	Incidence of Type 2 Diabetes Mellitus (T2DM)

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Non-Communicable Diseases (NCDs) are responsible for the death of 41 million people (71%) worldwide. Everyone is at the mercy of NCDs especially people from low and middle-income countries where they account for more than three-quarters of the (32 million people) of death recorded in 2018 (World Health Organization (WHO), 2018). These diseases are slow-progressing and are projected to increase by 17% in 2030. Compared to the world's population over the same period, which, is expected to rise by only 14%, NCDs can be seen as a leading cause of disability soon (GBC Health, 2013). Non-communicable diseases such as cardiovascular, diseases, diabetes and cancer cost about RM 9 billion losses in productivity annually to the Malaysian economy (WHO, 2020).

The four major NCDs that have absolute attention from leaders worldwide are cardiovascular diseases, cancers, persistent respiration illnesses, and diabetes. 17.9 million deaths have been because of cardiovascular illnesses, 9.0 million dying from cancer, 3.9 million dying because of respiration illnesses, and 1.6 million deaths to diabetes. Diabetes may have the smallest range of reasons for dying globally as compared to the opposite 3 principal NCDs, but, it's miles a silent killer that goals human beings from all age groups. In 1916, Elliott Joslin became one of the main voices on diabetes and treatment. His first diabetes textbook is called "The Treatment of Diabetes Mellitus". He accumulated 1,000 of his diabetes instances and mentioned how he decreased the dying charge amongst his sufferers by 20%. Elliot's idea on extending one's lifestyle and stopping headaches is to manipulate a good management of one's blood glucose through diet, exercising, and steady testing.

Diabetes Mellitus is a disease that is spreading and silently killing people worldwide. There are extensive studies conducted to analyse the impact of various health behaviours, health infrastructure, environmental factors and risk factors due to diabetes; however, little research focuses on the socioeconomics or economic factors that caused diabetes, especially in Malaysia.

Diabetes is a chronic state where the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. When one consumes food, the food will be broken down into a type of sugar which we called glucose. This glucose will be utilised by our body cells for growth and energy. Without insulin, glucose cannot be absorbed by the cells and the cause can be either a damaged pancreas (Type 1 Diabetes Mellitus) or the body is resistant to insulin reaction (Type 2 Diabetes Mellitus). A person is classified as diabetic when their fasting plasma glucose concentration value is greater than or equal to 7.0 mmol/L or on medication for raised blood glucose.

To further explain, Type 1 Diabetes Mellitus (T1DM) is usually diagnosed among children, teenagers and young adults. In this case, the pancreas produces little or no insulin at all because the insulin-producing cell in the pancreas has been compromised. This is a genetic condition since birth or hereditary. However, Type 2 Diabetes Mellitus (T2DM) is non-insulin-dependent diabetes or adult-onset diabetes. T2DM is usually diagnosed among people who are 40 years old and above, yet, the prevalence of diabetes is getting more common among children and adolescents in today's society worldwide.

The main focus of this study is to look at T2DM instead of T1DM and gestational diabetes. The reason behind this specification is that T1DM is hereditary, while gestational diabetes is a temporary high blood sugar condition among pregnant ladies and it does not have a permanent effect on the mother given that the mother takes precaution steps to lower their sugar level. According to International Diabetes Federation (2020), T1DM (0-14 years old) is only 0.5% of the total diabetes cases reported and children who are diagnosed with T1DM are unpreventable because it is solely based on genetic hereditary (from their parents especially if the parents have a diabetes family history). In the case of T2DM, it is preventable and T2DM prevalence is caused by increased sugar consumption and unhealthy lifestyle which can be prevented by practicing a healthier lifestyle. Therefore, the focus of this research is on T2DM.

Similarly, the study developed two separate models to investigate T2DM determinants in Men and Women in Malaysia, because different studies have suggested different views on who is more prone to developing T2DM. It is in line with the World Health Organization's view in 2019 when it supported the case that gender influences people's responsiveness to different health conditions. Over the years, there has been a significant debate on the association between gender and T2DM. Studies have shown that sex of patient significant interfere with the T2DM condition of the patient. McGill et al. (2013) argued that gender impacts the treatment outcomes of T2DM. They reportee that female patients had higher reduction in fasting plasma glucose (FPG) and severe hypogylycemia than male patients. Kautzky-Willer, Kosi, Lin, and Mihaljevic (2015) also showed similar results as females had higher hypoglycaemia than male counterparts.

In further previous studies, Raphael et al. (2003), Gallego and Sepulveda (2005), Song et al. (2012) and Al Mansour (2019) also found that T2DM is more prevalent in women due to the mortality rate caused by diabetes. On the opposite, Begg et al. (2007) and Magliano et al. (2018) maintained that life loss is slightly higher among men as men recorded a higher prevalence of diabetes and they did not live as long as women. However, Seuring, Goryakin and Suhrcke (2015) concluded that both male and female sexes have a negative relationship with the prevalence of diabetes. Hence, the need to understand and research the gender-specific association between socioeconomic position along biomarkers along gender lines using the national-based cross-sectional study of Malaysia between 1990 and 2020, since, in Malaysia overweight and obesity, are the primary risks factors for T2DM, is not only restricted to a particular gender.

Diabetes symptoms are less visible and people are unaware of this condition until complications set in. IDF Diabetes Atlas, 9th Edition (International Diabetes Federation, 2020) showed that in 2020, 463 million adults are currently living with diabetes for the age group of 20-79 years old. These statistics are expected to surge to 700 million diabetes patients by 2045. Diabetes has roughly caused 4.2 million deaths worldwide and statistically, 79% of adults with diabetes were living in low and middle-income countries. Besides, it is also worth highlight that, 1 out of 2 people with diabetes were undiagnosed. (International Diabetes Federation, 2020). While in Malaysia, the overall total population is 31.95 million people, where 51.4% (16.42 million) are male and 49% (15.53 million) are female.

The prevalence of T2 Diabetes mellitus in Malaysia has been on an increasing trend. For instance, in 1990, the total number of diabetes patients stood at 752,611. The number increased to 1.35 million in 2000, by 2010 it rose to 1.82 million and at the end of 2019, it jumped up to 2.1 million people (Institute for Health Metrics and Evaluation, 2020).

It is therefore obvious that in Malaysia, diabetes disease is becoming more chronic, as it continued to increase. The percentage increase was higher at 79% from 1990 to 2000, 34% from 2000 to 2010 and 14.3% from 2010 to 2019. Averagely, its increase was at 42.4% for the period under study. As of 2019, about 4.1% of the total population (which is about 3.9 million people) are diagnosed with diabetes. (National Health and Morbidity Survey, 2019). It is based on this highlight, that the Malaysia Health Ministry declared that the number of diabetic patients has exceeded the total anticipated. Ministry of Health Malaysia expected that 1 out of 5 adults from the age 18-year-olds and above would be diagnosed with diabetes by 2020, however, the prediction arrived earlier in 2015.

In Malaysia, the total number of people with a prevalence of diabetes in 2019, was estimated at 2.23 million which is about 6.98% of the total population. Out of this estimated number, 53.05% of the total diagnosed T2DM patients are male while 49.32% were female. Both sexes showed an increasing trend of diabetes prevalence from 1970 until 2019. Besides that, the prevalence of diabetes among males is slightly higher compared to females. However, on a general note, the association between population growth and T2DM prevalence has been a positive one, suggesting that population growth trends in the same direction as T2DM in Malaysia.

According to WHO, an individual is considered to be obese if their BMI is $\geq 30kg/m^2$. As for the prevalence of obesity in Malaysia, Figure 1.1 illustrated a steady increase in the population who is obese.

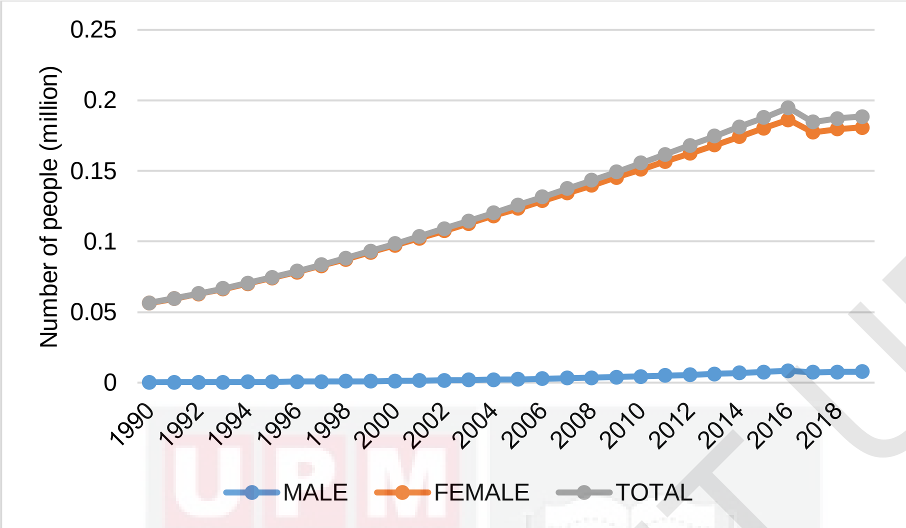

Figure 1.1 : Malaysia's Mean BMI (Total) from 1990-2019
(Source: NCD Risk Factor Collaboration [NCD-RisC], 2020)

As of 2019, there are a total of 0.189 million of the Malaysian population are classified as obese, with 0.008 million males and 0.181 million females. Averagely, for the period under study, 1990-2019, males and females are obese at 0.122 and 0.003 respectively (NCD Risk Factor Collaboration (NCD-RisC), 2020). This clearly, indicates that females are more obese than males in Malaysia. Hence, this gender-based study, since previous studies (Begg et al. (2007) and Magliano et al. (2018)) found that males are more obese than females.

1.1.1 Relationship between BMIT and T2DM Prevalence in Malaysia (1990-2019)

Figure 1.2 presents the initial affiliation between Obesity and T2DM prevalence, which is fine.

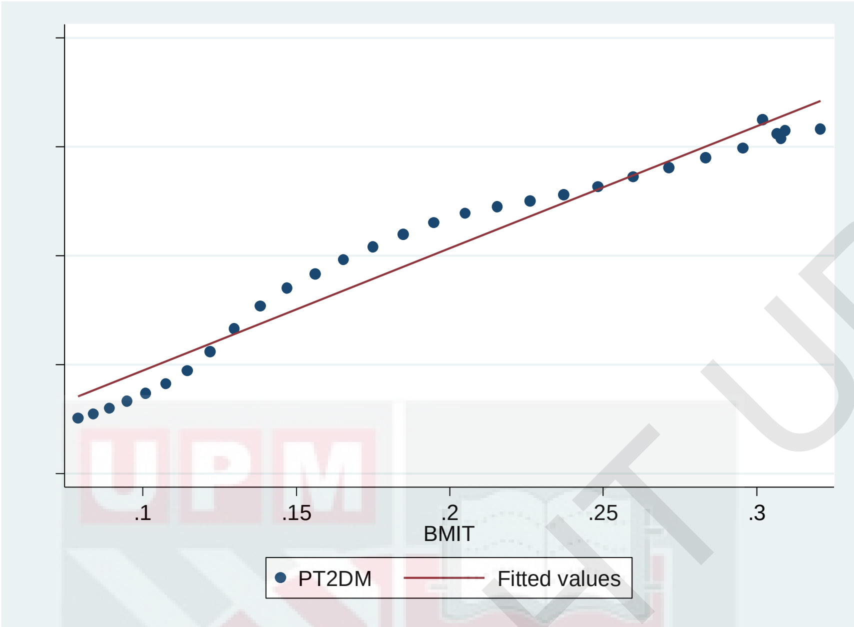

Figure 1.2 : Scatter Plot of Obesity and Prevalence of T2DM in Malaysia (1990-2019)
(Source: Researcher's computation from NCD-Risc (2017))

Looking at the slope of the fashion line, we will draw an inference that a fine affiliation exists between Obesity and T2DM prevalence, wherein T2DM will increase with growth in the wide variety of obese. However, these final results appear to indicate a few factors of affiliation, however, it cannot finish the numerical degree of the effect till a similarly analysis.

In Malaysia, the share of the population by education attainment is becoming more and more competitive at the upper secondary school level due to an increasing trend from 2017 (74.29%) to 2019 (89.07%). Tertiary education is still considered low among Malaysian as only 17.94% of the population completed their bachelor's degree. Educational attainment is a proxy for a social variable because better education is associated with better health (Al-Naggar et al. 2017). Education help individuals to be acquainted with Diabetes Self-Management knowledge which helps those with type 2 diabetes to be successful in maintaining healthy levels of blood glucose. Whereas, for the non-patients, it provides them with the procedures to direct decisions about exercise, weight loss and diet. (Helen, Sarah, Kenley, James, and Gary Klein, 2013). Abougalambou and Abougalambou (2013) found that low-level educational attainment results in higher chances of hypertension and results in T2DM among the Malaysian population. Studies have shown that patients having high education have the capability to monitor blood glucose (SMBG) and avoid T2DM in most cases (Tharek et al., 2018). Patients with low educational attainment generally have poor health literacy and do not have the ability to attend diabetes education programmes and comprehend their implications. Contrastingly, patients having high educational status are more likely to have adequate health literacy. Thus, their high health literacy helps them avoid the consequences of T2DM (Askelson, Campo, & Carter, 2011). Studies have argued that considering the pace with which T2DM is spreading in Malaysia, diabetes self-management education (DSME) workshops are pertinent. However, the outcomes of these initiatives are highly associated with the education of diabetic patients.

1.1.2 Relationship between Education and T2DM Prevalence in Malaysia (1990-2019)

The preliminary analysis in Figure 1.3 depicts the scatter plot of the relationship between education and T2DM prevalence There is a positive relationship between education and T2DM prevalence.

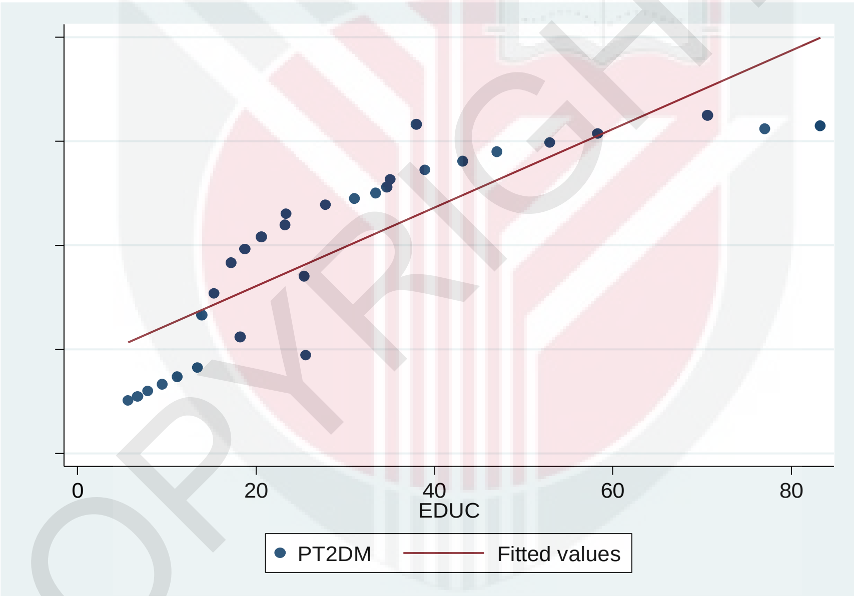

Figure 1.3 : Scatter Plot of Education and Prevalence of T2DM in Malaysia (1990-2019)
(Source: Researcher's computation from UNESCO 2020 and NCD-Risc (2017)

Health expenditure in Malaysia has been fluctuating from 2000 till 2017. The highest health expenditure according to the percentage of GDP was in 2015 at 3.89% which has a small difference compared to 2017 at 3.86%. Taking from Figure 1.4, the total GDP in 2017 is USD318.96 billion, thus, the health expenditure in 2017 is equivalent to USD12.31 billion. (World Bank, 2020).

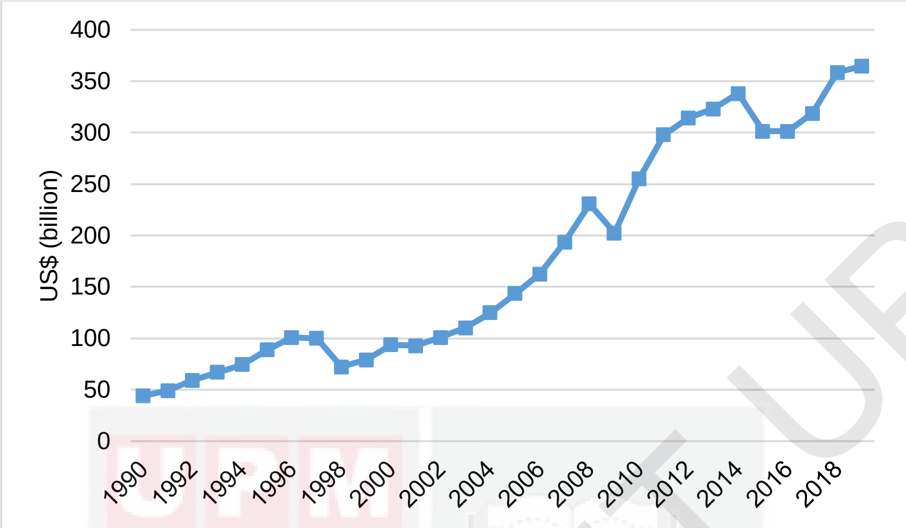

Figure 1.4 : Malaysia's GDP (US$ billion) from 1990 till 2019
(Source: World Bank Data, 2020)

According to Malaysian National Health Accounts reports, 1997-2017, specifically in 2017, expenditures for public health services which includes health promotion and prevention (i.e. NCD), stood at RM 2,961 million or US$ 688.73 million, constituting about 5% of the total health expenditure. Even though the government increased the allocation of health expenditure in Malaysia, still, the awareness of healthy lifestyles and diabetes among Malaysian is questionable as there is plenty of news indicating unhealthy lifestyles among people. AIA Berhad (2017) established that 15% of employees from 47 organizations and 5,369 employees in urban areas have 4 or more health risk factors but 45% of those believe they are in good health or very good health. Apart from this, the research constituted an average of 64% of employees are physically inactive, 90% practice an unbalanced diet and 12.5% are obese.

1.1.3 Relationship between GDPC and T2DM Prevalence in Malaysia (1990-2019)

Figure 1.5 is the preliminary analysis of the association between the GDP per capita and the T2DM prevalence, which shows a positive one, where, with an increase in income the prevalence of T2DM is also increasing. This shows that an increase in income, does not guarantee better health or commonly known as health cannot be bought with monetary value (Agardh et al., 2011; Bird, Lemstra, Rogers, and Moraros, 2015; Ching, Zakaria, Paimin, and Jalalian, 2013).

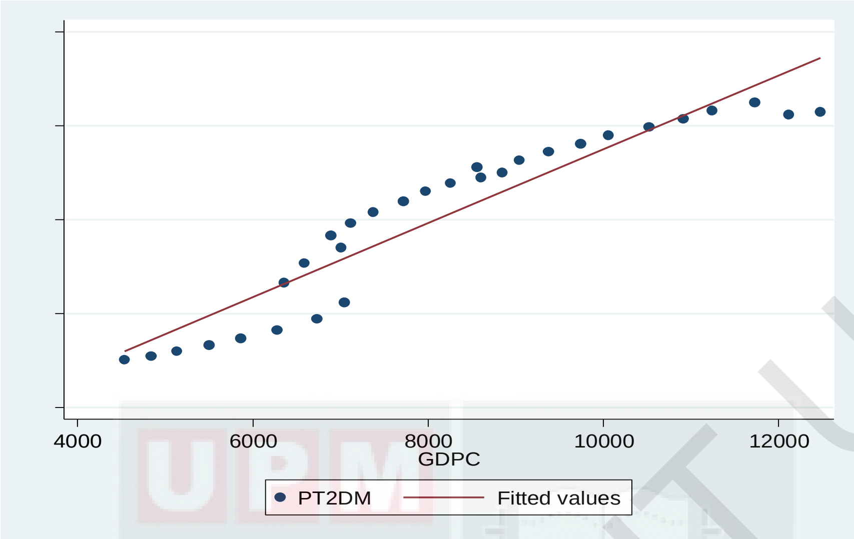

Figure 1.5 : Scatter Plot of GDPC and Prevalence of T2DM in Malaysia (1990-2019)
(Source: Researcher's computation from WDI World Bank, 2020 and NCD-Risc 2017)

In their study, Bird, Lemstra, Rogers, and Moraros (2015) reported that the prevalence of T2DM, associated comorbidities, such as high blood pressure and being overweight or obese, as well as its primary behavioural component, physical inactivity, were all positively correlated with income per capita. They further argued that income is a significant but largely disregarded risk factor for type 2 diabetes despite the fact that increasing income is one of the major sociological factors associated with T2DM. Agardh, Allebeck, Hallqvist, Moradi, and Sidorchuk (2011) also argued that increasing incomes result in obesity and sedentary behaviour which are risk factors for T2DM. They further argued that people in high-income groups are more inactive and fatter in developing countries such as Malaysia. Ching, Zakaria, Paimin, and Jalalian (2013) also reported households in Malaysia having increased income also increased the prevalence % of T2DM. They opined that per-capita income is an important socio-economic factor which has does not guarantee reduced T2DM cases.

1.1.4 Relationship between HEXPC and T2DM Prevalence in Malaysia (1990-2019)

Figure 1.6 presents the preliminary association between health expenditure per capita and T2DM prevalence rate, which is also positive. This shows that when increasing T2DM cases, healthcare expenditure also increases. Therefore, there is a positive association exists between health expenditure per capita andT2DM prevalence rate, where T2DM increases with an increase in health expenditure per capita. (Ganasegeran et al., 2020; Slabaugh, Curtis, Clore, Fu, & Schuster, 2015).

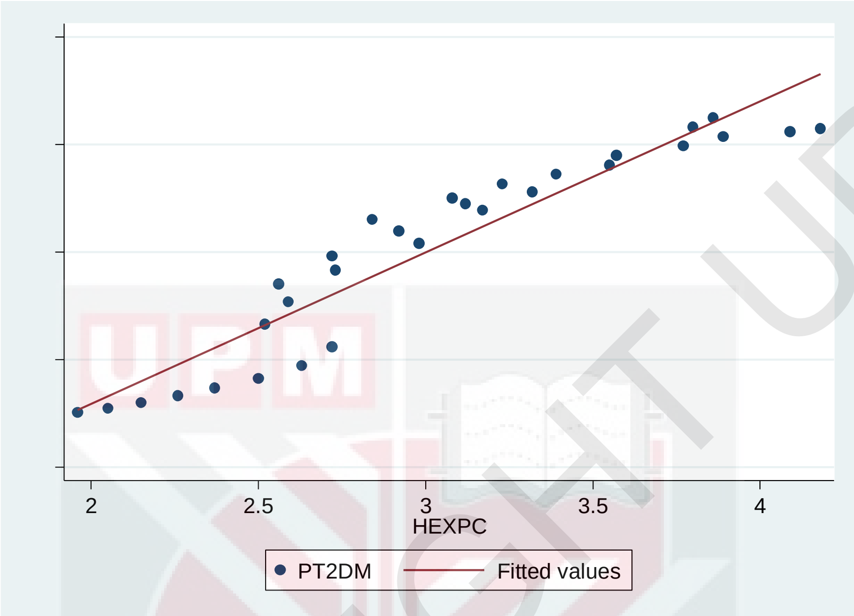

Figure 1.6 : Scatter Plot of HEXP and Prevalence of T2DM in Malaysia (1990-2019)
(Source: Researcher's computation from WDI World Bank, 2020 and NCD-Risc, 2017)

Studies have shown that T2DM has serious direct and indirect effects on patients which are amplified due to the burden of economic costs of the disease. While the indirect costs mostly consist of financial losses due to disability and deaths, travel expenses, nutrition costs, productivity losses, and income loss, the direct costs primarily concern the consumption of healthcare resources such as pharmaceuticals, outpatient, and inpatient costs (Slabaugh, Curtis, Clore, Fu, & Schuster, 2015). Over the past three decades, the cost burden of T2DM has increased significantly in Malaysia. The financial cost to the healthcare system alone is substantial, even without taking into account the expenses of lost productivity and worse patient quality of life. Although Malaysia has a parallel healthcare delivery system from both private and governmental healthcare institutions, financing for healthcare delivery in Malaysia is heavily supported by the government. Budgetary support for the Malaysian Ministry of Health (MOH) in 2018 was MYR 28.7 billion (equal to USD 7.1 billion), or around 9% of overall budgetary expenditures and government receipts. Nevertheless, the expenditure on per capita case of T2DM is increasing and contributing to the worsening scenario of T2DM in Malaysia (Ganasegeran et al., 2020). Figure 1.7

shows that labour productivity has been fluctuating from 1990 to 2019. The highest labour productivity was at 26,341 productivity in 2019.

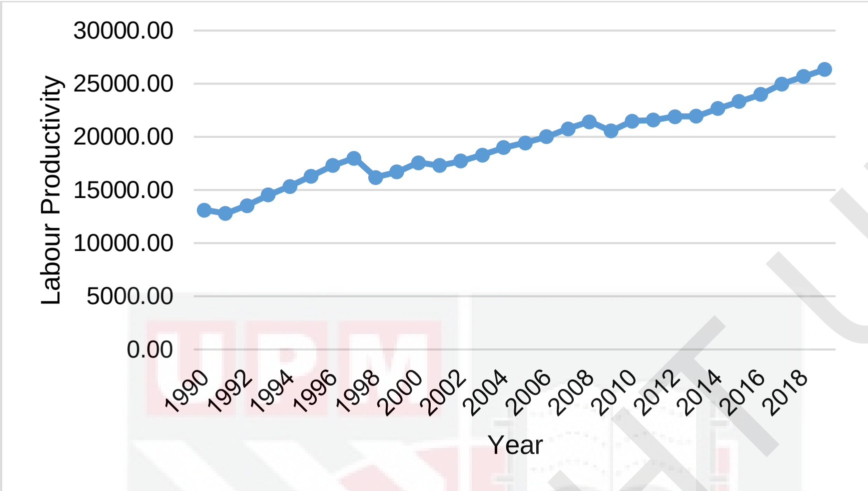

Figure 1.7 : Malaysia's Labour Productivity from 1990-2019
(Source: International Labour Productivity, ILO 2020)

1.1.5 Relationship between Labour Productivity and T2DM Prevalence in Malaysia (1990-2019)

The preliminary analysis in Figure 1.8 depicts the scatter plot of the relationship between labour productivity and T2DM prevalence. The relationship shows a negative relationship.

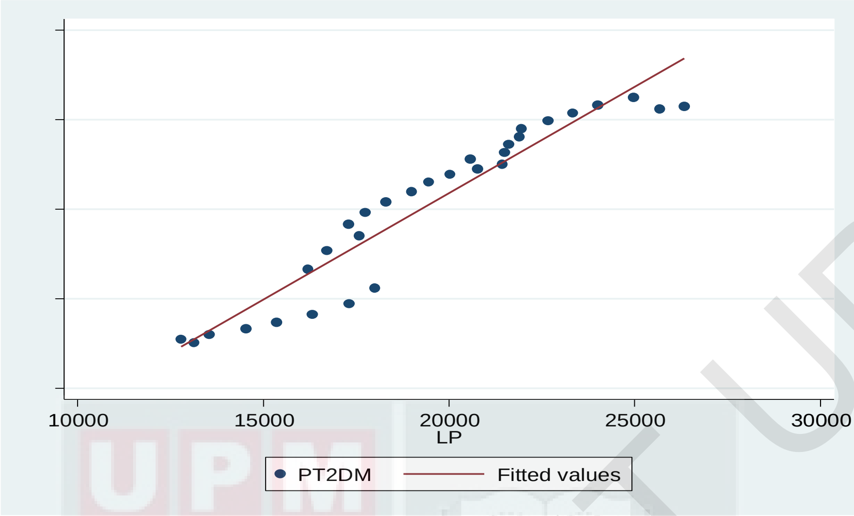

Figure 1.8 : Scatter Plot of LP and Prevalence of T2DM in Malaysia (1990-2019)
(Source: Researcher's computation from ILO, 2020 and NCD-Risc, 2017)

Dianna et al. (2018) stated that, with the presence of diabetes, labour productivity is lower among adults in the age group of 20-24 years compared to the age group of 65-69 years. Another study by Berhad (2017) concluded that for employees who are diagnosed with NCD(s) including heart attack, diabetes, hypertension and cancer, employers are more prone to profit loss and competitiveness reduction in the market due to loss of productivity, absenteeism and presentism. Borhanuddin et al. (2018) also concluded that T2DM places a significant impact on the work efficiency of the labour and impacts their overall performance. This hurts the overall productivity of the organisation in which they work. Researchers have argued that T2DM has contributed to a decline in employee productivity in Malaysia (Idham, 2022). Because of this disease, some workers can be compelled to miss work or be unable to work full-time. Working while exhibiting signs of high or low blood sugar can be physically and mentally hurting. Diabetes and associated complications can lead to tension and discomfort, which can affect a worker's ability to do his job effectively. In fact, diabetes patients miss work 2-3 times more often than the general population due to illness. Thus, because they may not be in as excellent of health as their co-workers, those with diabetes or high blood pressure may be absent more frequently or require more frequent breaks (Al-Sanaani et al., 2022; Idham, 2022).

Therefore, with regard to the high percentage of diabetes reported, what are the main leading social determinants of diabetes in Malaysia according to gender? Does diabetes take into account gender differences? If the prevalence of diabetes continues to grow, it is expected that the number of diabetic patients will hit 7 million Malaysian by 2025.

Table 1.1 : Prevalence of T1DM and T2DM in Malaysia

Gender	Prevalence %
T1DM	
Male	42.4
Female	57.6
T2DM	
Male	54.2
Female	45.8

(Sources: Thangiah et al. 2022 and Zakaria, Hatta, Abidin, Ismail, and Ghani 2022)

1.2 Problem Statement

Diabetes is a silent, killer, it is undeniable that individuals would not be realised that they have diabetes until complications set in. Also, World Economic Forum has predicted that NCDs will bring high risk and the likelihood of negative economic impact, especially in developing countries, where they will suffer an estimate 1-5% GDP reduction due to NCDs alone. Over the years, the prevalence of T2Dm has witnessed a rising trend as the number of patients have risen significantly since 1990. In the future, the number of T2Dm patients is predicted to increase in Malaysia as it is taking the form of chronic health condition among people with poor diet and health facilities.

This huge number of diabetes patients can be related to an unhealthy lifestyle in Malaysia and a lack of awareness of diabetes. A study conducted by Maria, Geok and Pauline (2016) showed that sugar intake by both adult and children were more than 10% of total calories which exceeded WHO recommended limits of 5% or less of total calories. In another study, the Ministry of Health found that Malaysia of all age groups has tremendously increased their sugar consumption from around 15 kg (40g/day) to 50 kg (136g/day or 25 teaspoons) per person per year.

Going by this alarming number of diabetic patients, Malaysia is still lacking an effective long-term operational policy, strategy and action plan to curb diabetes. However, Malaysia does have a basic Global Action Plan to collaborate at national, regional and global levels to reduce the burden of non-communicable disease morbidity, mortality and disability which are preventable, so that these diseases would no longer be a barrier to society of all age to attain a higher standard of well-being and socio-economic development. (National Strategic Plan for Non-Communicable Disease (NSP-NCD), 2016- 2025). In addition, the global target is a 25% relative reduction in the risk of premature mortality from cardiovascular diseases, cancer, diabetes or chronic respiratory diseases.

In literature, studies have asserted that gender is associated with developing T2DM conditions. The development, awareness, presentation, diagnosis, therapy, and prevention of T2DM highly depend on gender and sex differences. Many studies have identified various risk factors of T2DM associated with age such as pathogenesis, age of beginning, identification, burden, or management of T2DM. Additionally, the male sex is recognised as a risk factor for diabetes in the American Diabetes Association (ADA) guidelines' sex-specific diabetes risk assessment tool (Glechner et al., 2015). In females, post-pregnancy obesity has been associated with the cause of T2DM and hypertension (Timpka et al., 2018). However, in the Malaysian context, such explorations are not extensive which creates certain research gaps with regard to the linkage between gender and T2DM in Malaysia.

Zhang et al (2010) found that 16% of the national Malaysian healthcare budget accounted for diabetes costs which placed Malaysia as one of the top 10 countries in the world as having the largest share of healthcare spending on diabetes. From the aspect of household, low-income family is the one that suffers the most due to the long-term cost of treatment and the cost of unhealthy behaviour. A study by the Ministry of Health Malaysia stated that low-income families with diabetic patients spent 20% of their household income on caring for a family member with diabetes, while some households spent more than 10% of their income on tobacco in the poorest households.

Another critical effect of T2DM is that it badly influences labor productiveness. Existing research factors a specific effect of diabetes on labor marketplace elements along with task capacity, work overall performance, and macroeconomic productiveness (Breton et al., 2013). The majority of cost-of-infection research referring to T2DM bases their estimates of oblique expenses on productiveness losses introduced on through both short- or long-time period morbidity, e.g., absenteeism, presenteeism, and incapacity pension (Chaker et al., 2015). Pedron, Emmert-Fees, Laxy, and Schwettmann (2019) argued that it's miles hard to realize and objectively estimate the results of T2DM on labour overall performance and productivity. For this purpose, diverse styles of diabetes mellitus and its related headaches should all be cautiously taken into consideration while growing an empirical method to examine this association. This asserts the want for similar research to discover this association.

Thus, without proper research on diabetes mellitus, the number of cases will rapidly increase, as it silently strikes people at their most productive age, impoverishing families as well as reducing the life expectancy of older people. Despite being largely preventable, T2DM accounts for the vast majority of diabetes cases. This epidemic will deteriorate the health status of the people that are the pillar and generator of an economy of a country, which, will eventually hurt the economic growth if it is not handled as soon as possible. With the lack of policy plans and strategies from the government itself, the people especially vulnerable households will be overwhelmed by the cost of treatment and lack of work productivity.

It is based on this background that this study investigated the social determinants of T2DM in Malaysia and also examine how it affects labour productivity intending to suggest ways of mitigating these risks factors for T2DM, as this will enhance the growth of the Malaysian economy.

1.3 Research Questions

Based on the above discussions, this thesis answers the following questions:

i. What are the social determinants of T2DM according to gender?
ii. What is the impact of T2DM on labour productivity?

1.4 Research Objectives of Study

i. To investigate the social determinants of T2DM based on gender;
ii. To examine the impact of T2D on labour productivity.

1.5 Significance of the Study

The significance of this study is both theoretical and practical. From a theoretical perspective, there are less studies conducted on T2DM even though it is currently one of the major risk factors that are associated with cardiovascular diseases. The possibility of dying due to diabetes is low. However, studies have shown that diabetes death is often caused by complications such as cardiovascular disease. Diabetes caused high blood sugar which is a major risk factor for cardiovascular disease; the current leading cause of death in Malaysia (National Health and Morbidity Survey 2019).

Most of the diabetes studies conducted in Malaysia are scientific studies, with less focus on the social determinants of diabetes which could impact economic growth. Therefore, this study is conducted to fill up the gap of the lack of economic research on the issue in Malaysia with the hope that the Malaysian government, as well as the citizen, will look at this matter more seriously. One of the uniqueness of this study is to look at the social determinants of diabetes according to gender.

From a practical perspective, this study will provide information that can help policymakers and practitioners to decide on a cost-effective mechanism to supply better health services that would reduce diabetes mortality rate whilst the population gain awareness of the danger of diabetes as a silent killer after identifying the determinants of T2DM in Malaysia. The research will investigate the impact of T2DM on economic growth by using labour productivity as a measure. It is commonly known that healthier individuals will be more productive and more active in their life. T2DM is a type of chronic disease that requires constant care and treatment to keep it under control. The treatment they will be receiving may impair their performance at work which will eventually reduce their productivity at work. The significance of this research also lies in the fact that T2DM has been an increasing issue in the Malaysian working population and it has badly affected their performance and ability to deliver their targets in terms of professional duties (Idham, 2022). Furthermore, the burden of T2DM on the ability to work has been found to be much more than many other NCDs and CVDs (Breton et al., 2013). Research studies have been done in developed countries such as the US and Singapore which have found a significant effect of T2DM on labour productivity (Phan et al., 2014). However, there is a lack of such studies in the Malaysian context despite the increasing number of T2DM cases. Thus, it is vital to conduct research Malaysian population to estimate the effect of diabetes on Malaysia's labour productivity.

The outcome of this study shall shed more light on whether males or females are more vulnerable to developing T2DM in Malaysia and also acquaint the citizens and socioeconomic factors responsible to create awareness of the danger of diabetes and the need to live a healthy lifestyle. This will enable them to minimize exposing themselves to these risk factors while working closely with their health teams. Policymakers and practitioners decide on a cost-effective mechanism to provide better health services, by allocating substantial resources toward reducing the death rate resulting from diabetes. In the same vein, it will alert the government of Malaysia on the need to implement policies aimed at managing/curbing these factors associated with developing T2DM, especially the GDP, Health expenditures and Urbanization. While for co-researchers, it will be a useful source of reference for further research on the same topic.

1.6 Scope of the Study

This study is conducted on Malaysia using social, economic and environmental variables for the period of 30 years (1990 to 2019). The study used Type 2 Diabetes Mellitus (T2DM) measured by the death rate resulting from it, as the dependent variable in objective one, while objective two has labour productivity as the dependent variable. Both objectives have social. economic and environmental variables as the independent variables, including other explanatory variables as control variables.

1.7 Organizational of Chapter

This paper is structured in the form of Chapters 1 to 5. Chapter 1 is the introduction chapter which provides the overview of the whole study and the core motivation for this research. Chapter 2 is a literature review that states the previous theoretical and empirical studies while Chapter 3 explains the methodology that will be used in this paper. Chapter 4 is the analysis of data and provides the results of the research. Lastly, the paper draws a conclusion and policy recommendation in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the researcher summarises previous research on the topic- of diabetes. The first part of this chapter will be looking at the Grossman model for an economic analysis of health, while, the second part will explore the Production Theory to determine the impact of diabetes on labour productivity. The last part of this chapter is to identify the gap in literature, which will be the direction for this research.

2.2 Theoretical Perspectives

2.2.1 Health Demand Theory

By using the concept of health demand, the social determinants of T2DM such as healthcare expenditure can be explained. The application of economics theory in the health sector known as health economics enables us to understand health outcomes from an economics perspective. This theory applies to this topic of research because it is aimed at looking at the determinants of T2 Diabetes Mellitus in Malaysia, having considered its expenditure on health to see whether it has yielded good outcomes. Arrow (1963) started the research on the efficient allocation of the medical care industry to satisfy the needs of different individuals; hence, the origin of the topic of health economics.

Then, Becker (1965) originated the idea of household production theory which postulated that ageing causes the depreciation of human capital stock, where, individuals will seek medical care using their own time to produce or reproduce health capital. When the marginal cost of health production equals the marginal benefit of improved health status in terms of “healthy time”, investment in health production is considered optimal. A direct influence of health status on household utility is the “pure consumption” effect, while an indirect influence of health status such as higher labour income is the “pure investment” effect. This implies that expenditure on T2DM will be deemed optimal only in case it yields marginal benefits equaled to marginal costs involved in the treatment of T2DM.

Grossman based his model development on relying heavily on the human capital theory previously developed by Becker (1965), Ben-Poath (1967) and Mincer (1975). Grossman (1972) developed a human capital theory that described the demand for health and health care. Leibowitz (2004) indicated that Grossman Model improvised Becker's (1965) Home Production Theory by incorporating an investment concept on top of the consumption concept. He also stated that

Grossman highlighted the most important feature which is the role of time and taking education as one of the factors where an individual use education to increase one's efficiency in producing health, besides, shadow price reduction at any stage of life. Grossman's seminal model differs from traditional health demand theory as he perceived an individual as both a consumer and a producer of health. A health production function is where the consumption of medical care and other goods determines health and these health inputs are an investment that influences the rate of depreciation of health stock. This multi-period Grossman model forecast a decrease in demand for health due to ageing while the demand for medical services elevate as an individual optimize medical services for their benefit. Gallego and Ramirezy Sepulveda (2005) asserted that theoretically, Grossman's (1972) theory plays an important role in determining health status, while, works by Wagstaff (1993), Gerdtham et al. (1999) and Grossman (2000) implies an important causal relationship between socioeconomics status and health outcomes in the later years. This also serves as the basis for understanding the way the educational level of the people impacts their T2DM.

Nonetheless, Grossman Model was criticised by Zweifel and Breyer (1997) as the model does not cater to the influence of uncertainty. For instance, Zweifel and Breyer (1997) pointed out that Grossman Model ignorance on possible stochastic shocks such as illness or accidents which may prompt a permanent decline of health status could cause lesser control of an individual's health in the long run. As cited in Muzurura (2016), Muurinen disagrees with Grossman's unspecific role of education and suggested a link between allocative efficiency gains of education to the concept of use-related depreciation of health stock.

2.2.2 Production Theory

The production can be used to explain the impact of T2Dm on labour productivity by using the lens of Production Theory. The production theory primarily deals with the study of production, or the economic process of creating outputs from inputs (Sealey Jr & Lindley, 1977). A good or service that is appropriate for use or exchange in a market economy is produced using resources. Manufacturing, storing, shipping, and packaging all fall under this category. Some economists use the broad definition of production to refer to all economic activity aside from consumption. Other than the final purchase, economists consider every commercial activity to be some of the production. This production is pivotal for the effective overall growth of the business and overall economy. For the production process to remain effective, employees are the most important factor. In case, employees are unable to perform their roles effectively, this would result in reduced performance.

There are three main aspects that should be focused on while performing the production process including the volume of the product or service that was created, the design of the produced commodity or service, and the flow of the good or service generated over time and space (Jarkas & Horner, 2011). If employees are frequently absent from work or do not have the ability to perform their tasks, labour productivity will be reduced. For T2DM patients, this theory implies that such employees will not be able to attend their jobs regularly and perform the production process effectively resulting in low labour productivity.

Production is the process of combining numerous immaterial (plans, knowledge) and material inputs to create something for consumption (the output). It is the process of producing a product, a good or a service, that is valuable and enhances people's utility. Companies provide these products to the target markets to obtain revenue. The outputs can be badly affected if the worker(s) have T2DM condition as it will impact their work efficiency leading to reduced labour productivity and eventually economic growth.

According to this theory, among the most important elements of the production function, Labour is one of the most critical (Buesa, Heijs, & Baumert, 2010). Labour is the human capital that is available to convert natural resources or raw materials into finished goods. All people who are able to work in the economy and offer a range of services to other people or enterprises are considered to be part of the human capital. Given that workers can be distributed throughout many sectors of the economy to produce goods or services for consumers, this factor of production is a flexible resource. When using other economic resources, human capital can also be enhanced through training, job duties, or company endeavours. However, if the labour is physically challenged due to a health condition like T2DM, production is badly impacted and labour productivity diminishes (Min et al., 2019).

2.3 Empirical Perspectives

2.3.1 Social Determinants of Type 2 Diabetes Mellitus

2.3.1.1 Population (according to gender) and Type 2 Diabetes Mellitus (T2DM)

Macintyre, Hunt and Sweeting (1996) conducted research that supports the findings from two perspectives. The precise perspective stated that female morbidity factors vary according to different social groups, And the wide angle concluded that ladies' lives appear to be much less wholesome than men's lives. This conspicuous paradox of rationalization lies in the dedication to human fitness and illness, that's a complicated courting among organic and social influences. Raphael et al. (2003) discover that the superiority of diabetes is better amongst girls from poorer communities. He mentioned that gender performs a critical function in figuring out the superiority of diabetes as girls must undergo youngsters even as worrying about the fitness desires in their circle of relatives members. Therefore, to provide enough nutrition for her family members, she will compromise her own nutritional needs which will cause complications in the future such as lower birth weight or a higher likelihood of her children developing diabetes in the future.

Gallego and Ramirezy Sepulveda (2005) found that women have a higher life expectancy than men; however, they have worse health status than men in Colombia. The conclusion is reached by using two data survey sets, which compromised a total of 28,477 individuals, the researcher employs order probit estimations to estimate the health capital in a developing country after a deep reform of its healthcare sector. From the perspective of mortality rate due to diabetes, Begg et al. (2007) found that male with the prevalence of diabetes has a higher mortality rate than female as they did not live as long as a female in Australia. Kavanagh et al. (2010) highlighted that the development of an appropriate intervention to reduce socioeconomic inequalities in diabetes and cardiovascular disease can be done by understanding and researching the gender-specific association between socioeconomic position along biomarkers. The study is conducted in Australia as a part of the Australia Diabetes, Obesity and Lifestyle (AusDiab) study by using the national-based cross-sectional study of 11,247 adults aged 25 years and above, between 1999 and 2000.

As we have mentioned earlier, Siegel et al. (2011) also conducted their research by looking at different income levels countries and gender. Song et al. (2012) found that women with spouse tend to provide more unmet needs support for their spouses, which led to further neglects of their self-care diabetes in the Korean American community. In this study, researchers employ social cognitive theory which is used to illustrate the complex interplay among personal, environmental, cultural and behavioural factors for T2D management as well as self-care. In a univariate and multivariate analysis, Diabetes Mellitus among South Kivu Congolese adults in urban and rural areas suggested that the prevalence of diabetes increases as age increases for adults who are greater than 40 years old (Katchunga et al., 2012). The outcome of gender inequality toward health conditions is further supported by Seuring, Goryakin and Suhrcke (2015) who concluded that both male and female sexes have a negative relationship with the prevalence of diabetes.

Magliano et al. (2018) studied the productiveness burden of diabetes at a populace level through the usage of an age-precise mortality fee and a productiveness index as a result of diabetes in Australia through the usage of a dataset from National Diabetes Services Scheme (NDSS). One of the findings highlighted decrease mortality costs amongst the “non-diabetic” populace as compared to the diabetic populace for an age institution of 20 to sixty five years old. The year of lifestyles misplaced is barely better amongst Australian guys as guys recorded a better occurrence of diabetes and that they did now no longer stay so long as girls. In 2019, World Health Organization supported the case of gender influencing people’s responsiveness to a specific fitness conditions. By accomplishing a cross-sectional observe in 5 number one healthcare centre in Majmaah, Saudi Arabia, Al Mansour (2019) additionally discovered that the superiority of diabetes is barely better in women than males.

2.3.1.2 Health Expenditure and Type 2 Diabetes Mellitus (T2DM)

Villarreal-Rios et al. (2000) indicated that government spending on T2DM patients in Mexico is three times higher than in Sweden. As the awareness of health economics increases, research had been performed to combine the connection among fitness and economics. Amiri and Ventelou (2012), revisited Toda-Yamamoto Approach with the aid of using the usage of Granger causality to investigate the causality among GDP and healthcare expenditure for OECD countries. They observed that there may be a most important bidirectional Granger causality among GDP and healthcare expenditure. Healthcare expenditure is mainly a channel to help people with a chronic situation so that they would be able to recover and return to work in the shortest period. Siegel et al (2012) found that at an average increase contribution of GDP from the service industry at 5%, 10% and 20%, the prevalence of T2DM will increase by 4.9%, 10.0% and 20.9% by using generalized linear models in 94 countries. In the same vein, Kim (2016) also found that healthcare spending has a moderate influence on the rate of death for patients with T2DM, external injuries and suicide. On GDP, Zahra et al (2015) study showed that GDP has a negative relationship between mortality rates due to cardiovascular diseases (CVD) and diabetes in low-income countries compared to high-income countries. They concluded that the high mortality rate resulting from a high prevalence of risk factors may be due to ineffective management and treatment strategies in the countries. The research was conducted in 72 countries, where Malaysia is one of the sample countries.

Then, Ogurtsova et al. (2017) found that, in 2015, a total of US$673 billion accounts for global health expenditures due to diabetes and is expected to hike up to US$802 billion in 2040. For instance, in the United Kingdom (UK), 80% of the total medical cost in the UK was spent on treating diabetes complications and the UK could have saved £340 million in the first five years if the government takes more initiative to improve diabetes management in the country. According to Afroz et al. (2019), diabetes and its complications are making an individual be in an economic burden in the country. He found out that out of the 1,253 participants, 14.8% have macro-vascular complications, 20.7% have micro-vascular complications, and 27.9% have both. The complication in each diabetic patient requires a higher average annual cost and also leads to hospitalization, using multiple logistic and non-parametric regression analyses.

This highlights that previous studies have given importance to health expenditure as an important social determinant of T2DM. However, most of these studies include the T2DM population from western countries such as the UK, US, Sweden and more. Only a few studies have considered the Malaysian population and that was too many years ago. Since the current Malaysian population has much more cases of T2DM than in the past years, there is a significant gap in the latest studies on the association between T2DM and health expenditure. Thus, the current study aims to fill this gap by evaluating this association in the Malaysian population.

2.3.1.3 Obesity and Type 2 Diabetes Mellitus (T2DM)

Katchunga et al. (2012) conducted a univariate analysis in urban areas that portrayed a higher risk of diabetes among obese adults; however, the risk of diabetes among obese adults is insignificant in multivariate analysis in the Democratic Republic of Congo. In rural areas, the results also show an insignificant relationship between obesity and the prevalence of diabetes. Basu et al. (2013) established that the South Asian population has higher chances of developing metabolic syndrome and contracting diabetes at lower levels of obesity (assessed by BMI) as compared to Caucasians. He further revealed that using the measurement of BMI 25 – 30 kg/m (overweight) in their study is more relevant than using 30 – 40 kg/m (Obesity) in East and South Asia countries due to the possibility of weight gain rather than overt obesity that caused the prevalence of obesity. According to Hussein et al. (2015), 75% of the Malaysian population who is diagnosed with T2D have obesity issues and 72% of people from the group were overweight with a mean BMI of 27.8 kg/m. They also established that an increase in the prevalence of obesity and diabetes are parallel as well as inseparable among Malaysian.

Goryakin, Monsivais and Suhrcke (2017) researched that highlight the increasing prevalence of T2D is due to the increase consumption of Sugar-Sweetened Beverages (SSB). They found that from the year 1999 to 2014, the price of SSB decreased and soft drink sales per capita significantly increased during the period. With the decrease in SSB price, and increase in soft drink sales per capita, the average BMI has increased which leads to a higher prevalence of diabetes among children and adolescents. Sapra, Gupta and Sapra (2018) are highly aware that, diabetes is an epidemic that is growing and is increasingly affecting children and adolescents worldwide, hence, they conducted another research on the effect of BMI on the prevalence of diabetes and depicted a positive relationship between BMI and diabetes. In another research, Amkraut, Zaina and Abu-Rabia (2018) have also proven that Bedouin women are more prone to diabetes and obesity. The researchers pointed out the fact that Muslim Arab women have a less active lifestyle due to traditional social expectations where, Muslim women are expected to stay home, dress modestly and take care of their family member's needs.

Apart from that, Fallahzadeh, Ostovarfar and Lotfi (2019), essential attention is at the quantification of the effect of bodily activity, coronary heart diseases, preferred weight problems (measured the usage of BMI), crucial weight problems (ratio of waist to hip ratio) and life-style elements (smoking, tough drug use and alcohol consumption) as modifiable elements a good way to have an effect on T2D diabetes at a populace stage in Yazd, Iran. They discovered that crucial weight problems is diagnosed because the foremost indicator for decreasing the occurrence of T2D many of the human beings in Yazd, Iran. In a examine through Carlsson et al. (2019) there's a substantial nice courting among the occurrence of kind 2 diabetes and imply BMI in guys and women. Recently, Al Mansour (2019) additionally discovered that weight popularity suggests a substantial affiliation with T2D many of the semi-city populace of Saudi Arabia.

The maximum occurrence of T2D turned into said from the Gulf which turned into Bahrain (25.7%), Oman (16.1%), and Kuwait (21%).

2.3.1.4 Education and Type 2 Diabetes Mellitus (T2DM)

According to Wamala et al., as cited in Raphael et al. (2003), they maintained that a metabolic syndrome that would lead to the prevalence of diabetes is highly significant among women with lower education attainment even after considering the age, family history, smoking, lack of exercise and alcohol consumption aspects. Although, Kavanagh et al. (2010) have advocated that education is an influencing factor on people to acquire and comprehend health information for their health benefit. Clark and Utz (2014) employs that individuals with greater education attainment are most likely to have better health status compared to an individual with lower health status as they perceived that individuals with higher education are more socio-economically stable and actively educating themselves on healthcare by participating in preventive healthcare (eating healthily and healthier food intake) while avoiding obesity. Matsushima as cited in Summers and Hayes (2015) mentioned that the educational achievement, job attainment and income level of T1D siblings have a higher chance of encountering job refusal compared to their siblings without diabetes.

On the other hand, Kim (2016) finding shows a contradictory result where an increase in education spending will increase the diabetes mortality rate. He argues that education spending would not decrease the prevalence of diabetes but the improvement in education/health behaviours of a person is the main key to reducing the prevalence of diabetes and mortality rates. Berniell, Mata and Valdes as cited in Kim (2016), supported the finding by proposing positive spillover effects of health education engagement between children in elementary school and their parents. Al-Naggar et al. (2017) found that the majority of the respondents in Saudi Arabia and Western Nepal have poor knowledge, attitude and practice toward diabetes mellitus disease. On the other hand, the researchers found that the primary care centre in Malaysia shows that Malaysian are well equipped with diabetes knowledge as well as outline a better attitude towards the care of their diseases.

Sapra, Gupta and Sapra (2018) further improvised Raphael et al. (2003) research by conducting a study on the prevalence of obesity among adolescents and awareness about diabetes in Delhi, India. They specific the study according to private schools, government schools, science students and non-science students, which indeed produced different results. Students from private schools are generally from middle or upper socioeconomic status (SES), whereas students from government schools are generally from lower SES families. Private school students with higher parental literacy rate and better learning facilities have a higher level of diabetes awareness compared to government school students and students with a science background has higher awareness due to better science education background. Carlsson et al. (2019) stated that the differences in socioeconomic status for each individual possess a different level of diabetes risk. It is observed that using meta-analysis, low socioeconomics position, especially income education and occupation position contributes to an increase of 30 – 40% in diabetes incidence.

This shows that education has a deep association with the way T2DM progresses among the population as more populated patients are less likely to develop T2DM. However, research on the Malaysian population is lagging which asserts the need to conduct empirical studies to investigate the association between education and T2DM.

2.3.1.5 Environmental and Type 2 Diabetes Mellitus (T2DM)

Hill et al. (2013) stated that urbanization and economic growth cause diabetes growth through several factors such as increasing access to high-fat and calories dense foods and beverages, an increase in consumption portion as well as an increase in processed food consumption. They concluded that the US has a higher rate of diabetes and obesity in rural areas compared to urban centres. This may be due to the fact that rural area community has less access to health care, higher poverty rate, lower socioeconomic status and neighbourhood environments. The study was conducted throughout the U.S on 18 years old and above population by comparing the prevalence of diabetes among high-poverty and low-poverty area public housing residents with 10 to 15 years of follow-up by using the Behavioral Risk Factor Surveillance System (BRFSS).

Sidawi and Deakin (2013) developed research that particularly examines the potential of smart city technologies in promoting healthier lifestyles among the residents especially diabetic residents in the Kingdom of Saudi Arabia (KSA). The research concluded that smart city technologies did not promote healthier lifestyles as perceived. The plan and layout of the cities are made up of mixed land usage within a built environment for a high-density population. Mixed land usage is defined as the diverse structure of tenure and green spaces that also have good connectivity, a systematic public transport system and offers safe pedestrian as well as cycling facilities. Due to a strategically planned city layout that has high accessibility and easier routes between destinations, this smart city development has developed an unhealthy lifestyle among the residents. Gatimu, Milimo and Sebastian (2016) used data collected in an ongoing longitudinal Study of Ageing and Adult Health (SAGE) Wave 1 from 2007 to 2008 in Ghana to conduct a cross-sectional study. The data collected are from 5,269 households and 5,573 people, whereby, all the household members aged 50 years and above are invited to participate, while respondents from a household without any 50 years old and were randomly selected. The study only processed data from completed sets and sets with missing data were omitted. The pool of respondents comprises 55% male and 45% female respondents and 60% of the total respondents are from rural areas. The research deduced that urban areas respondents had a significantly higher prevalence of diabetes compared to those in rural areas.

Amkraut, Zaina and Abu-Rabia (2018) established that Bedouins which are an Arab population living in Israel who lives in the planned city have higher diabetes prevalence compared to those who remained in unrecognised villages. The researchers explained that this situation is connected to "epidemiological transition theory", which is related to modernisation and urbanisation in populations across the globe. Population such as Alaskan Natives, Navajo Indians, Guatemalans, Australian aboriginals, Zuni Indians and migrating rural Indians are also experiencing the same trend as the Bedouins. This study employed a cross-sectional study by using the Clalit Health Services database and the researchers highlighted a limitation that should be taken into consideration when applying this data. Bedouins who are living in unrecognised villages have less health care services access which might lead to underestimation of diabetes prevalence.

2.3.2 Impact of Type 2 Diabetes Mellitus on Labour Productivity

2.3.2.1 NCDs and Labour Productivity

Non-communicable diseases (NCDs), which currently account for 36 million deaths annually (or 63% of all adult deaths), are the leading cause of morbidity and mortality worldwide. T2DM is one of the most serious NCDs. Other examples of NCDs include coronary heart disease (CHD), stroke, chronic obstructive pulmonary disease (COPD), cancer, and chronic kidney disease (CKD) (Chen & Bloom, 2019). NCDs have a variety of effects on economic growth which have been reported by various previous researchers. For instance, because unhealthy populations may be associated with NCDs, people may be less productive as they take more sick days and are generally less energised (Jäckle & Himmler, 2010). According to recent studies, NCDs have a negative causal influence on hours worked and productivity at work (He, Liu, & Salvo, 2019). It has been noted that students having NCDs has lower rates of school attendance and weaker cognitive function which results in a population with a lower level of education which underperform in their professions (Currie, Hanushek, Kahn, Neidell, & Rivkin, 2009).

A survey study conducted by Mayer-Foulkes (2011) showed that NCDs have significant long-term macroeconomic effects. The sheer weight of the working-age population and the elderly suggests significant effects on investment, saving, and labour, as well as increased human capital degradation. Each of them has an effect on long-term economic growth. Quantifying these effects is an area of scientific emphasis mainly because of the importance of labour productivity in the economic growth of any economy.

2.3.2.2 T2DM and Labour Productivity

Lavigne et al. (2003) conducted thorough research comparing the work performance between T2DM and non-T2DM workers. The research stated that at the early stage of diabetes diagnosis work attendance between T2DM and non-T2DM employee is the same; however, in terms of work efficiency, a T2DM employee shows a significant productivity drop as the year pass which eventually leads to work absenteeism and lastly workforce exit. This profound finding used a sample consisting of 472 employees in New York State, USA with a majority of 445 individuals who works in one major US corporation. It further maintained that diabetic men recorded a loss of an extra 4 hours per month per person worth of work productivity as compared to female. The researchers also stated that a limited efficiency loss can be perceived and reported, as when the limit is reached, adding more comorbidities in a model will have little effect on the overall efficiency loss.

A large-scale study conducted with probit regression to examine the effect of diabetes on labour market outcomes by using secondary data from Health and Retirement Studies in the United States from 1992 to 1994 has shown a reduction in the absolute probability of working of 4.4% and 7.1% for female and male respectively (relative to their counterparts without diabetes).

From the perspective of work limitation, it is reported that 5.4% of work limitations are among males compared to 6.0% among females. Hence, they suggested that programs that raise diabetes awareness will aid in the prevention/reduction of future loss in employment and work productivity (Tunceli et al., 2005). Korff et al. (2005) predicted a decrease in labour productivity due to the factors that increase the number of diabetes symptoms, lower educational attainment, depressive illness and complication of diabetes. This study was conducted by a multidisciplinary team from the Center for Health Studies of Group Health Cooperative (GHC) with the collaboration of Psychiatry at the University of Washington, composed of 1,642 individuals; excluding retirees and homemakers. Also, they found that 19% of the sample study indicates a significant sign of work disability. Similarly, they found out a majority (60%) of the participants with T2DM has a BMI≥ 30kg/m2 (Obesity) and 6.7% of the employed individuals have missed 5 working days in the prior month, while 4.0% reported having severe difficulty with work tasks.

Jacobs and Johnson (2001) conducted a study with a sample size of 84,572 individuals in the age range of 18 to 65 years old, which consists of 2,405 T2DM individuals has demonstrated a considerable impact of T2DM on economic behaviour in the labour force (reduction by 3.5%). Besides that, a diabetic patient with complications and one without complications show a huge difference in labour productivity reduction. Employees with complications show a 12% reduction in labour productivity and worked 3.2 days less every 2 weeks compared to those without complications in the absence of differentiation according to the type of diabetes. Besides, Bloom and Cannings as cited in Amiri and Ventelou (2012), also pointed out that, healthier people can work harder and longer, apart from being able to think more clearly. Apart from this, a study also tested the theory of diabetes for different gender on labour productivity. T2DM male workers with formal job categories are less likely to face a reduction in their employment chances compared to diabetic male workers with physical/skills demand jobs. Therefore, men in Mexico are more prone to drop out of the workforce compared to US or Canadian working men as Mexico's working male is mostly into physical/skills labour-intensive jobs. The study also found that diabetic patients do not simply receive a uniform penalty as the impact of diabetes may change as time passed (Minor, 2013).

Breton et al. (2013) bring forward research that shows 52% of the studied population in North America, Europe and Australia has T2DM and neuropathic symptoms which caused a reduction of $2 weekly due to illness and reduced performance during the working period compared with 28% of individuals without T2DM. The researchers found a significant loss of productivity due to diabetes (either with or without neuropathic symptoms at a different magnitude), where, individuals with T2DM and neuropathic symptoms recorded a total of 26.3 days of productivity loss annually, 11.9 days of productivity loss annually for an individual with diabetes illness only and lastly a 12.0 days productivity loss for an individual without diabetes using a cross-sectional study between 1985 till 2009 in 3 different continents. Abu Salem, Hegazy and Mohamed (2016) also concluded a significant correlation between work productivity and work absence among the Arabic population in urban and rural areas.

Another study conducted by Summers and Hayes (2015) established that, from an interview with employers, 1% of the companies would not consider an individual having T2DM as an employee and hence, many T2DM patients normally tried to hide their diagnosis from employers. Arshad and Malik (2015) highlighted a 1 % increase in life expectancy will contribute to a 14% increase in productivity and they also found that the health variable plays a more important role than the education variable in Malaysia's labour productivity scale. Apart from identifying an increase in mortality rate among the T2DM population in Australia, Magliano et al. (2018) also found a relatively higher productivity loss-adjusted life years (PALYs) among men and younger people. It estimated an average loss of 1.4 PAYLs per person in a year (1.41 in men and 1.39 in women). The research is mainly focusing on paid full–time employment and did not capture the loss of productivity in unpaid work or part-time employment. In another study, a reduction of 15.1% in productivity–adjusted life years (PALYs) were seen among the current T2DM-diagnosed Chinese population in China which is equivalent to roughly 1.3 PALYs per person over a working lifetime (Hird et al., 2019).

These studies show that most of the research conducted on the association between T2DM and labour productivity is focused on non-Malaysian contexts which leaves a significant research gap for T2DM effects in Malaysia. Thus, more research studies are needed to assert how T2DM is impacting economic growth in Malaysia. The current study intends to fill this research gap.

2.3.2.3 Physical Capital and Labour Productivity

Baily (1990) conducted research to challenge the current theoretical neoclassical models where capital's effect on productivity is small and also the existence of diminishing returns to physical capital. Baily concluded that there is a limit in the long-run rate of capital accumulation that contributes to the US economy, still, if the federal increase the capital formation, it would lead to an upward shift of future GNP growth, even though it would be a slightly small gain. Several previous studies by Barro and Sala-I-Martin (1991), Young (1992) and Singh and Trieu (1996) also found a significant positive impact of capital formation (physical capital) and human capital in economics using a country-specific study in Japan, Korea as well as Taiwan.

Ongo and Vukenkeng (2014) used the endogenous growth model with the generalised least square method and concluded a positively strong significant relationship between private investment (measured by gross capital formation) and economic growth in CEMAC regions, where, the result is reinforced by human capital vector. Akpolat (2014) used panels DOLS and FMOLS to compare the efficiency of physical (gross capital formation) and human capital (education expenditure and life expectancy at birth) on GDP between developed and developing countries (Malaysia is one of the sample countries) for a period between 1970 until 2010. Both variables contribute to higher output growth or more efficiency in developed countries compared to developing countries. Bleischwitz and OECD as cited in Stocker et al. (2015), resources productivity is maximizing the efficient use of natural resources to produce goods and services in the economy, whereby, labour or capital productivity describes the relationship between economic output (in terms of monetary terms) and it also acts as a physical indicator for material or resource inputs. Also, they found that labour harms labour productivity when they factor in environmental growth issues and resource scarcity which is vital for academic study as well as policymakers in the EU.

Bal et al. (2016) indicated that better funding in each physical and human capital is the predominant indication for increase via way of means of the usage of the ARDL method via way of means of taking India because the pattern country. It is located that better capital formation brought on monetary increase in the end that is regular for the reason that India desires extra capital for utilisation in intake in addition to manufacturing functions from 1970 to 2012. In the equal vein, Cvetanoska and Kozheski (2019) intention to examine the correlation except the informal dating among gross constant capital formation and labour productiveness during 2004 to 2016 the usage of 3 separate panel analysis. Taking out in step with worker as a proxy to labour productiveness, the researchers located that more gross constant capital formation will growth marginal labour productiveness, which ultimately contributes to a growth in labour demand and employment.

2.3.2.4 Human Capital and Labour Productivity

Miller and Upadhyay (2000), using endogenous growth theory, and taking total factor productivity as the dependent variable and human capital as the independent variable, found a contradicting effect between high and middle-income countries. Human capital has a positive effect in middle–income countries but a negative effect in high-income countries. They further clarified that the effect of human capital on total factor productivity in low-income countries will shift from negative to positive as the country increase its level of openness. Unless low-income countries reach a certain level of trade openness, there will be counterproductive effects on human capital investment.

Bloom, Canning and Sevilla (2004) affirmed that a healthier person contributes more towards a country's development; healthier people can be more productive, and has higher life expectancy which will eventually lead to better learning ability and creativity development that will reduce income inequality. The impact of human capital can be direct or indirect on labour productivity. As the nation and employers increase their investment in the education and healthcare system for the benefit of the population, this will groom a healthier and more resourceful labour supply that will tremendously generate positive economic growth as well as labour productivity in the future. Research focusing on the effects of human capital on labour productivity growth in Malaysia's manufacturing sector was conducted by Elsadig (2006) which used total factor productivity (TFP) as the dependent variable with a set of data from 1987 to 2001. The research divided the human capital into semi-skilled and unskilled labour inputs. The researcher concluded that materials account for the largest share of the cost, although the shortage of skilled labour accounts for a serious constraint on capital utilisation.

Controversially, Ongo and Vukenkeng (2014) found that the labour force negatively impacts the economic growth in CEMAC regions as opposed to all the other studies that have a positive relationship which can be explained by several factors. The researchers justify that, the unemployment rate in CEMAC regions is high and a part of the sub-regions does not have realistic employment following the country's labour supply. They also found that human capital has a positive sign but is insignificant, even though the government has offered free higher education and private secondary education is available at an affordable rate in Congo while primary education is also given for free. In Cameroon also, primary education is free and the government offers vast professional training opportunities to youth, yet, the effort is compromised due to the scarcity of a decent workforce. Another study done in Malaysia used motivation, management support, supervision and technology as the independent variables to determine the factors that affect labour productivity in Malaysia by randomly distributing 150 sets of questionnaires Razak et al. (2014), found a significant relationship between motivation, supervision and technological towards labour productivity in Malaysia.

Pelinescru (2015) applied Solow structural econometric models extended by Mankiw, Rommer and Weil (1992) to examine the role of human capital as a growth factor and called for attention to the influence on sustainable development of the countries due to lower investment in human capital in accordance to EU's 2020 Strategy using Eurostat database annual data from 2000 to 2012. The study revealed that the qualification of employee (secondary education) and the increase of innovative capacity of human capital positively influence labour productivity and has a significant positive effect on EU country's GDP per capita. Mohd and Zubaidah (2015) employed panel data analysis that covers 14 states in Malaysia, spanning from 2009 to 2012 to study the impact of human capital on Malaysia's labour productivity by mainly focusing on the education and health status variables. The results estimated using the fixed effects generalised least squares (GLS) model deduced that both health status and education show a significant role in improving Malaysia's labour productivity. They also found a significant negative effect of labour supply growth on labour productivity, which they argued that a fairly constant increase in capital formation and a much faster increase in the number of workers could result in supply-side Malaysia's economy diminishing returns. The researchers also highlighted that during the period of study, one-third of the total labour supply increment are foreign workers, where 95% of them are semi and low-skilled migrant workers. In terms of education, they found that only secondary and tertiary education levels in Malaysia are significant and have a positive effect in Malaysia, but, secondary education level has much higher effects on productivity in Malaysia.

Education and human capital are perceived to be some of the most important factors in determining economic growth. Islam et al. (2016) conducted a study on the role of education and human capital in Malaysia's economic growth by distributing 100 sets of questionnaires to the people in the Bahau, Negeri Sembilan area. They concluded a significant positive relationship between education and human capital on Malaysia's economic growth. It is emphasised that individuals with higher education are more skilled and are considered productive workers. Hence, they suggested that, to maximise the effectiveness of education input, the quality of education needs to be further improvised. Maciulyte-Sniukiene and Matuzeviciute (2018) divided their research into relatively high productivity (RHP) and relatively low productivity (RLP) countries in European Union (EU), which they found a significant difference in labour productivity between RHP and RLP countries. The impact of human capital development on productivity is found to be higher among RLP countries than RHP countries. The researchers concluded that RHP countries might have exhausted their productivity potential. This research was conducted using panel data analysis on all the EU member states (except for Luxembourg and Croatia). Besides that, the research also found a significant positive effect of health expenditure on productivity exhibited in the second and third years after the cost incurred.

The study conducted by Awotunde (2018) evaluates the role of capital accumulation on labour productivity growth in Nigeria which highlighted health and education expenditure as the independent variables by applying the endogenous growth model and efficiency theory in Nigeria for a time frame of

1970 to 2014 using ordinary least square method of estimation. The study found that an increased allocation of health expenditure by the government increases the level of labour productivity growth while the impact of an increased share of education expenditure varies across time.

2.3.2.5 Trade Openess and Labour Productivity

Miller and Upadhyaya (2000) defined that, trade openness means increasing exports to GDP, and improving terms of trade while lowering the real value of domestic currency which generally will bring benefits to total factor productivity. The result was proven by running an analysis on 498 observations consisting of 83 countries by using panel data from the period of 1960 to 1989. Rodrigues and Rodrik (2001) concluded that future research should thread their analysis cautiously when interpreting the effect of trade openness on economic growth as there is a high tendency to overstate the systematic evidence in favour of trade openness has had a substantial influence on policy around the world. The main concern from this study is that some studies will overstate the positive expectation of trade openness that is unlikely to be met, which may force out other institutional reforms that could potentially provide greater benefits to the nation as a nation's administrative capacity and political capital are often scarce. Thus, having a clear sense of policy priorities is of the utmost importance. Then Ismail, Rosa and Sulaiman (2011) conducted research to estimate the labour productivity in Malaysia by employing several models such as pooled least square model, fixed effect model and one or two-way random effect models with time-series data. The studies enclosed 24 observations by time series from 1895 to 2008 for 6 sub-industries, making a total of 144 panel data observations. Several independent variables such as the number of workers, economic openness, technology, foreign direct investment (FDI), foreign workers, dummy capital–intensive industry, and dummy FDI interaction with capital intensive – industry as well as dummy time are used. The finding found that an increase in the number of local workers and FDI leads to decreases in labour productivity. The entry of foreign investors along with their cutting-edge technologies as well as expertise has lowered labour productivity in the manufacturing sector in Malaysia as there is a wide gap between local and foreign firms. This leads to a negative relationship between economic openness and labour productivity. The researchers further explain that there are too many abroad semi-skilled workers that control the technology which limits the local's capability to absorb these new technologies technique. Hence, it is recommended that the government promotes human capital investment, through more quality education and training opportunities so that more locals can learn to manoeuvre these new technologies as this technology is vital to increase production as well as labour productivity.

Another study done in India by Bal et al. (2016) prompted that trade openness is another form of capital formation for India. When the country opens up its economy to foreign investors, it has a multiplier effect of rising investment which increases investment and employment in the long run.

2.4 Literature Gap

Overall, T2DM is a major issue in Malaysian which should be given more attention. It is impacting on various factors including factors such as employee productivity. This implies that in order to overcome the co sequences of T2DM, it is pivotal However, despite the existence of useful theoretical frameworks, no major attempts have been made in Malaysia to empirically examine the socioeconomics determinants of T2DM in Malaysia by using health production functions derived empirically in a comprehensive manner. Studies at the household level which is focusing on one specific small study area in Malaysia are almost widely available in the literature databases. However, there are limited studies attempted at the macro level; at least to the author's best knowledge. Hence, the author adopted macro-level research that is commonly used by researchers from overseas in Malaysia. Due to extensive studies conducted overseas, it is concluded that lifestyle factors and socioeconomic status are important determinants of mortality and have a considerable larger marginal impact on death rates than medical utilization. The health care system is a large field where it is not restricted to medical care only. To maintain and enhance the population's health status, socioeconomics and lifestyle factors that caused diseases as well as shorten an individual's life expectancy should be given more credit and utilise when developing a health care policy. However, these factors have been ignored in the current literature in the Malaysian context which signifies the need to conduct the latest studies to assess the impact of social determinants on T2DM. These factors should be studies extensively since they are directly impacting the exacerbation of T2DM in Malaysian context.

Labour productivity is an economic growth measurement and it is undeniable that the younger generation will be the future leader of the country. With regard to the economics associated with T2DM, most studies in the Malaysian context focus on only the cost burden of the disease. However, these studies do not take labour productivity of the people into account despite the fact that it is highly important for Malaysian economic growth. The role of health capital that contributes to invigorating efficiency and economic development has been recognised for quite some time, yet, to our best of cognition, studies that incorporate health is still lacklustre, as most of the studies on human capital only use education and skills as proxies. Labour productivity is an economic growth measurement and it is undeniable that the younger generation will be the future leader of the country someday. Ironically, researchers in Malaysia realize the importance of health in driving the countries country's economy; however, only a few studies have ventured into the household or companies company level and least focus on the macro level without realising the importance of macro-level research contribution to the nation's policy development. This implies that studies should increase their focus on exploring the exact relation between labour productivity and T2DM in Malaysia. This leaves a significant research gap pertaining to the impact of T2DM on labour productivity which this study intends to fill.

CHAPTER 3

RESEARCH AND METHODOLOGY

3.1 Introduction

The objective of this chapter is to unfold the methodology that is employed in this study. It contains the theoretical literature and frameworks used, including the model specification based on the Autoregressive Distributed Lag (ARDL) approach to achieving all the objectives of the study. There are also sub-sections that explain the estimation procedure, and definition, measurement and source of each variable used in the study.

3.2 Theoretical Framework

This sub-section further explore the theoretical literature that was earlier highlighted (refer to section 2.2 and 2.3). The first part of the theoretical literature discusses Health Demand Theory and the second part explores more on Endogenous Growth Theory in accordance with two different objectives in this study.

3.2.1 Health Demand Theory

Health Demand Theory developed by Grossman (1972) described the demand for health and health care at a micro or household level, however, this study looked at the demand for health from a macro perspective. Though, a few adjustments to Grossman's initial model have been initiated in several studies from Auster et al. (1969), Silver (1972) to Hadley (1982) in the early days of research. Then the modified model has further examined some studies (Thornton, 2002; Nixon & Ulmann, 2006; Arthur & Oaikhenan, 2017; Rahman, Khanam & Rahman, 2018) to determine the existence of new evidence that can support the impact of medical care, socioeconomics, lifestyle and environmental factors on population health status that promoted nation's health in the current era.

Grossman's (1972) health production function is specified below:

$$H = F(X) \qquad \textbf{Equation 3.1}$$

where *H* is a measure of individual health output and *X* is a vector of individual inputs to the health production function *F*. The elements of the vector include medical care utilisation, nutrient intake, income, consumption of public goods, education, time devoted to health-related procedures, initial individual endowments like genetic makeup and community endowments such as the environment. (Marmot and Wilkinson, 2000; Case, 2000; Bobak et al, 2000; Thornton, 2002; Fayissa & Gutema, 2005; Fayissa & Traian, 2013; Arthur & Oaikhenan, 2017; Rahman, Khanam & Rahman, 2018).

This theoretical model (Equation 3.1) was designed for the analysis of health production at a micro level. Therefore, to transform the model to macro-level analysis without losing the theoretical background, this research adopted a model from Thornton (2002), Fayissa and Gutema (2005) as well as Fayissa and Traian (2013). Hence, the initial elements of vector X were represented by per capita variables and regrouped into sub-sectoral vectors of economics, social and environmental factors as follows:

$$h = F(Y, S, E) \qquad \textbf{Equation 3.2}$$

where *Y* is a vector of per capita economic variables reflecting the joint effect of social and economic factors, *S* is a vector of per capita social variables, and *E* is a vector of per capita environmental factors. In its scalar form, Equation 3.2 can be rewritten as such:

$$\boldsymbol{h = f\ (y_1, y_2, \dots, y_n, s_1, s_2, \dots, s_m, e_1, e_2, \dots, e_g)} \qquad \textbf{Equation 3.3}$$

where *h* is an individual's health status proxied by the diabetes death rate per 100,000 population (Zahra et al., 2015; Fayissa and Traian, 2013). We further disintegrate Equation 3.3 as represented below according to their vectors, while, *n*, *m*, and *g* represent the number of variables in each sub-group respectively.

$$Y = (y_1, y_2, \dots, y_n) \qquad \textbf{Equation 3.4}$$

$$S = (s_1, s_2, \dots, s_m) \qquad \textbf{Equation 3.5}$$

$$E = (e_1, e_2, \dots, e_g) \qquad \textbf{Equation 3.6}$$

Using the Cobb-Douglas production function, we further transform Equations 3.3, 3.4, 3.5, and 3.6 into as follow:

$$h = \Omega \prod y_i^{\eta i} \prod s_j^{\beta j} \prod y_i^{\gamma k} \qquad \textbf{Equation 3.7}$$

where *ηi*, *βj*, and *γk* are elasticities.

From Equation 3.7, Ω estimates the initial health stock as pointed out by Grossman (1972). It is an observed health status measurement, given that there are no health depreciation or health improvement due to changes in socioeconomic and environmental factors used in the production system. Similarly, $\prod y_i^{\eta i} \prod s_j^{\beta j} \prod y_i^{\gamma k} - 1) \times 100\%$ is the estimation of the percentage change in health status due to socioeconomic and environmental factors. According to Behrman and Deolalikar (1988), selecting an appropriate range of input in the empirical analysis should be priorities and not just those that are identified with public health measures or curative medicine in advanced countries. Besides that, due to limited sufficient quality data on the necessary variables, variables for the empirical analysis in this research are limited. The variables representing economic factors are limited to GDP per capita (y_1) and health expenditure per capita (y_2); variables representing social factors are limited to education (s_1), a lifestyle that is characterised by a Prevalence of BMI≥30kg/m^2 (s_2); and a variable representing environmental factors is urbanisation (e_1).

Taking the logarithm of Equation 3.7 and rearranging the equation yields the following linear aggregate health production function:

$$lnh = \alpha_0 + \sum \eta_i (lny_i) + \sum \beta_j \left(lns_j\right) + \sum \gamma_k (lne_k) + \epsilon \qquad \textbf{Equation 3.8}$$

where, i = 1,2; j = 1,2; k = 1; y denotes the income vectors; s is a vector of socioeconomic variables; e is a vector of environmental variables and lastly, ϵ is the classical error term.

The parameters in Equation 3.8 were used to obtain an empirical model for an econometric estimate in the following section. The results determined the relative importance and significance of the factors used in the health production function of diabetes death rate according to gender in the region.

3.2.2 Endogenous Growth Theory

Labour productivity refers to "the total volume of output (measured in terms of Gross Domestic Product, GDP) produced per unit of labour (measured in terms of the number of employed persons) during a given time reference period" (ILO, 2020). Bloom and Canning (2000) indicated that there are several channels where health could affect productivity. The four specific mechanisms are the direct impact of health capital on labour quality, the impact of health capital on education, health capital incentive for savings and capital investment as well as health capital demographics effects.

Accordingly, the present study adopts the most commonly used methods to calculate labour productivity which was utilized in Hassan, Norashidah and Nor

(2016). The study adopted the augmented Solow model, (Cobb-Douglass production function) to estimate the impact of healthcare expenditure and infectious diseases on labour productivity which is in line with studies from Bhargava et al. (2001), Hicks (1979), Wheeler (1980), Barror and Sala-I-Martin (1991), Romer (1990) and Lucas (1998). This endogenous growth theory undertakes the function of the stock of labour, capital and human capital in the form of a stock of health and level of education as the output. Therefore, to achieve the objective of this study which is to investigate the impact of T2DM on labour productivity, this study adapted the endogenous (augmented Solow) model in the form of:

$$Y = AK^{\propto}(hL)^{\beta} \qquad \textbf{Equation 3.9}$$

where *Y* = Output level; *K* = total physical capital stock; *L* = total number of workers; *h* = human capital in each unit of the labour force, which implies that the total quantity of human capital is equivalent to human capital per person *h* multiples the total labour force *L* (assuming all labour is identical); *A* = Level of Total Factor Productivity; *α* = Elasticity of capital input to output; and *β* = Elasticity of labour input to output.

To transform the equation into a natural logarithm, an error term is first added;

$$Y = AK^{\alpha}(hL)^{\beta} + \epsilon \qquad \textbf{Equation 3.10}$$

To express Equation 3.10 in the natural logarithm, and at the same time augment the model to incorporate other control or relevant variables to this study. Hence, the empirical estimation is stated as follows:

$$lnY_t = \alpha_0 + \alpha_1 lnK_t + \alpha_2 lnh_t + \alpha_3 lnL_t + \alpha_4 ln\delta Z_t + \epsilon_t \qquad \textbf{Equation 3.11}$$

where *Y* is the output level representing the productivity per worker which is the dependent variable for the equation that analyses the impact of T2DM and labour productivity; *K* is the vector of total physical capital stock; *h* is the vector of human capital proxied by education; *L* is the vector of labour supply; *δZ* is the vector of parameters of other control variables. α_0 is a constant term whilst, α_1, α_2, α_3, α_4 are the explanatory variable coefficients. The letter *t* represents a vector of the time, while the ϵ is the error term.

3.3 Model Specification

This sub-section demonstrates the model specification for two different objectives. The first model specification is to investigate the determinants of T2DM according to gender, while the second model specification is to determine the impact of T2DM on labour productivity. To assess both objectives, this studying employed Autoregressive Distributed Lag (ARDL) approach on annual time series from 1990 to 2019 in Malaysia. A series of tests was further elaborated in the latter part of this chapter. Meanwhile, the specification for each of the objectives is presented separately as shown below.

3.3.1 Estimation Model: Determinants of Type 2 Diabetes Mellitus (Male)

To achieve the first objective which is to investigate the determinants of T2DM according to gender by using the relevant variable discussed in sub-section 3.2.1, two separate estimation model is developed to cater to male and female investigation in this study. Hence, by using the above framework from Equation 8 and following Fayissa and Traian, (2013); Zahra et al., (2015), the general male empirical estimation model can now be written as:

$$DRM_t = \alpha_0 + \alpha_1 GDPC_t + \alpha_2 HEXPC_t + \alpha_3 PM_t + \alpha_4 BMIM_t + \alpha_5 URB_t + \epsilon$$ **Equation 3.12**

The Equation 3.12 will transform by applying natural log (*ln*). The reason behind this is that it will help in alleviating the skewness in the data resulting in a log-normal distribution. Eventually, it will help increase the validity of the results. Therefore, log-transformed model is provided in Equation 3.13.

$$lnDRM_t = \alpha_0 + \alpha_1 lnGDPC_t + \alpha_2 lnHEXPC_t + \alpha_3 lnPM_t + \alpha_4 lnBMIM_t + \alpha_5 lnURB_t + \epsilon$$ **Equation 3.13**

where, α_0 is the constant term, while other α_s are the coefficient of the parameters to be estimated. The error term is captured by ϵ and is assumed to be normally distributed with zero mean and constant variance while *t* represents the time trend. *lnDRM* is a male individual's health status proxied by diabetes death rate per 100,000 male population. Economics variables are proxied by *lnGDPC* and *lnHEXPC*. *lnGDPC* represents Gross Domestic Product (GDP) per capita (constant 2010 USD) and *lnHEXPC* represents health expenditures per capita. Next, *lnPM* and *lnBMIM* are male completion rate of primary education and Male Prevalence of BMI≥30kg/m^2 respectively which stands for social variables. Lastly, *lnURB* is urban population stands for environmental variables.

3.3.2 Estimation Model: Determinants of Type 2 Diabetes Mellitus (Female)

Next, the framework from Equation 8 was also used to assess the determinants of T2DM in the female population following Fayissa and Traian (2013); Zahra et al. (2015), which can be written as follows:

$$DRF_t = \alpha_0 + \eta GDPC_t + \eta HEXPC_t + \beta PF_t + \beta BMIF_t + \gamma URB_t + \epsilon_t \quad \textbf{Equation 3.14}$$

The Equation 3.14 will transform by applying natural log (*ln*). Again, the reason behind is same that it will help in alleviating the skewness in the data resulting in a log-normal distribution. Eventually, it will help increase the validity of the results. Therefore, log-transformed model is provided in Equation 3.15.

$$lnDRM_t = \alpha_0 + \alpha_1 lnGDPC_t + \alpha_2 lnHEXPC_t + \alpha_3 lnPM_t + \alpha_4 lnBMIM_t + \alpha_5 lnURB_t + \epsilon \quad \textbf{Equation 3.15}$$

where, α_0 is the constant term and ϵ_t is the error term which is also assumed to be normally distributed with zero mean and constant variance, while *t* refers to the time trend. η, β and γ are another set of parameters' coefficients to be estimated. *lnGDPC*, *lnHEXPC* and *lnURB* parameters in the female equation are the same as the parameters in the male equation (Equation 3.15). On the other hand, *lnDRF* represents the diabetes death rate per 100,000 female population and is the proxy of female's health status, *lnPF* refers to female primary school completion rate and *lnBMIF* stands for Female Prevalence of BMI≥30kg/m^2.

In the models for objective 1, it can be seen that all variables are similar except BMI and education which are different. Economics male/female related variables such as wages are generally not used in such studies mainly because they vary significantly across the two genders depending upon the sector in which the individual is working.

3.3.3 Estimation Model: The Impact of Type 2 Diabetes Mellitus on Labour Productivity

Labour productivity is used as the dependent variable to investigate the impact of labour productivity determinants such as physical capital stocks, human capital level and labour as specified by Hall and Jones (1999) and Hassan, Norashidah and Nor (2016). The equation for the empirical estimation can now be written as:

$$lnLP_t = \alpha_0 + \alpha_3 lnID_t + \alpha_1 lnCP_t + \alpha_2 lnEDUC_t + \alpha_4 lnPG_t + \alpha_5 lnHEXPC_t + \alpha_6 lnOPN_t + \epsilon_t \quad \textbf{Equation 3.16}$$

where *lnLP* is the labour productivity, *lnCP* is the gross capital formation representing physical capital, *lnEDUC* is the share of the population that has completed primary, secondary and bachelor's degree and *lnID* is the recorded number of new cases in the population, respectively. *lnID* is the main variable that represents T2DM as it shows the prevalence of T2DM in the form of the number of cases of T2DM. Labour is a proxy by *lnPG* which is population growth. *lnHEXPC* is health expenditure per capita and *lnOPN* is trade openness. These two variables are also control variables. α_0 is a constant term, while α_1, α_2, α_3, α_4, α_5, and α_6 are the coefficient of the explanatory variables that are to be estimated. ϵ_t is the error term assumed to be normally distributed with zero mean and constant variance, t is the time trend.

3.4 Method of Estimation

This section discusses the methodology that was used to estimate the empirical model as specified in Equations 3.12, 3.13, and 3.14 for two different objectives as stated. An ARDL approach is applied to time series data to estimate the bound test as well as the long-run relationship and short-run relationship between the dependent and independent variables of an equation.

Even though there are alternative approaches such as studies from Johansen and Juselius (1990) and the conventional Johansen (1998) cointegration test, this study chose to use the ARDL approach for cointegration due to some advantages. Firstly, irrespective of whether the variables are purely **I**(0), purely **I**(1) or mixed, the ARDL approach is applicable (Sulaiman and Abdul-Rahim, 2014). Secondly, ARDL is possible for different variables to have different lags, but it is impossible with the standard cointegration test. Besides that, long-run and short-run coefficients can be obtained simultaneously with ARDL (Chindo et al., 2015 and Emran, SHilip and Alam 2007). Finally, with Narayan (2005) set of critical values, ARDL is applicable for studies that have limited sample data, which is within a range of 30 to 80 observations.

Before conducting a bound test, a unit root test was carried out to determine the order of integration for each variable. Lastly, to complete the estimation process, an assessment of the reliability as well as efficiency of the estimates was conducted using various diagnostic test.

3.4.1 Stationary Test

Since this study employs ARDL cointegration approaches to investigate the long-run relationship between variables in a time series analysis, a stationary test is needed to examine the variable's integration order. Pesaran, Shin and Smith (2001) stated that short sample size with a combination of purely **I**(0), **I**(1) or mixed series are suitable for ARDL cointegration. Firstly, a unit root test consisting of augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) is conducted to check for variables stationarity, besides ensuring none of the series is **I**(2). The ADF model is as follows:

$$\Delta Y_t = \beta_0 + \varphi Y_{t-1} + \sum_{i-1}^{k} \beta i \Delta Y_{t-i} + \mu_t \quad \text{(Intercept only)} \quad \textbf{Equation 3.17}$$

$$\Delta Y_t = \beta_0 + \beta_1 T + \varphi Y_{t-1} + \sum_{i-1}^{k} \beta i \Delta Y_{t-i} + \mu_t \quad \text{(Intercept and Trend)} \quad \textbf{Equation 3.18}$$

The parameter of interest in the ADF model is φ and the hypothesis statement shown as follows:

$H_0 : \varphi = 0$ (Not stationary)

$H_0 : \varphi \neq 0$ (Stationary)

3.4.2 Cointegration

After conducting a stationary test to identify the order of integration of the variables, the study proceeds to perform a bounds test to test for a long-run relationship among variables. Before the estimation, optimum lag lengths were selected based on the After conducting a stationary test to identify the order of integration of the variables, the study proceeds to perform a bounds test to test for a long-run relationship among variables. To test the long-run cointegration relationship among the variables, the following hypotheses are as stated:

$H_0 : \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0$ (Not cointegration)

$H_0 : \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq 0$ (Cointegration exists)

When the computed F-statistics exceed the upper bound critical value provided by Narayan (2005), the null hypothesis is rejected and it's safe to conclude the existence of a cointegration relationship between variables. Having said that, if the computed F-statistics fall below the lower bound, the null hypothesis cannot be rejected which suggests that there is no long-run relationship between the variables (no cointegration). However, if the case of computed F-statistics falls in between the lower and upper bound critical values, the result of the bound test is said to be inconclusive.

Having identified the existence of a cointegration relationship between variables, the study can proceed to estimate the short-run and error correction coefficients. Thomas (1997) highlighted the importance of the ARDL-ECM model whereby, a robust and dynamic method is needed to successfully reduce multicollinearity cases while increasing the reliability and stability of t-ratios in testing for statistical significance. Therefore, following Pesaran et al. (2001) general model, the ARDL model for determinants of T2DM and its impact on labour productivity (two separate objectives of study) can be specified as follows:

i. ARDL model for Determinants of Type 2 Diabetes Mellitus (Male)

$$\Delta lnDRM_t = \alpha_0 + \alpha_1 lnDRM_{t-1} + \alpha_2 lnGDPC_{t-1} + \alpha_3 lnHEXPC_{t-1} + \alpha_4 lnPM_{t-1} + \alpha_5 lnBMIM_{t-1} + \alpha_6 lnURB_{t-1} + \sum_{t=1}^{p} \theta_1 \Delta lnDRM_{t-i} + \sum_{i=0}^{p} \theta_2 \Delta lnGDPC_{t-i} + \sum_{i=0}^{p} \theta_3 \Delta lnHEXPC_{t-i} + \sum_{i=0}^{p} \theta_4 \Delta lnPM_{t-i} + \sum_{i=0}^{p} \theta_5 \Delta lnBMIM_{t-i} + \sum_{i=0}^{p} \theta_6 \Delta lnURB_{t-i} + \epsilon_t$$

where, α_1 to α_4 are the long-run parameter and θ_1 to θ_4 are the short-run parameters, while ϵ_t is the error term as well as denoting the lag length of the autoregressive process *t* is the time trend for the ARDL model (Male Determinants of T2DM).

ii. ARDL model for Determinants of Type 2 Diabetes Mellitus (Female)

$$\Delta lnDRF_t = \beta_0 + \beta_1 lnDRF_{t-1} + \beta_2 lnGDPC_{t-1} + \beta_3 lnHEXPC_{t-1} + \beta_4 lnPF_{t-1} + \beta_5 lnBMIF_{t-1} + \beta_6 lnURB_{t-1} + \sum_{t=1}^{p} \delta_1 \Delta lnDRF_{t-i} + \sum_{i=0}^{p} \delta_2 \Delta lnGDPC_{t-i} + \sum_{i=0}^{p} \delta_3 \Delta lnHEXPC_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta lnPF_{t-i} + \sum_{i=0}^{p} \delta_5 \Delta lnBMIF_{t-i} + \sum_{i=0}^{p} \delta_6 \Delta lnURB_{t-i} + \epsilon_t$$

where, β_1 to β_4 are the long-run parameter and δ_1 to δ_4 are the short-run parameters, while ϵ_t is the error term as well as denoting the lag length of the autoregressive process t is the time trend for the ARDL model (Female Determinants of T2DM).

iii. ARDL model for The Impact of Type 2 Diabetes Mellitus on Labour Productivity

$$\Delta lnLP_t = \gamma_0 + \gamma_1 lnLP_{t-1} + \gamma_2 lnCP_{t-1} + \gamma_3\, lnEDUC_{t-1} + \gamma_4 lnID_{t-1} + \gamma_5 lnPG_{t-1} + \gamma_6 lnHEXPC_{t-1} + \gamma_7 lnOPN_{t-1} + \sum_{t=1}^{p} \emptyset_1 \Delta lnLP_{t-i} + \sum_{i=0}^{p} \emptyset_2 \Delta lnCP_{t-i} + \sum_{i=0}^{p} \emptyset_4 \Delta lnID_{t-i} + \sum_{i=0}^{p} \emptyset_5 \Delta lnPG_{t-i} + \sum_{i=0}^{p} \emptyset_6 \Delta lnHEXPC_{t-i} + \sum_{i=0}^{p} \emptyset_7 \Delta lnOPN_{t-i} + \epsilon_t$$

where, γ_1 to γ_4 are the long-run parameter and $\emptyset_1$ to $\emptyset_4$ are the short-run parameters, while ϵ_t is the error term as well as denoting the lag length of the autoregressive process t is the time trend for the ARDL model (Impact of T2DM on Labour Productivity).

3.4.3 Diagnostic Tests

Like any other time series analysis, a diagnostic test is vital to assessing the validity, efficiency and reliability of the estimated model. The estimated model is deemed to be reliable if the model passes the major diagnostic tests. Contradictory, if the models fail to pass the diagnostic tests, then the deduced inference is voided.

For this study, two types of major diagnostic tests were conducted. The first is Residual Diagnostic. Under Residual Diagnostic, three (3) types of the test were conducted which are:

i. Jarque – Bera Normality Test
ii. Breusch – Godfrey Serial Correlation LM Test
iii. Heteroskedasticity Test

All the above requires the p-value to be greater than 1%, 5% or 10% significance level to pass the test to avoid non-normal error by using J-B Normality Test, serial correlations by using B-G LM Test and heteroscedasticity by using Heteroskedasticity Test (BPG).

The second is Stability Diagnostic. Under Stability Diagnostic, two (2) types of the test were conducted which are:

i. Ramsey RESET test
ii. Cumulative sum of recursive residuals (CUSUM) Test
iii. Cumulative sum of square of recursive residuals (CUSUMSQ) Test

Likewise, the estimated model needs to have a p-value to be greater than 1%, 5% or 10% significance level to pass the test to avoid functional-form misspecifications by using Ramsey RESET Test. Based on Pesaran, Shin and Smith (2001) recommendation, CUSUM and CUSUMSQ Test is needed for the stability test. The model is deemed to be stable along the sampled period, given that all the residuals are within the dotted lines of critical bounds at a 5% significance level.

3.5 Definition of Variables

Table 3.1 presents the list of variables that were used in this study as defined by the World Health Organization (WHO) and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Table 3.1 : Definition of Variables

Variables	Abbreviation	Definition
Male Death Rate	MDR	Male deaths per 100,000 population for T2DM
Female Death Rate	FDR	Female deaths per 100,000 population for T2DM
Labour Productivity	LP	It measures output per worker in the economy during a given time reference period
Gross Domestic Product (GDP) per capita	GPDC	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or depletion and degradation of natural resources. Data are in constant 2010 USD.
Health Expenditure per capita	HEXPC	Total Health Spending per Person (constant 2019 U.S. dollars)
Gross Capital Formation	CP	Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.
Trade Openness	OPN	The sum of exports and imports of goods and services is measured as a share of GDP.
Population Growth	PG	The annual population growth rate for year t is the exponential rate of growth of the midyear population from year t-1 to t, expressed as a percentage. The population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.
Urbanization	URB	Refers to people living in urban areas as defined by national statistical offices.
Education	EDUC	Share of the population by education (primary, secondary and bachelor) attainment for both sexes.
Male Primary School Level Attainment	PM	Share of the population by education attainment for male

Table 3.1 : Continued

Variables	Abbreviation	Definition
Female Primary School Level Attainment	PF	Share of the population by education attainment for female
Male Prevalence of Body Mass Index (BMI) $\geq$30kg/m^2	BMIM	Defined as a person's weight in kilograms divided by the square of the individual's height in meters (kg/m^2). An individual is considered obese if the Body Mass Index (BMI) is greater than or equal to 30 kg/m^2.
Female Prevalence of BMI$\geq$30kg/m^2	BMIF	Defined as a person's weight in kilograms divided by the square of the individual's height in meters (kg/m^2). An individual is considered obese if the Body Mass Index (BMI) is greater than or equal to 30 kg/m^2.
Incidence of Type 2 Diabetes Mellitus (T2DM)	ID	Number of new T2DM cases in the population in the particular year

3.6 Variables, Measurement and Data Sources

This section contains the measurement, abbreviation and data sources for all the data used in this study as tabulated in Table 3.2.

Table 3.2 : List of Variables

Variables	Measurement Units	Abbreviation	Data Sources
Male Death Rate	Death per 100,000 population	DRM	Institute for Health Metric and Evaluation, IHME (2017)
Female Death Rate	Death per 100,000 population	DRF	Institute for Health Metric and Evaluation, IHME (2017)
Labour Productivity	Output per worker (Constant 2010 USD)	LP	International Labour Productivity, ILO (2020)
Gross Domestic Product (GDP) per capita	Constant 2010 USD	GDPC	World Bank (2020)
Health Expenditure per capita	Constant 2019 US dollar	HEXPC	Institute for Health Metric and Evaluation, IHME (2017)
Gross Capital Formation	Percentage of GDP	CP	World Bank (2020)
Trade Openness	Percentage of GDP	OPN	World Bank (2020)

Table 3.2 : Continued

Variables	Measurement Units	Abbreviation	Data Sources
Population Growth	Percentage of annual population growth rate	PG	World Bank (2020)
Urbanization	Percentage of the total population	URB	World Bank (2020)
Education	Share of the total population by educational attainment	EDUC	United Nations Educational, Scientific and Cultural Organization, UNESCO (2020)
Male Primary School Attainment	Share of the male population by educational attainment	PM	United Nations Educational, Scientific and Cultural Organization, UNESCO (2020)
Female Primary School Attainment	Share of the female population by educational attainment	PF	United Nations Educational, Scientific and Cultural Organization, UNESCO (2020)
Male Prevalence of Body Mass Index (BMI) ≥30kg/m2	Male age-standardized prevalence of obesity in percentage	BMIM	NCD Risk Factor Collaboration, NCD-Risk (2017)
Female Prevalence of BMI≥30kg/m2	Female age-standardized prevalence of obesity in percentage	BMIF	NCD Risk Factor Collaboration, NCD-Risc (2017)
Incidence of Type 2 Diabetes Mellitus (T2DM)	New cases per 100,000 population	ID	Institute for Health Metric and Evaluation, IHME (2017)

3.7 Description of Data Used in the Study and Their Expected Signs

This section further describes the characteristics of each variable used in the study. In general, Malaysia is the study area for this research and the year of study from 1990 to 2019 (30 years).

3.7.1 Variables of Determinants or T2DM according to Gender

i. Dependent Variable
   a. Death Rate (h)

The dependent variable is health proxied by the death rate of males and females according to the respective equation which indicates the number of deaths due to T2DM per 100,000 population (Zahra et al., 2015; Fayissa and Traian, 2013). The analysis is based on country-level data from Institute for Health Metric and Evaluation, IHME (2017) for Malaysia spanning from 1990 until 2019. To cater for two years of missing data which appears to be unavailable, a simple averaging method was used in filling the data. By taking an average of the previous four years' data, it was used to fill in the missing data gap. (Muchemwa, 2011). Mortality or life expectancy is more suitable for developing countries because apparently life expectancy gradient is steeper for low-level gross national income per capita while, life expectancy is no longer significant in high-income countries (Tompa, 2002).

Besides that, the mortality rate is used as the dependent variable instead of the prevalence of diabetes. This is because healthcare centre accessibility varies according to country, which means that countries were less access to care may have individuals with undiagnosed diabetes. This group of individuals is the people who may have not been to any healthcare centre for their diabetes treatment and are most likely to die from complications quicker. Therefore, by using mortality rate as the dependent variable, this research accounts for healthcare quality differences across countries that could affect diabetes prevalence (Siegel et al., 2012).

ii. Independent Variables

a. GDP per capita (y_1)

A higher level of income leads to the consumption of higher quality goods and services and better medical services which concluded positive results on health status. Fayissa and Gutema (2005) also stated that individuals had the general propensity to diverge from high-stress jobs that may affect an individual's health status, as their income grows. However, some research argues that, beyond some threshold, a level of affluence, even with increasing income, better health can no longer be bought. (Wilkinson, 1992; Fuschs, 1994; and Christiansen, 1994). Therefore, the expected GDP per capita sign is still ambiguous.

b. Health Expenditure per capita (y_2)

The sum of public and private expenditures on health is equal to total health expenditure. The total health expenditure as a percentage of gross domestic product in Malaysia is considered as low compared to neighbouring countries such as Singapore, the Philippines, China, Sri Lanka and Korea (Ministry of Health Malaysia, 2017). The effect of health expenditure is ambiguous, depending on an individual medical expenses' decision. If the medical expenses made do not detriment healthy living decisions, then it had a positive effect on health or vice versa (Fayisa and Gutema, 2005). The complete data set of Malaysia's total health expenditure (% of GDP); ranging from 1990 until 2019 was obtained from the World Bank (2020).

c. Primary School Attainment (s_1)

Primary school attainment is a proxy for a social variable. Better education is associated with better health (Al-Naggar et al. 2017). Therefore, the coefficient of education is expected to have a positive effect on the death rate. This implies that an increased share of the population who completed primary school education would result in a reduced mortality rate due to T2DM. The set of data obtained from UNESCO is incomplete; hence, the researcher also applied to interpolate method, by taking GDP per capita s the proxy to calculate the missing data (Noor et al., 2014).

d. Prevalence of Body Mass Index (BMI) ≥30kg/m^2 (s_2)

Obesity is thought to be a high-risk factor for metabolic syndrome and T2DM. According to WHO, individuals are classified under the obesity category when their BMI is greater than or equal to 30kg/m2. It has also been proven to have a great impact on health. National Health and Morbidity Survey (NHMS) 2019 stated that 30.4% of Malaysia are overweight and 19.7% are obese. Therefore, obesity is perceived to have a positive impact on the mortality rate. Malaysia obesity data was obtained from NCD Risk Factor Collaboration, NCD-Risc (2017). The missing data were filled in by taking an average from the previous four years' data.

e. Urban Population (e_1)

The urban population represents the percentage of the population living in urban areas and is obtained from the World Bank (2020). Urbanization is deemed to have a dual impact on health (Thornton, 2002). However, if the development of urban areas reflects stress or the level of pollution is high, then it would have a negative consequence on health. Thus, the expected sign of the urban population is ambiguous.

3.7.2 Variables of Impact of T2DM on Labour Productivity

i. Dependent Variable
   a. Labour Productivity (Y)

Chronic diseases such as heart disease, stroke and diabetes are responsible for a larger share of the foregone income of all deaths in the countries. From countries' perspective, chronic diseases reduce life expectancy and ultimately economic productivity, thus depleting the quality and quantity of countries' labour force. On the other hand, a healthier population would improve the human capital quality, which subsequently brings a greater positive impact on an individual's productivity by reducing incapacity, disability and workdays lost (Abegunde and Stanciole, 2006). The data is obtained from International Labour Organization's database, ILO (2020).

ii. Independent Variable
   a. Gross Capital Formation (K)

Ongo and Vukenkeng (2014) stated that capital accumulation is considered an important factor of economic growth where it contributes to the increase of production level. Therefore, the sign of the gross capital formation variable is expected to be positive. (Bal, Dash and Subhasish (2016); Singh and Trieu (1996). The full set of complete data is obtained from the database of Work Bank (2020).

b. Education

Human capital knowledge and skills that socially contribute to economic growth are generated by investing in education which encouraged inequality reduction, especially in developing countries. The increase in labour productivity due to high education investment in learning quality, technological advancement and awareness of human capital would bring tremendous economic progression (Cremin and Nakabugo, 2012). Hence, education is expected to have a positive relationship in regard to labour productivity. Education in this context is the summation of primary, secondary and bachelor's degree attainment which is showing an effect of economic improvement among emerging Asian countries (Nurul, Kasim and Roslinah, 2015). The set of data obtained from UNESCO is incomplete, hence, the researcher also applied to interpolation method, by taking GDP per capita as the proxy to calculate the missing data.

c. Incidence of Diabetes (h_2)

Pocas (2014) asserted that the health capital variable plays an important role in explaining the growth and convergence process, whereby, the improvement and maintenance of good health in most OECD countries has contributed to higher human accumulation, productivity and economic growth. Therefore, the burden of diseases or health issues does possess a negative effect on productivity, which is generally known to the public. However, there is still less attention paid to the health capital impact in Asian countries which are currently undergoing rapid industrialization growth. This study employed the incidence of T2DM as a parameter of human capital to assess its impact on labour productivity. The data is obtained from the Institute for Health Metric and Evaluation, IHME (2017) for the year 1990 until 2017. The missing data is filled by taking an average of four previous years' data.

d. Population Growth (L)

Saha (2013) confirmed a unidirectional relationship between health and total factor productivity, which implied a positive good health effect on total factor productivity. For the labour force to increase their productivity, they must be healthy. Kumar and Kober (2012) justified that, access to good sanitation, better nutrition and health capital significantly affects total factor productivity through labour supply. The growth of a healthy labour supply enhanced the labour's ability to work for a longer period as well as reduce absenteeism from work, thus increasing labour productivity and at the same indirectly promoting economic growth. Therefore, the population growth variable is expected to have a positive sign. This set of data is obtained from World Bank (2020); spanning from 1990 to 2019.

e. Health Expenditure per capita (δZ)

Numerous studies have concluded a positive connection between health and growth. Grossman (1972) and Van Zon and Muysken (2001) pointed out that health capital is a form of human capital investment. Thus, an increase in health expenditure led to higher labour supply and better economic growth, which the author can safely conclude that, a positive expected sign between the relationship of health expenditure and labour productivity. Institute for Health Metric and Evaluation, IHME (2017) only provides a set of data ranging from 2000 – 2017. Hence, by using interpolate method and GDP per capita taken as the proxy, the missing data for the total health expenditure is calculated (Mohd, 2014).

f. Trade openness (δZ)

Trade openness was measured by taking the sum of exports and imports divided by GDP [(exports + imports) / GDP]. Export, Import and GDP data were taken from the World Bank (2020), whereby the year of study is ranging from 1990 to 2019. Trade openness led a country to further liberalise their trade with foreign countries which would bring substantial economic efficiency. (Bal et al. (2016); Miller and Upadhyaya (2000). Consequently, the expected sign of trade openness is positive.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and findings which include descriptive statistics, regression analysis and diagnostic tests based on the method described in the previous chapter. The chapter is divided into three sub-sections. The first sub-section consists of descriptive statistics for all variables used in this study. This sub-section will be describing the mean, standard deviation, minimum (min) and maximum (max) value, the number of observations (Obs.), skewness as well as kurtosis. The second sub-section will record the finding of the first sub-objectives which is to determine the social determinants of Type 2 Diabetes Mellitus (T2DM) according to gender in Malaysia. This sub-section will also show several tests result that were conducted. The structure of the third sub-section of this study is the same as the second section, however, third sub-section will be focusing on the second objective which is to determine the impact of T2DM on labour productivity in Malaysia.

4.2 Descriptive Statistics

This sub-section will cover the descriptive statistics of Objectives 1 and 2 variables in this study. Table 4.1 described the data used in the estimation of the relationship between two sub-objectives. The first is an estimation of the relationship in terms of the T2DM Death Rate with economic, social and environmental variables. The second is an estimation of the relationship in terms of labour productivity to physical capital, human capital and labour variables.

Table 4.1 : Descriptive Statistics of the First Objective

Variables	Mean	Standard Deviation	Min	Max	Obs.	Skewness	Kurtosis
DRM	5.358	1.354	3.197	7.258	30	0.303	1.546
GDPC	8148.256	2213.027	4536.967	12478.21	30	0.328	2.169
HEXPC	231.306	118.557	69.950	495.402	30	0.625	2.379
BMIM	0.003	0.002	0.0002	0.008	30	0.587	1.863
PM	25.148	2.908	19.791	38.662	30	3.248	17.121
URB	65.008	8.318	49.794	76.794	30	-0.341	1.883
DRF	6.551	1.547	4.165	9.753	30	0.005	1.946

Table 4.1 : Continued

Variables	Mean	Standard Deviation	Min	Max	Obs.	Skewness	Kurtosis
BMIF	0.122	0.043	0.056	0.186	30	0.019	1.620
PF	23.329	2.660	19.044	32.921	30	1.448	6.827
ID	77582.95	20074.25	42669.93	101904.3	30	-0.525	1.804
GCF	27.915	7.437	17.836	43.639	30	1.035	2.648
OPN	1.711	0.303	1.231	2.204	30	0.011	83.251
PG	2.001	0.494	1.327	2.817	30	0.049	1.607
EDUC	30.919	20.735	5.682	83.251	30	1.022	3.309

(Source: EViews10 computation. DRM= Death Rate for Male; DRF= Death Rate for Female, GDPC= GDP per capita; HEXPC=Health Expenditure per capita; BMIM= Prevalence of BMI≥30kg/m2 (Male); PM=Primary School Level Attainment (Male); URB= Urban Population; BMIF= Prevalence of BMI≥30kg/m2 (Female); PF=Primary School Level Attainment (Female); GCF=Gross Capital Formation; OPN=Trade Openness; PG=Population Growth; EDUC= Educational Level Attainment (Primary, Secondary and Bachelors)

Fifteen (15) variables with annual data for Malaysia over a period of 30 years are used. The statistics show that data for all variables are complete. According to the minimum and maximum, all the data are in the positive range. Out of the Fifteen (15) variables, only two (2) variables are negatively skewed. The two (2) are Urban Population (URB) and Incidence of T2DM (ID). It is also observed that the incidence of T2DM has the highest volatility recorded judging by the highest recorded standard deviation.

Table 4.2 : Descriptive Statistics of the Second Objective

Variables	Mean	Standard Deviation	Min	Max	Obs.	Skewness	Kurtosis
LP	19331.82	3706.144	12788.61	26341.31	30	0.042	2.189
ID	77582.95	20074.25	42669.93	101904.3	30	-0.525	1.804

(Source: EViews10 computation.LP=Labour Productivity, ID=Incidence of T2DM)

4.3 Unit Root Test

The unit root test results in Table 4.3 shows that respective variables can be assumed to be stationary, given that they are stationary at either level or first difference.

The death rate for both Males and Females (DRM and DRF), Male Obesity (BMIM), Male Primary School Attainment (PM), Urban Population (URB), Female Primary School Attainment (PF) and Population Growth (PG), is considered to be I(0) stationary at level. The remaining variables- Gross Domestic Product per Capita (GDPC); Health Expenditure per Capita (HEXPC); Female Obesity (BMIF); Labour Productivity (LP); Incidence of Diabetes (ID); Gross Capital Formation (GCF); Openness (OPN) and Education (EDUC) are all stationary at I(1). Pesaran et al. (2001), developed an ARDL Bound Test which needed justification from the stationary test result. All the variables listed above are used in 3 different models which are to investigate the determinants of T2DM according to gender and another model on T2DM impact on labour productivity in Malaysia.

Table 4.3 : Unit Root Test for First Objective

	ADF		PP	
Variable	**Constant**	**Constant & Trend**	**Constant**	**Constant & Trend**
		Level I(0)		
DRM	-1.398***	-3.449***	-1.240	-1.745
GDPC	5.977	-0.613	0.778	-1.029
HEXPC	-4.439	2.351	5.713	3.736
BMIM	-3.955***	0.987	0.793	-1.967
PM	-4.776***	-5.065***	-4.733***	-5.065***
URB	-9.736***	-2.622	-7.066***	0.490
DRF	-1.545**	-4.92***	-1.911	-2.145
BMIF	-0.848	-2.024	-0.785	-1.388
PF	-4.398***	-5.375***	-4.382***	-5.376***
LP	-0.158	-2.311	0.055	-2.411
ID	-1.545	-1.109	-1.749	-0.982
GCF	-1.339	-2.072	-1.344	-2.977
OPN	-0.408	-1.898	-0.599	-2.064
PG	-4.155***	-3.304	-0.967	-2.064
EDUC	2.628	0.856	1.555	-2.262

Table 4.3 : Continued

	ADF		PP	
Variable	**Constant**	**Constant & Trend**	**Constant**	**Constant & Trend**
		First Difference I(1)		
DRM	-2.191	-2.144	-2.199	-2.152
GDPC	-5.021***	-4.182**	-5.021***	-5.133***
HEXPC	0.091	-3.011	-3.445**	-4.722***
BMIM	0.462	-2.442	-4.513***	-4.670***
PM	-8.759***	-8.589***	-26.543***	-26.029***
URB	-0.723	-7.893***	-0.903	-7.142***
DRF	-2.354	-2.285	-2.329	-2.268
BMIF	-4.157***	-4.198***	-4.139***	-4.176***
PF	-8.901***	-4.876***	-27.679***	-27.863***
GCF	-5.537***	-5.436***	-5.560***	-5.462***
OPN	-2.615	-3.382***	-4.017***	-5.515***
PG	-0.741	1.937	-2.506	-2.448
EDUC	-7.488***	-4.387***	-8.031***	-11.854***

Notes: SIC is used to determine the lag length while testing the stationary of all variables. ***, ** and * indicate rejection of the null hypothesis of non-stationary at 1%, 5% and 10% significance level, respectively.

Table 4.4 : Unit Root Test for the Second Objective

	ADF		PP	
		Level I(0)		
Variable	**Constant**	**Constant & Trend**	**Constant**	**Constant & Trend**
LP	-0.158	-2.311	0.055	-2.411
ID	-1.545	-1.109	-1.749	-0.982
		First Difference I(1)		
LP	-5.644***	-5.526***	-5.643***	-5.525***
ID	-5.814***	-6.200***	-5.814***	-6.861***

4.4 Empirical Result (Determinants of Type 2 Diabetes Mellitus Male)

4.4.1 ARDL Bound Test

In this part, ARDL model estimation using AIC with a maximum lag order of 3 presented the result of the estimated ARDL Bound Test. The result of the bound test is recorded in Table 4.5.

Table 4.5 : Results for ARDL Bound Test for Determinants of Type 2 Diabetes Mellitus (Male)

F-Statistics	Lags	Significance level	Critical Bound F-Statistic♣	
			I(0)	I(1)
10.804[a] K(5)	3	1%	3.06	4.15
		5%	2.39	3.38
		10%	2.08	3

Notes: The superscript “a” indicates that the statistic lies above the upper bound. Source of the critical values: ♣Narayan (2005).

The result tabulated in Table 4.5, recorded that the computed F-statistic (10.804) is greater than the upper critical bound (4.15) at a 1% significant level, which confirms a long-run association (cointegration) among the variables in the model. The null hypothesis (H0: ϴ1 = ϴ2 = ϴ3 = ϴ4 = 0) that no long-run determinants of T2DM among male diabetic patients are conclusively rejected at a 1% significance level. Therefore, Narayan (2005) suggested that there is compiling evidence for cointegration between the death rate of T2DM among males and its determinant.

4.4.2 ARDL Long-run and Short-run Coefficients Estimation Results

Since the ARDL bounds testing approach confirms that the ARDL model is the best fit for the present study, the next step is to examine the existence of a long-run and short-run relationship among the estimated variables for determinants of T2DM among males. The variables used are Male Death Rate (DRM) which is the dependent variable, while, GDP per capita (GDPC), Health Expenditure per capita (HEXPC), Male Primary School Level Attainment (PM), Male Prevalence of BMI≥30kg/m2 (BMIM), and Urban Population (URB) are the independent variables. The long-run equilibrium shows a relationship between variables without any short-run shock and the estimate of the short-run coefficients shows a dynamic adjustment of all variables. The estimated result of the long-run and short-run are tabulated in Tables 4.6 and 4.7 respectively.

Table 4.6 : Estimated Long-run Male T2DM Determinants Using ARDL with an Optimal Lag (2, 2, 3, 3, 3, 2)

Dependent Variable: lnDRM				
Variables	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
lnGDPC	-1.171***	0.143	-9.995	0.000
lnHEXPC	-2.267***	0.757	-5.439	0.000
lnPM	1.543**	0.565	2.730	0.034
lnBMIM	1.588***	0.298	5.329	0.001
lnURB	2.299	3.852	0.597	0.572
Constant	-23.143	18.909	-1.224	0.267

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10% level respectively.

All the variables are statistically significant except for lnURB in the long run. lnURB does not appear to be one of the main causes of the diabetes mortality rate in Malaysia. This is in line with Hussein et al. (2015), who argued that 75% of diabetic Malaysians diagnosed have obesity issues and established proof that the prevalence of obesity and diabetes are parallel in Malaysia. The 1.588% increase in the death rate of males due to diabetes mellitus in Malaysia. Obesity is associated with a high mortality rate from all causes in men because it increases excess weight around the abdomen, hence a greater risk of developing T2DM. This finding is in tandem with several studies on the topic (such as Hu, 2003; Chobot, Górowska-Kowolik, Sokołowska & Jarosz-Chobot, 2018; Gupta & Bansal, 2020).

On the other hand, the expected sign of lnGDPC is said to be ambiguous, but, our study showed that lnGDPC has a negative relationship towards diabetes mortality and is statistically significant at a 1% significant level which has the same expected sign as Zahra et al. (2015) and Kim (2016). Since the specified DRM model is in a log-linear form, the coefficient of independent variables can also be interpreted as the elasticity for DRM. The coefficient of lnGDPC is 1.171 implies that in the long-term, keeping other variables constant, a 1% change in GDP per capita brings about a 1.171% decrease in DRM.

lnHEXPC expected sign is also ambiguous and according to our study, lnHEXPC is statistically negatively related to diabetes mortality. Referring to the work of Fayissa and Gutema (2005), where, the studies deduced that, a higher level of health expenditure per capita may improve the life expectancy of an individual by allocating higher allocation to upgrade the provision of health facilities. However, if the expenditure increment hurts an individual's health status whereby the expenditure is collected from the user's fees or through taxation at the individual's expense then health expenditure has a reverse effect on life expectancy improvement. The result also shows that the coefficient of lnHEXPC is -2.267 which implies that in the long-term, a change in 1% of health expenditure per capita will impact DRM negatively by 2.267%.

Next, lnPM shows a positive effect on DRM in the long-term at a 5% significance level and the elasticity indicates that a change in 1% of male primary school-level attainment will cause a 1.543% increase in DRM. This estimate is close to the work of Takashi and Mari (2019).

Table 4.7 tabulated the error correction model (ECM) and short-run dynamics. The finding reveals that all the variables are statistically significant except for the current URB. The coefficient of current GDPC lag, and GDPC first and second lag are statistically significant. The sum of the coefficients on the current (D(GDPC)), first lagged (D(GDPC(-1))) and second lagged (D(GDPC(-2))) change the role of GDP per capita is negative. The negative sign means that if GDP per capita increases, then diabetic male mortality rates will decrease. The positive sign may be justified by the work of Rawshani et al. (2016), who also reported a negative association between income per capita and T2DM mortality rates. In the case of Malaysia, the Department of Statistics of Malaysia (2019) stated that the service industry is the major contributor to GDP (54.17%).

Table 4.7 : Estimated Short-run and Error Correction Model (ECM) Male T2DM Determinants Using ARDL with an Optimal Lag (2, 2, 3, 3, 3, 2)

Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(LDRM(-1))	0.984***	0.040	24.489	0.000
D(LGDPC)	-0.261**	0.081	-3.232	0.018
D(LGDPC(-1))	-0.187*	0.077	-2.423	0.052
D(LHEXPC)	0.467***	0.071	6.615	0.000
D(LHEXPC(-1))	-0.458***	0.075	-6.076	0.000
D(LHEXPC(-2))	-0.375***	0.075	-4.998	0.002
D(LPM)	0.068**	0.019	3.430	0.014
D(LPM(-1))	-0.289***	0.031	-9.398	0.000
D(LPM(-2))	-0.187***	0.023	-8.108	0.000
D(LBMIM)	-0.197***	0.054	-3.677	0.010
D(LBMIM(-1))	1.027***	0.056	18.508	0.000
D(LBMIM(-2))	-0.511***	0.061	-8.449	0.000
D(LURB)	-4.074	2.672	-1.525	0.178
D(LURB(-1))	-16.124***	2.474	-6.515	0.000
CointEq(-1)*	-0.264***	0.021	-12.299	0.000

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively.

The coefficients of current, first and second HEXPC lag are also statistically significant where the sum of the coefficients is negative. When the value of total health expenditure accelerates, there will be a decrease in male diabetes mortality in the short run. This could be explained by Amiri and Ventelou (2012) studies, where they concluded that healthcare expenditure is one of the main channels of dealing with chronic disease.

Next, the sum of coefficients for the current, first and second PM lag is negative. In the short run, as the total primary school level attainment increases, the number of male diabetes mortality will decrease. Dube et al. (2014), found that diabetes self-management education programs in developing countries are effective in the short term, where, diabetic patients show a behavioural change and managed to keep their glycaemic under control during that period (≤ 9 months). As mentioned by Hwang and Shon (2014) as well as Al-Naggar et al. (2017), a community with higher education and good socioeconomic status had a lower prevalence of diabetes compared to a community with lower education attainment. Thus, communities with primary school-level attainment are perceived to be more prone to the prevalence of diabetes. This means that for a short span of 9 months or less, diabetic patients managed to keep their glycaemic under control and temporarily reduce the diabetes mortality rate in the short run.

Lastly, BMIM current, first and second lag are also significant in this short-run model at a 1% significant level. A positive BMIM coefficient indicates that when the total number of obese males increases, the male diabetes mortality rate will also increase. This finding is aligned with Hussein et al. (2015). URB is also insignificant in the short-run model.

Causality may arise from two channels within an error correction model. The channels could be the lagged differences that capture the short-run dynamics in the model and also the significance of error correction terms that defines the conventional tests of causality. The size and significance of the error correction term in each equation show the tendency of each variable that could potentially reinstate the equilibrium of diabetes in the male population.

Kremers et al. (1992) stated that the most efficient way to establish cointegration is when the error-correction term is significant and negative. The error correction coefficient (-0.264) is highly significant with a correct negative sign. The result implies that the death rate from diabetes mellitus and its determinants can adjust back to the steady state at a speed of 26.4% per annum taking approximately (1/0.264 = 3.79), three (3) years eight (8) months to converge back to the long-run equilibrium in the current year.

4.4.3 Diagnostic Tests for ARDL Regression

A diagnostic test for ARDL Regression is conducted to ensure a fairly high level of goodness of fit. Table 4.8 unfold the test conducted and their respective results. The tests include the Serial Correlation test; Heteroskedaticity; Normality test; Ransey test and Recursive tests (CUSUM and CUSUM square).

Table 4.8 : Diagnostic Test for ARDL Regression (Male)

Test Statistics	F-Version [Prob]
Breusch-Godfrey (LM test) Serial Correlation	10.964 [0.083]
Heteroskedasticity (BPG)	1.046[0.516]
Normality test (Jarque-Bera)	0.3297 [0.8480]
Ramsey Test	1.779 [0.239]
CUSUM	Normal
CUSUMQ	Normal

Note: values in parentheses […] are probability values.

The null hypothesis (H0) for the Serial Correlation test is that: there is no autocorrelation of any order between the error terms (disturbances) as against the alternative that: there is autocorrelation between the disturbances. For the Heteroskedasticity, the null hypothesis (H0) is that: the model is homoskedastic i.e. error variances are all equal or normally distributed against the alternative that the error variances are not equal or not normally distributed. Even though, the problem of heteroscedasticity is probable to be more common in cross-sectional studies than in time series data, nonetheless, conducting the test would clear all kinds of doubt regarding the equality of error variance.

In the case of the Normality test, the null hypothesis (H0) is that: all the values were from a population that is in line with the Gaussian distribution. Lastly, the Ramsey test null hypothesis (H0) is that: the functional form of a model is correct and does not suffer from omitted variables. For all the diagnostic tests, if P-value is greater than 0.05 (i.e. P-value > 0.05), we fail to reject the H0, otherwise, we reject the H0 and accept the alternative.

First, the LM test shows no serial correlation problem because the p-value (0.083) is greater than 0.05, as shown by the Breusch – Godfrey Serial Correlation LM Test result. The test for Heteroscedasticity, also shows that the residuals are Homoscedastic because the p-value (0.561) is also more than 0.05. The Jarque – Bera Normality Test result also indicates the model is free of non-normal error since the p-value (0.848) is also higher than the 5% level. Similarly, the Ramsey RESET Specification test and functional form do reject the misspecifications problem because the p-value is greater than 0.05.

Therefore, the null hypothesis that theoretically accounts for the model is not the best fit is rejected.

Besides that, taking Pesaran and Shin (1999) recommendation into account, this research also conducted a stability test for the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) in the short-run and long-run. Figures 4.1 and 4.2 depicted a graphical representation of CUSUM and CUSUMSQ results. The graph reveals a satisfactory plot of recursive residuals at a 95% significance level, where all the parameters are within the critically dotted lines. Hence, any trace of inconsistent parameter estimates is empirically dismissed and the standard significance of the conventional test statistics without a trace of nuisance parameters is further strengthened.

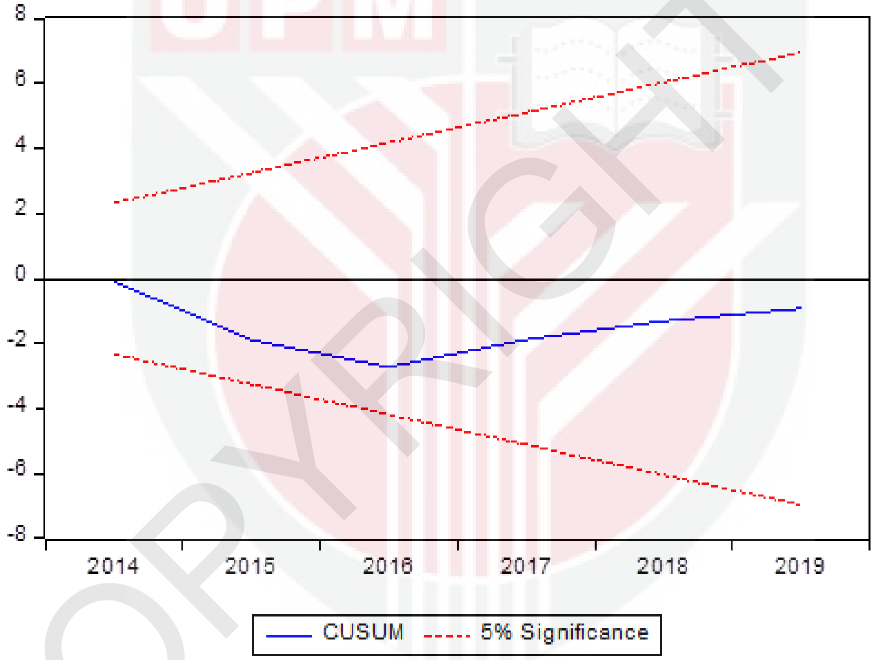

Figure 4.1 : Plot of CUSUM (Male)

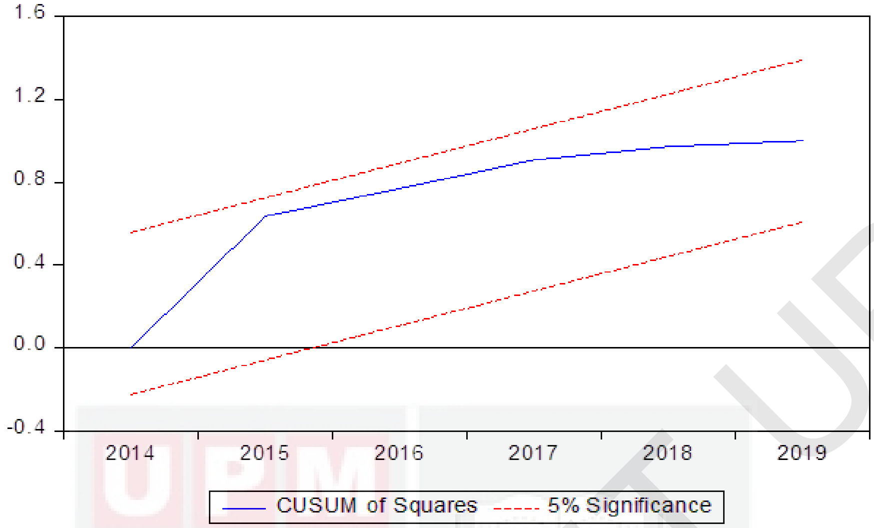

Figure 4.2 : Plot of CUSUM-squared (Male)

4.4.4 Robustness Check (Using T2DM Prevalence as a Dependent Variable)

The purpose of conducting a robustness check of a model is to ascertain whether the estimated parameters are receptive to any changes in the model specification. This doubt is cleared once the outcome finds the same estimates with smaller standard errors. Nonetheless, with multiple robustness checks, the doubt is likely to increase, especially when the outcome differs significantly from the initially obtained with substantial standard errors. (Lu & White, 2014).

This study presents the Long-run results in Table A1 in the appendix. The model was re-estimated using different T2DM i.e. its prevalence. Prevalence of T2DM measures the total number of those that are affected daily as reported by the Health Ministry of Malaysia. The reason is to verify if the social variables that determine the T2DM death rate can also determine its prevalence in Malaysia.

The result shows that only GDPC reduces T2DM prevalence among Men in Malaysia all at a 1% significance level, while HEXPC, BMIM (Obesity) and URB (the size of Urban Population) do increase it among Men in Malaysia. But only primary school attainment (PM) is not significant. This outcome is similar to what we found when we tested it on the Death rate from T2DM, where GDPC was found to reduce its death rate. Similarly, other variables: BMIM was found to increase the data rate (positive correlation) while HEXPC was found to decrease (negative correlation), while URB was insignificant.

Note: As shown in Table A2, all the models have passed the F-Bounds test (6.134> 4.15(Upper Limit)), the diagnostic tests for Serial Correlation (0.092) and Heteroskedasticity (0.239).

4.5 Empirical Result (Determinants of Type 2 Diabetes Mellitus Female)

4.5.1 ARDL Bound Test

The ARDL model estimation for female determinants of Type 2 Diabetes Mellitus (T2D) using AIC with a maximum lag order of 5 presented the result of the estimated ARDL Bound Test. The result of the bound test is recorded in Table 4.9.

Table 4.9 : Results for ARDL Bound Test for Determinants of Type 2 Diabetes Mellitus (Female)

F-Statistics	Lags	Significance level	Critical Bound	
			F-Statistic♣	
			I(0)	I(1)
8.475[a] K(5)	3	1%	4.134	5.761
		5%	2.91	4.193
		10%	2.407	3.517

Notes: The superscript "a" indicates that the statistic lies above the upper bound. Source of the critical values: ♣Narayan (2005).

Table 4.9 showed that the computed F-statistic (8.475) is larger than the upper critical bound (5.761) at a 1% significance level, which confirms a long-run association (cointegration) among the variables in the model. The null hypothesis (H0: ϴ1 = ϴ2 = ϴ3 = ϴ4 = 0) which is no long-run relationship between the determinants of T2DM for the female population is conclusively rejected at a 1% significance level. Hence, based on Narayan's (2005) recommendation, this model has compiled evidence for cointegration between the death rate of T2DM among females and its determinants.

4.5.2 ARDL Long-run and Short-run Coefficients Estimation Results

The ARDL bounds testing approach has approved that the ARDL model is indeed the best fit for the present study, hence, the research will proceed to examine the existence of a long-run and short-run relationship among the estimated variables for determinants of T2DM among females. Female Death Rate (DRF) will act as the dependent variable, while, GDP per capita (GDPC), Health Expenditure Per Capita (HEXPC), Female Primary School Level Attainment (PF), Female Prevalence of BMI≥30kg/m2 (BMIF), and Urban Population (URB) are the independent variables. The estimated long-run equilibrium portrays a relationship between variables without any short-run shock, whilst, the short-run coefficients estimate portrays a dynamic adjustment of all variables. Tables 4.10 and 4.11 tabulated the result of estimated long-run and short-run respectively.

Table 4.10 : Estimated Long-run Female T2DM Determinants Using ARDL with an Optimal Lag (1, 3, 3, 3, 2, 0)

Dependent Variable: lnDRF				
Variables	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
lnGDPC	-1.215***	0.117	-9.2455	0.000
lnHEXPC	-1.067***	0.416	-2.565	0.000
lnPF	0.585*	0.279	2.102	0.065
lnBMIF	1.251***	0.415	3.014	0.001
lnURB	-2.586	1.434	-1.803	0.105
Constant	2.851**	1.152	2.475	0.008

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively.

The first variable, lnGDPC has a negative coefficient and statistical significance at a 1% significant level. The -1.215 coefficient of lnGDPC implies a change of 1% GDP per capita will cause about a 1.215% rise in DRF in the long term while keeping the other variables constant. The effect of GDPC on the female mortality rate is a little higher than that of the male mortality rate. HEXPC is statistically significant at a 1% significance level. A change in 1% of health expenditure per capita will cause a 1.067% change in DRF, which implies that a 1% change in health expenditure per capita is associated with a 1.06% decrease in DRF. lnBMIF is also positively significant at a 1% significance level with a coefficient of 1.215., i.e. 1% increase in obesity is associated with an increased death rate of females from diabetes mellitus in Malaysia, as it also increases cancers such as breast cancer and endometrial cancer, thereby increasing the risk of death. This outcome is in line with previous studies (such as Hu, 2003; Chobot, Górowska-Kowolik, Sokołowska & Jarosz-Chobot, 2018; Gupta & Bansal, 2020) who argue that Obese women are prone to diabetes that in turn, increase the risk of cardiovascular disease. Whereas lnURB has an insignificant impact on the mortality rate.

The long-run result also discloses that female human capital in the form of lnPF has a significant positive impact on DRF at a 10% significance level. To be specific, a change in 1% of female primary school completion will lead to a 0.585% change in DRF. The result corroborates the findings of Raphael (2003) and Clark and Utz (2014)) where a positive relationship was reported between human capital and diabetes death rate.

Table 4.11 : Estimated Short-run and Error Correction Model (ECM) Female T2DM Determinants Using ARDL with an Optimal Lag (1, 3, 3, 3, 2, 0)

Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(LDRF(-1))	0.087	0.115	0.764	0.500
D(LDRF(-2))	0.599*	0.094	6.356	0.008
D(LGDPC)	-0.243**	0.048	-5.059	0.015
D(LGDPC(-1))	-1.346***	0.099	-13.622	0.000
D(LGDPC(-2))	-0.574***	0.110	-5.201	0.014
D(LHEXPC)	-0.609***	0.039	-15.320	0.000
D(LHEXPC(-1))	0.136**	0.041	3.266	0.047
D(LHEXPC(-2))	-0.186**	0.046	-4.069	0.027
D(LPF)	0.191***	0.013	14.568	0.000
D(LPF(-1))	-0.087***	0.016	-5.578	0.011
D(LPF(-2))	-0.075***	0.013	-5.724	0.010
D(LBMIF)	0.649***	0.095	6.817	0.006
D(LBMIF(-1))	4.691***	0.189	24.806	0.000
D(LBMIF(-2))	2.581***	0.461	5.603	0.011
D(LURB)	-12.963***	1.852	-7.000	0.006
D(LURB(-1))	-5.956**	1.797	-3.315	0.045
D(LURB(-2))	-5.606***	0.995	-5.635	0.011
CointEq(-1)	-0.573***	0.098	-5.847	0.000

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively.

Table 4.11 tabulated short-run dynamics and the error correction model (ECM) for determinants of T2DM among the female population. The result also signifies that all the variables are statistically significant in the short-run model except for the current DRF lag and. The sum of GDPC coefficients is negatively associated with female DRP which denotes that if GDP per capita increases, then female diabetic mortality rates will increase.

The sum of current, first and second HEXPC lag coefficients are also negative for the female mortality rate. The current, first and second PF lag coefficient has the same negative effect as the male, whereby, as the female primary school level attainment increases, the number of diabetes mortality will decrease. As for BMIF, all the current and lag values are significant at a 1% significance level and the coefficient has a positive value, which shows that an increasing number of obese females also contributes to the increase in female diabetes mortality rate.

Lastly, URB is insignificant in determining male diabetes mortality rate but it is significant at the 2 lag and current URB in determining female mortality rate. The coefficient of the URB lag is negative, which signifies an increase in the urban population, and the female mortality rate will decrease. Mahtab (2008) found that the nutrition status of rural girls is worse than boys, which results in high girl-child mortality, morbidity and maternal mortality. Hill et al. (2013) also found a higher rate of diabetes in rural areas compared to urban areas. They further stated that, due to limited healthcare access, higher poverty rates and lower socioeconomic status rural areas have higher death rates in the U.S.

The error-correction term is significant, then there is a concrete establishment of the existence of cointegration (Kremers et al., 1992). The error correction coefficient (-0.573) has a correct negative sign and is highly significant at a 1% significance level. This implies that 57.3% of the female death rate variation due to T2DM in the short run is explained by the variables presented in the model and it takes approximately (1/0.573 = 1.75) one (1) year Eight (8) months to converge back to the long-run equilibrium in the current year. In conclusion, females take 2 years shorter time than that males to converge back to long-run equilibrium in the current year. This means that the female mortality rate is higher than the male. This estimation is in line with Macintyre (1996), who concluded that female morbidity is higher than men. Besides that, Raphael (2003) also highlighted that women carry the responsibility of bearing children and caring for the whole family, which would compromise their own nutritional needs that lead to future complications such as lower birth weight or the likelihood of their children developing diabetes in the future. Then, Mahtab and Habib (2016) also concluded that women with diabetes often remain untreated, attempt self-medication or seek unqualified quacks. Diabetic women are said to be standing at the most disadvantage as this group of ladies will be discriminated against, divorced, separated or abandoned by the family or husband without any support.

4.5.3 Diagnostic Tests for ARDL Regression

The LM test result of serial correlation shows that the residuals are not serially correlated, since the p-value (0.077) is greater than the 0.05 level of significance. For the test of Heteroskedasticity, it shows that the residuals are Homoskedastic since the p-value (0.885) is also more than 0.05. The variables are normally distributed, as confirmed by the Jarque – Bera Normality Test result of the p-value (0.732), which is greater than 0.05. Similarly, the Ramsey RESET Specification test and functional form do reject misspecification problems. Therefore, the null hypothesis that theoretically accounts for the model is not the best fit is rejected. Hence, it is certain that the model of DRF estimated in this study is the best fit. All these tests are done at the 5% level of significance. The CUSUM SQ Test also shows that the variables are stable.

Table 4.12 : Diagnostic Test for ARDL Regression (Female)

Test Statistics	F-Version [Prob]
Breusch-Godfrey (LM test) Serial Correlation	73.33 [0.077]
Heteroskedasticity (BPG)	0.517[0.885]
Normality test (Jarque-Bera)	0.623 [0.732]
Ramsey Test	0.377 [0.601]
CUSUM	Normal
CUSUMQ	Normal

Note: values in parentheses […] are probability values.

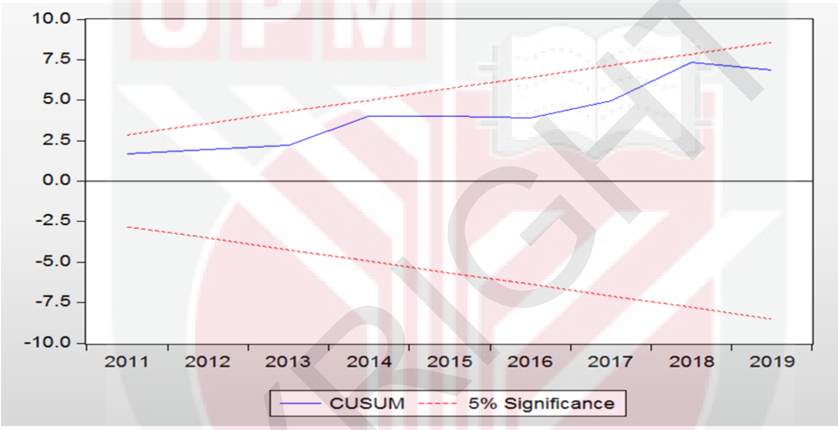

Figure 4.3 : Plot of CUSUM (Female)

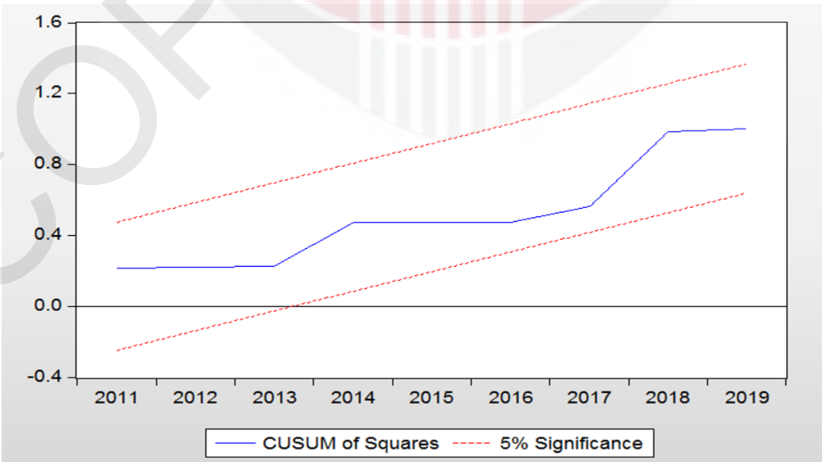

Figure 4.4 : Plot of CUSUM-squared (Female)

4.5.4 Robustness Check (Using T2DM Prevalence as a Dependent Variable)

This study presents the Long-run results in Table A3 in the appendix. The model was re-estimated using different T2DM i.e. its prevalence. Prevalence of T2DM measures the total number of those that are affected daily as reported by the Health Ministry of Malaysia. The reason is to verify if the social variables that determine the T2DM death rate can also determine its prevalence in Malaysia.

The result shows that GDPC, HEXPC, BMIF and URB are statistically at different levels of significance, but only PF is not. All these variables, except primary school educational attainment, are determinants of the T2DM prevalence among females in Malaysia, just like that of males. This outcome is similar to that of the death rate, where GDPC, HEXPC and BMIF were found to be significant determinants of T2DM among females in Malaysia. It then follows that the results are robust.

Note: As contained in Table A4, all the models have passed the F-Bounds test (8.51 > 5.956(Upper Limit)) and the diagnostic tests for Serial Correlation (0.126) and Heteroskedasticity (0.737), which are all higher than the 0.05 significance level.

4.6 Empirical Result (Determinants of Type 2 Diabetes Mellitus on Labour Productivity)

4.6.1 ARDL Bound Test

This part exhibits the estimated ARDL Bound Test whereby, the ARDL model estimation used AIC with a maximum lag order of 6. The test result of the bound test is recorded in Table 4.13.

Table 4.13 : Results of ARDL Bound Test for Impact of Type 2 Diabetes Mellitus on Labour Productivity

F-Statistics	Lags	Significance level	Critical Bound	
			F-Statistic♣	
			I(0)	I(1)
6.014 [a] K(5)	2	1%	4.134	5.761
		5%	2.91	4.193
		10%	2.407	3.517

Notes: The superscript “a” indicates that the statistic lies above the upper bound. Source of the critical values: ♣Narayan (2005).

The most appropriate cointegration test for series that are of a different order of integration with a smaller sample size is the one proposed by Narayan (2005) where the computed F-statistic value based on ordinary least squares (OLS) estimation must be above the upper bound critical value of Narayan's table. Based on the computed F-statistic in Table 4.13, the F-statistic (6.014) is indeed greater than the upper critical bound (5.761) at a 1% significant level. This result indicates that the variables in the model have a long-run relationship, hence, we can proceed to the estimation of the ARDL specification long-run model.

Table 4.14 presented the long-run equation for the impact of T2DM on Labour Productivity in Malaysia.

Table 4.14 : Estimated Long-run Impact of T2DM on Labour Productivity

Dependent Variable: lnLP				
Variables	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
lnHEXPC	0.707***	0.076	9.347	0.000
lnID	-0.293	0.174	-1.689	0.125
InGCF	-0.145	0.088	-1.649	0.134
InOPN	-0.003	0.052	-0.058	0.955
lnPG	0.490***	0.110	4.440	0.002
In EDUC	0.114	0.148	0.768	0.455
Constant	9.602***	1.949	4.927	0.000

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively.

The long-run results disclose that only lnPG and lnHEXPC are statistically significant at a 1% significance level. Whereas ID, GCF and OPN are not significant. By implication, in Malaysia, the incidence of diabetes (even though negatively signed) is not one of the determinants of labour productivity. This may be due to many diabetic patients who normally tried to hide their diagnosis from employers.

lnPG and lnHEXPC both have the same positive effect on labour productivity and are both statistically significant at a 1% significant level in the long run. This outcome implies that a 1% growth in population leads to a rise in labour productivity by 0.5%. Similarly, a 1% increase in HEXPC is associated with a 0.7% increase in the productivity of labour, with all other variables remaining constant. The estimated positive lnPG sign is close to the work of Arshad and Malik (2015), while lnHEXPC is more aligned with Maciulyte-Sniukiene and Matuzeviciute (2018) and Awotunde (2018).

4.6.2 ARDL Long-run and Short-run Coefficients Estimation Results

It appears that the effect of EDUC on labour productivity is insignificant in the long-run, this may be because employers are reluctant to pay for skilled workers and hire more cheap low skilled foreign workers than local workers. This outcome is contrary to the study by Arshad and Malik (2015) who concluded that higher and better education qualification along with great health status significantly contributes to higher labour productivity. This is because Malaysia's economy is mostly dominated by the manufacturing, construction and mining sectors, as argued by Arshad and Malik (2015) who found that Malaysia economy is largely dependent on manufacturing, construction and mining sectors (which are more labour-intensive jobs.) Thus, even with higher education growth among these groups of workers, it does not apply to blue-collar workers.

Table 4.15 present the short-run equation for the impact of T2DM on Labour Productivity in Malaysia. The short-run results disclose that lag 2 of LP, current and lag 1 LHEXPC, lag ID, all GCF and current LPG are statistically significant at the conventional level of significance, i.e 1% and 5%.

Table 4.15 : Estimated Short-run and Error Correction Model (ECM) Impact of T2DM on Labour Productivity Using ARDL with an Optimal Lag (3, 2, 2, 3, 1, 1)

Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(LLP(-1))	-0.156	0.114	-1.373	0.203
D(LLP(-2))	-0.269***	0.088	-3.067	0.013
D(LHEXPC)	0.340***	0.044	7.652	0.000
D(LHEXPC(-1))	-0.278***	0.076	-3.659	0.005
D(LID)	0.013	0.041	0.323	0.754
D(LID(-1))	-0.105**	0.047	-2.236	0.052
D(LGCF)	0.125***	0.018	7.029	0.000
D(LGCF(-1))	0.171***	0.037	4.581	0.001
D(LGCF(-2))	0.108***	0.023	4.617	0.001
D(OPN)	0.062	0.036	1.720	0.119
D(LPG)	0.868***	0.099	8.798	0.000
D(EDUC)	0.123**	0.047	2.617	0.045
CointEq(-1)	-0.693***	0.119	-5.824	0.000

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively.

Starting with lnGCF, gross capital formation is insignificant in the long run, but now significant and an expected sign. The finding is the same as the studies from Singh and Trieu (1996) as well as Bal et al. (2016).

The incidence of diabetes (ID) lag 1 does play a role in determining Malaysia's labour productivity in the short-run, by hurting labour productivity, which is in line with the study carried out by Sandeep, Rodney and Kenneth (2014) also shows a negative relationship between ID and LP in the case of the U.S, but contrary to that of Reviriego et al. (2016), who found an insignificant relationship between diabetes and labour productivity among white-collar workers compared to blue-collar workers. In the long run, ID remains statistically insignificant which implies that it does not cause a significant impact on labour productivity in Malaysia. It can be associated with the fact that currently Malaysia is facing labour shortage issues in the post-pandemic era (Khan, Khan, & Tan, 2021) which signifies that the proportion of T2DM-affected labour force might be too small to cause an impact on labour productivity.

LnHEXPC and lnPG both have the same positive effect on labour productivity and are statistically significant at a 1% significant level in the short run. The sum of the current and first HEXPC lag is positive which indicates that an increase in health expenditure per capita also contributes to an increase in labour productivity. The estimated positive lnPG sign is close to the work of Arshad and Malik (2015), while lnHEXPC is more aligned with Maciulyte-Sniukiene and Matuzeviciute (2018) and Awotunde (2018).

In the case of Education, it is only the current EDUC that is positive 0.123, which denotes that, with an increase in total lower secondary attainment, the effect of labour productivity will increase in the short run. Even though the service sector contributes to GDP at an estimate of 54.5% in 2012, the service sector is presumed to be the economy's supporting sector.

The error correction coefficient (-0.693) substantiates the long-run relationship among the variables and denotes that the speed of adjustment of the variables' convergence to equilibrium is at 69.3% or it will take approximately (1/0.693 = 1.44) one (1) year four (4) months.

4.6.3 Diagnostic Tests for ARDL Regression

Just like in previous models, the LM test results in Table 4.16 shows no serial correlation problem because the p-value is greater than 0.05, as shown by the Breusch – Godfrey Serial Correlation LM Test result.

Table 4.16 : Diagnostic Test for ARDL Regression (Impact of T2DM on Labour Productivity)

Test Statistics	**F-Version [Prob]**
Breusch-Godfrey (LM test) Serial Correlation	8.173 [0.107]
Heteroskedasticity (BPG)	0.364 [0.968]
Normality test (Jarque-Bera)	0.497 [0.779]
Ramsey Test	0.591 [0.571]
CUSUM	Normal
CUSUMQ	Normal

Note: values in parentheses […] are probability values.

The residuals are Homoskedastic since the p-value (0.885) is more than 0.05 as confirmed by the result of the test of Heteroskedasticity. The Jarque – Bera Normality Test result also indicates the model is free of non-normal error since the significance value is higher than the 0.05 level. Similarly, the Ramsey RESET Specification test and functional form do reject misspecification problems. Therefore, the null hypothesis that theoretically accounts for the model is not the best fit is rejected. Thus, our model is perceived to produce a reliable outcome having passed the major diagnostic test of non-normal error, serial correlation and functional-form misspecification.

This research also conducted a stability test on the model using CUSUM and CUSUMSQ tests following a recommendation by Pesaran, Shin and Smith (2001). The model is presumed to be stable along the sampled period if all the residuals are within the dotted lines of the critical bound at a 5% significance level. Figures 4.5 and 4.6 outlined the model's stability test graph result in terms of the CUSUM and CUSUMSQ test respectively. All the figures show that the model is reasonably stable over the studied period.

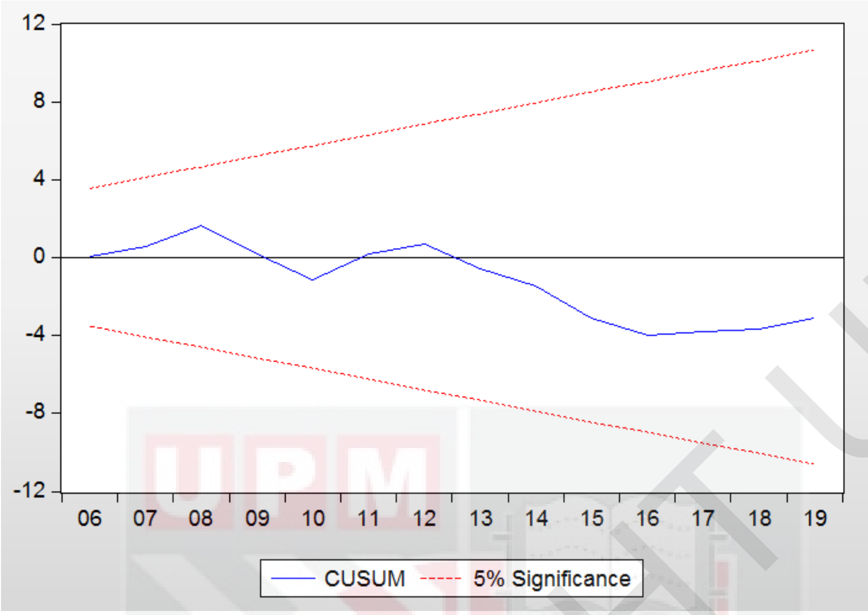

Figure 4.5 : Plot of CUSUM (Impact of T2DM on Labour Productivity)

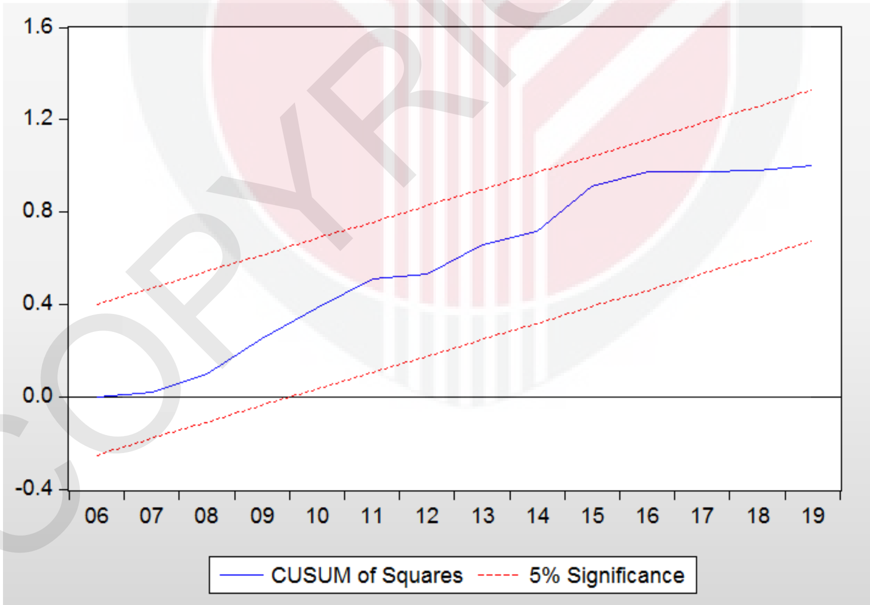

Figure 4.6 : Plot of CUSUM-squared (Impact of T2DM on Labour Productivity)

4.6.4 Robustness Check (Using T2DM Prevalence in Place of ID)

This study presents the Long-run results in Table A5 in the appendix. The model was re-estimated using a different measure of T2DM i.e. its prevalence instead of incidence to see how it affects labour productivity. Prevalence of T2DM measures the total number of those that are affected daily as reported by the Health Ministry of Malaysia. The reason is to verify if T2DM prevalence affects labour productivity in Malaysia.

The result shows that all the variables of interest do affect labour productivity. HEXPC, GCF, PG and EDUC are all significant and positive, while other variables PT2DM and OPN do reduce labour productivity in Malaysia. Note: all the models have passed the F-Bounds test (6.341 > 5.691(Upper Limit)) and the diagnostic tests for Serial Correlation (0.092) and Heteroskedasticity (0.994), which are all higher than the 0.05 significance level. So also is the specification and normality.

CHAPTER 5

CONCLUSION AND POLICY IMPLICATION

5.1 Summary of the Research

This study was conducted with the aim to evaluate the determinants of Type 2 Diabetes Mellitus (T2DM) based on gender and its impact on labour productivity in Malaysia. The study employed time series data in Malaysia from 1990-2019. The data were analysed using quantitative methods including descriptive statistics and Autoregressive Distributed Lag (ARDL) approach. Therefore, the first objective of the study examined the social determinants of T2DM according to gender in Malaysia from 1990 to 2019 using the ARDL approach to co-integration. The second objective investigated the impact of T2DM on Malaysia's labour productivity from 1990 to 2019 using the same data analysis approaches.

5.2 Summary of Findings

The results revealed a strong association between GDP per capita, health expenditure per capita and primary school attainment as the social determinants of T2DM in Malaysia for both males and females in the long run. Also, it seems that obesity is only a social determinant for T2DM for Men, whereas for females it is not. Previous studies have highlighted that the prevalence of diabetes is highly correlated to the prevalence of obesity, but this study only found that it is one of the main determinants of diabetes mortality rate in Men alone. Also, the urban population is insignificant to be considered as a determinant of the T2DM mortality rate in Malaysia for both sexes, even though the results show that urbanization has a negative impact on the diabetes mortality rate, but in this context, it did not affect Death rate in Men (DRM) and Female (DRF).

In the short run, the social determinants of T2DM for males are GDP per capita, male primary school attainment, obesity and urban population. While the social determinants for female Death rate are all the variables in the short run. Both sexes have almost the same significant variable except that female has an extra significant variable which is urbanization. This shows that even in the short run, in rural areas females face a high possibility of diabetes mortality rates. Female plays a huge role in taking care of the family, bearing children and often put's their family benefit first before themselves. Apart from this, due to traditional culture and thoughts which do not priorities females in an entity, females in rural areas will face higher girl-child mortality, morbidity and maternal mortality as they are denied the same treatment received by the male. In the long run, obesity has a positive and significant relation with DRM.

The results revealed that Malaysia's labour productivity is not affected by the T2DM incidence (ID), because ID is insignificant. However, labour productivity can be significantly improved when the population growth and health expenditure per capita increase in the long run. Nonetheless, gross capital formation and trade openness are insignificant because a larger share of capital formation and better trade openness should have contributed significantly to increasing labour productivity but the result shows otherwise. This can be explained by a study by Ismail, Rosa and Sulaiman (2011) who argue that foreign investors often enter Malaysia's marketing along with their cutting-edge technologies as well as expertise to manoeuvre the machine which caused the labour productivity to drop as the locals do not have the skills to operate the machine. This situation has also created a wide gap between local and foreign firms, which eventually lead to a negative relationship between trade openness and labour productivity. All the variables except the current Incidence of diabetes (ID) have an impact on labour productivity in the short run. Surprisingly, from this study, the incidence of diabetes does not show any evidence of impacting Malaysia's labour productivity.

5.3 Policy Implication

The significance of this study, as earlier mentioned, is to provide information that can assist policymakers and practitioners decide on a cost-effective mechanism to supply better health services that would reduce diabetes mortality rate whilst the population gain awareness of the danger of diabetes being a silent killer. Based on the findings, some of the recommendations are as follows:

i. The government and policymakers should raise health spending for raising public awareness and educating people more about the risks of T2DM, particularly for a group of individuals with lower educational attainment.
ii. Policymakers should develop strategies that support economic progress as it will raise people's per capita incomes, enabling them to take healthcare measures to control their diabetes.
iii. Additionally, the government should take steps to inform more people about the risks and preventative measures associated with T2DM, as many patients who are uneducated or have low educational attainment are unaware of how to treat these conditions. To raise T2DM knowledge among those with poor educational attainment, policymakers should periodically arrange seminars and social gatherings.
iv. Since the core cause of diabetes mellitus is obesity and increasing BMI. In this regard, with high sugar intake, one of the effective ways that the government can consider is to increase sugar taxation and encourage more natural sugar replacements such as honey and fruits. This strategy appears to be more effective than having endless workshops as this move will affect the purchasing decision among consumers.

v. More importantly, changes in policy, the social and physical environment, and customs are necessary to curb the spread of the twin epidemics of obesity and diabetes.

vi. The estimation of the determinant of T2DM is an important input for public policy development. It helps the policymakers and generally the public to understand the main drive behind the prevalence of diabetes and how it affects productivity that could eventually harm economic growth. Even though the incidence of diabetes does not directly affect labour productivity in Malaysia. However, still, it is undeniable that diabetes has left high death statistics in Malaysia. Therefore, care and prevention must be taken before the overwhelming burden of diabetes prevalence and mortality rate hike becomes the main culprit for an economic downturn.

vii. Lastly, the government should also implement specific health initiatives for managing diabetes and make sure that health services are evenly distributed to communities with the highest diabetes prevalence.

5.4 Limitation and Future Research Direction

The limitation of this study is that, due to a lack of data, the author did not take into account comorbidity symptoms. People with diabetes will not be able to regulate their blood sugar level and if it is not controlled, the spike of abnormal sugar levels in the body can lead to coma and death if not treated. However, there is also evidence that shows the death of diabetes was also due to complications from other diseases such as high cholesterol and high blood pressure, which is a risk factor for cardiovascular disease as well as kidney diseases that can lead to premature death. Thus, future research should include comorbidity diseases as one of their independent variables.

Next, to study further the effect of diabetes on labour productivity, future research should consider segregating labour productivity according to white and blue-collar workers. Compared to white-collar workers, blue-collar workers require more manual labour that needs a healthy and fit physique. Therefore, there might be a significant effect of diabetes on blue-collar workers as they require a healthier body for their work routine. On the other side, there might be a possibility of higher diabetes prevalence among white-collar workers due to their sedentary lifestyle as their profession requires less body movement and more on the managerial or administrative role.

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APPENDICES

Table A1 : Robustness Test Results for Male T2DM Prevalence Determinants using ARDL with an Optimal Lag (2, 2, 3, 3, 3, 2)

Dependent Variable: lnPT2DM				
Variables	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
lnGDPC	-1.349**	0.409	-3.289	0.013
lnHEXPC	0.587**	0.179	3.271	0.014
lnPM	-0.245	0.131	-1.877	0.103
lnBMIM	0.382***	0.068	-5.543	0.000
lnURB	4.201***	0.552	0.7611	0.000
Constant	-13.531***	3.533	-3.829	0.006

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively

Table A2 : Diagnostic Checks

Test Statistics	F-Version [Prob]
F-Bounds test	6.134 > 4.15 (upper limit)
Breusch-Godfrey (LM test) Serial Correlation	5.096 [0.092]
Heteroskedasticity (BPG)	1.715 [0.238]
Normality test (Jarque-Bera)	0.243 [0.882]
Ramsey Test	0.423 [0.321]
CUSUM	Normal
CUSUMQ	Normal

Note: values in parentheses […] are probability values.

Table A3 : Robustness Test Results for Female T2DM Prevalence Determinants Using ARDL with an Optimal Lag (2, 2, 3, 3, 3, 2)

Dependent Variable: lnDRF				
Variables	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
lnGDPC	-1.453***	0.630	2.306	0.005
lnHEXPC	-1.839*	0.976	-1.884	0.067
lnPF	0.736	0.838	-0.878	0.429
lnBMIF	1.438***	0.654	2.199	0.003
lnURB	5.097**	1.745	2.920	0.043
Constant	6.94507***	7.247	-0.869	0.005

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively

Table A4 : Diagnostic Checks

Test Statistics	**F-Version [Prob]**
F-Bounds test	8.51 > 5.761(upper limit)
Breusch-Godfrey (LM test) Serial Correlation	6.956 [0.126]
Heteroskedasticity (BPG)	0.711 [0.737]
Normality test (Jarque-Bera)	0.342 [0.822]
Ramsey Test	0.432 [0.701]
CUSUM	Normal
CUSUMQ	Normal

Note: values in parentheses […] are probability values.

Table A5 : Robustness Test Results for Impact of PT2DM on Labour Productivity

Dependent Variable: lnLP				
Variables	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
lnHEXPC	0.200**	0.073	2.741	0.022
lnPT2DM	0.525***	0.136	3.867	0.003
InGCF	0.213***	0.054	3.941	0.003
InOPN	-0.158**	0.054	-2.949	0.016
lnPG	0.501***	0.073	6.889	0.000
In EDUC	0.069***	0.023	2.986	0.015

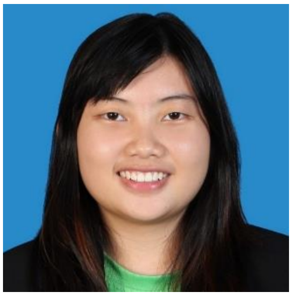
Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10% level respectively

Table A6 : Diagnostic Checks

Test Statistics	**F-Version [Prob]**
F-Bounds test	6.341 > 5.691(upper limit)
Breusch-Godfrey (LM test) Serial Correlation	6.394 [0.092]
Heteroskedasticity (BPG)	0.244 [0.994]
Normality test (Jarque-Bera)	0.712 [0.212]
Ramsey Test	0.531 [0.147]
CUSUM	Normal
CUSUMQ	Normal

Note: values in parentheses […] are probability values.

BIODATA OF STUDENT



Tan Jia Er earned her Bachelor’s Degree in Economics from University Putra Malaysia (UPM) in 2018 and continued her academic journey by undertaking Master of Science (Economics) with the health economics expert, Dr.Norashidah Mohamed Nor. While hustling for her Master’s Degree, her first official employment is with Department of Statistics Malaysia as the Statistician Officer (PSH G41) for over a year. She is one of the key person to plan, coordinate and supervise Malaysia’s Census 2020 project in terms of operation, financial planning and training. Then, she joined 2X Marketing as a Data Associate and 6 months into the job, she is the Data Analyst. Her progression did not stop there as 1 year later, she is promoted to Senior Data Analyst. Her responsibility includes conducting marketing and campaign analysis, transferring plethora of data to dashboard and provides recommendation for campaign optimization.

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