Fuzzy Logic-Based Predictive Model for the Risk of Type 2 Diabetes Mellitus

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ABSTRACT

This article presents a predictive model that can be used for the early detection of Type 2 Diabetes Mellitus using fuzzy logic. In order to formulate the model, risk factors associated with the risk of T2DM were elicited. The predictive model was formulated using fuzzy triangular membership functions following which the rules needed for the inference engine was elicited from experts. The model was simulated using the MATLAB Fuzzy logic Toolbox. The results of the study showed that the sensitivity of 11.67% and 100% precision for the low risk was recorded for both cases, specificity of 41.67% compared to 48.33% for the moderate risk, while there was 0% and 13.33% for the high risk. In conclusion, this model will help the doctor to know what course of preventive actions for a patient with high risk and what advice to give to those with low and moderate risk so that the occurrences of the diseases can be prevented altogether and thereby reducing the number of people dying from Type 2 Diabetes Mellitus diseases worldwide.

KEYWORDS

Blood Pressure, Diabetes Mellitus, Fuzzy Logic, Gestational Diabetes, Predictive Model

INTRODUCTION

Diabetes mellitus is an endocrine-metabolic disorder characterized by chronic hyperglycaemia and gives rise to the risk of micro-vascular (retinopathy, nephropathy, and neuropathy) and macro-vascular (ischaemic heart disease, stroke and peripheral vascular disease) damage. Diabetes Mellitus is also associated reduced with life expectancy and diminished quality of life (American Diabetes Association, 2014). Diabetes Mellitus (DM) may present itself with characteristic symptoms such as thirst, polyuria, blurring of vision, and weight loss. In most severe forms of DM, ketoadidosis or a non–ketotic hyperosmolar state may develop and lead to stupor, coma and, in absence of effective treatment, death (Mashael, 2013). People with DM are at increased risk of cardiovascular, peripheral vascular and cerebrovascular disease.

Several patho-genetic processes are involved in the development of DM which include processes which destroy the beta cells of the pancreas with consequent insulin deficiency and may result in resistance to insulin action. The abnormalities of carbohydrate, fat and protein metabolism are due to
deficient action of insulin on target tissues resulting from insensitivity or lack of insulin (Ozougwu et al., 2013). The prevalence of diabetes has been increasing rapidly worldwide since 2003 when the World Health Organization has predicted that by 2030 the number of adults with diabetes would have almost doubled worldwide, from 177 million in 2000 to 370 million (WHO, 2003). In 2010, the estimated worldwide prevalence of diabetes among adults was 285 million (6.4%) and this value was predicted to rise to around 439 million (7.7%) instead of the initial projection of 370 million by 2030 (Shaw et al., 2010).

Recent estimates indicated there were 171 million people in the world with diabetes in the year 2000 and this is projected to increase to 366 million by 2030. This increase in prevalence was expected to be more in the Middle Eastern crescent, Sub-Saharan Africa and India (Wild et al., 2004). In Africa, the estimated prevalence of diabetes is 1% in rural areas, up to 7% in urban sub-Sahara Africa, and between 8-13% in more developed areas such as South Africa and in population of Indian origin Africa (Jyoti et al., 2011). The prevalence in Nigeria varies from 0.65% in rural Mangu (North) to 11% in urban Lagos (South) and data from the World Health Organization (WHO) suggested that Nigeria had the greatest number of people living with diabetes in Africa (Wild et al., 2004). It is pertinent to note that clinical criteria are often used to classify patients with DM into Type 1 (T1DM) and Type 2 Diabetes Mellitus (T2DM). These criteria include a cut off age of thirty years and insulin requirements or usage since diagnosis. For T2DM additional clinical criteria for diagnosis includes history of usage of oral hypoglycaemic agents or usage of combination of insulin and the oral hypoglycaemic agents (Ogbera and Akpebeh, 2014).

Type 2 Diabetes Mellitus (T2DM) risk factors allow for a prediction of an individual’s predisposition to developing T2DM disease. The presence of multiple risk factors increases an individual’s chance of being affected by T2DM in an exponential and not additive manner (Lopez et al., 2006). Risk factors could be modifiable or non-modifiable. Non-modifiable risk factors include age, sex, race and a positive family history. Modifiable risk factors include smoking, excess alcohol use, unhealthy diet, obesity, hyperlipidaemia, sedentary or physical inactivity (Ibekwe, 2015). Type 2 diabetes is due primarily to lifestyle factors and genetics. A number of lifestyle factors are known to be important to the development of type 2 diabetes, including obesity (defined by a body mass index of greater than thirty), lack of physical activity, poor diet, stress, sedentary, and urbanization. Dietary factors also influence the risk of developing type 2 diabetes. Consumption of sugar-sweetened drinks in excess is associated with an increased risk (Malik et al., 2010). The type of fats in the diet is also important, with saturated fats and trans–fatty increasing the risk and polyunsaturated and monounsaturated fat decreasing the risk. Eating lots of white rice appears to also play a role in increasing risk (Hu et al., 2012).

Towards reducing the burden of DM (majorly T2DM) in Nigeria, there is need for concerted efforts by healthcare professionals and stakeholders in the health industry to put in place preventative measures, a better functioning health insurance scheme and a structured T2DM program. Therefore, earlier detection, public awareness and people’s education seem to be the way out as human behaviour may slow down progress in the eradication of diseases. People are eating less fruits and vegetables, more sugar, salt and saturated fat (Subbalakshmi et al., 2011). This together with decreases level of physical activity and other unhealthy habits has resulted in more cases of T2DM and other diseases such as Diabetes mellitus disorder (Omar et al., 2016). Due to scarce resources and inadequate health provision, given the difficulty of long-term drug treatment in low-income countries, primary prevention assumes a greater public health importance (Adedoyin et al., 2008). There exist compelling data to show increase in incidence and prevalence of DM in the continent. The estimated prevalence of diabetes in Africa is 1% in rural areas, and ranges from 5% to 7% in urban sub-Saharan Africa (Ogbera et al., 2014).

Predictive research aims at predicting future events or outcomes based on past patterns observed within a set of variables and has become increasingly popular in medical research. Accurate predictive models can inform patients and physicians about the future course of an illness or the risk of developing
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