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Influence of ABO blood groups and demographic characteristics on the prevalence of type 2 diabetes in Lagos, southwest Nigeria

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Abstract

Background: The literature shows that ABO blood groups and demographic characteristics influence susceptibility to type 2 diabetes mellitus (T2DM) and may be used to stem the rising incidence of the disease. However, these associations vary geographically, which necessitates the need to determine the association in every locality. This study determined the ABO blood groups and demographic characteristics of 486 type 2 diabetic patients with no family history in selected hospitals in Lagos, Nigeria.

Results: The results showed that age class 50–59 years (35.8%) was the most susceptible to T2DM, while age class 30–39 years (8.6%) was the least. Female diabetics accounted for 56.8%, while males constituted 43.2%. Diabetes was less prevalent among singles (9.5%), while married couples had the highest prevalence (55.6%). Primary school leavers were the least diabetic (9.9%), while secondary school leavers were the most diabetic (41.6%). Approximately 59.05% of the patients were overweight, while 5.35% were underweight. Blood group O positive was the most prevalent (38.5%; $p < 0.05$), followed by A positive (20.2%; $p < 0.05$), and the least was AB negative (4.5%). Severe conditions were less common among groups O positive and A positive ($p < 0.05$) compared to other blood groups. Thus, the relatively high prevalence of T2DM among blood groups O and A could be due to natural selection owing to their fitness.

Conclusions: ABO blood groups and demographic characteristics influenced the prevalence of T2DM in the city. Residents with blood groups O and A positive should pay special attention to T2DM.

Keywords: ABO blood groups, Age, Gender, Type 2 diabetes mellitus, Weight

Background

The burden of type 2 diabetes mellitus (T2DM) is increasing worldwide and raising concern (Yahaya et al. 2020). Type 2 diabetes mellitus is currently a top cause of death and reduced lifespan (Lin et al. 2020). In 2019, around 463 million adults (20–79 years) lived with

diabetes mellitus (DM), mostly T2DM, and resulted in 4.2 million deaths (IDE, 2019). Of these figures, about 79% occurred in low- and middle-income countries (IDE, 2019). The estimated cost of treating the affected in the mentioned year was over USD 760 billion dollars (IDE, 2019). Due to a lack of funds and poor healthcare system, sub-Saharan Africa is the worst hit by the effects of DM and Nigeria bears the greatest burden in the region (Pastakia et al. 2017; Ugwu et al. 2019). According to Adeloye et al. (2017), the prevalence of DM in Nigeria has doubled in the last two decades (from 2.2% in 1997

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to nearly 6% in 2015). At the minimum, 2,743,800 million Nigerians were diabetic in 2019 (IDF Africa, 2019). Overall, these showed that T2DM has reached an epidemic level and a new management strategy is necessary to complement the existing ones.

Fortunately, recent studies such as Anifowoshe et al. (2017) and Oladele et al. (2020) show that ABO blood groups influence susceptibility to diseases which can be employed as a management strategy. For instance, peptic ulcer is common among individuals with blood group O, whereas cancer of the stomach and tumors of salivary glands are more frequent among blood group A individuals (WHO, 2013). Some studies including Qureshi and Bhatti (2003) and Bener and Yousafzai (2014) also show that ABO blood groups influence susceptibility to DM. ABO blood groups are hereditary and are controlled by a gene on chromosome nine known as the ABO gene or immunoglobulin (Zahid et al. 2016). Thus, some cases of T2DM may be genetic (Abdel-Gaffar et al. 2020; Yahaya et al. 2020). There are also pieces of evidence indicating that environmental factors and demographic characteristics influence susceptibility to diseases (Yahaya et al. 2017). Notably, Shittu et al. (2017) reported a high prevalence of DM and pre-diabetes among females and people less than 61 years in Oyo State, Nigeria. Aldossari et al. (2018) also reported more DM among singles than married people in Saudi Arabia. Education levels were also reported by Aladeniyi et al. (2017) to be associated with T2DM prevalence in Akure, southwest of Nigeria.

Overall, these showed that ABO blood groups and demographic characteristics can provide preliminary data for managing an individual's health as well as determine the distribution of diseases in a population. However, demographic characteristics and the distribution of ABO blood groups vary worldwide, even among ethnic groups (Fufa and Debelo 2019). Therefore, to effectively use ABO blood groups and demographic characteristics to predict and manage a disease, there is a need to determine the distribution of the two factors among individuals suffering from the disease in the population. There is a dearth of such studies among the diabetic population in Lagos, Nigeria, similar to other developing nations. This study, therefore, determined the distribution of ABO blood groups and demographic characteristics among type 2 diabetic patients in selected hospitals in Lagos, Nigeria.

Methods

Description of study locations

This study was carried out at Alimosho and Isolo General Hospitals in Lagos, Nigeria. Lagos is the capital of Lagos State on latitudes 6° 30' N–6° 40' N and longitudes 3° 00' E–4° 00' E (Yahaya et al. 2019). The state is bounded

by the Atlantic Ocean on the south, Benin Republic on the west, and Ogun State on the north and east. Lagos is ranked among the most populated and rapidly growing cities in the world (Yahaya et al. 2020). The city is the economic hub of Nigeria and the most industrialized in the country. Lagos has a high prevalence of DM with an 11% incidence rate compared with a 2.2% national prevalence (Shittu et al. 2017), necessitating the current study.

Alimosho General Hospital is situated along Km 4, Isheri-Lagos State University (LASU) Road in Alimosho Local Government Area of the state. Isolo General Hospital is situated at 120/121 Mushin Road, Osolo Way, Isolo, Lagos. The two hospitals are centrally located in Lagos and thus serve many patients. The central locations of the two hospitals and the high number of patients they serve were instrumental to their selection for the study.

Study population and data collection

A retrospective and cross-sectional study of 865 type 2 diabetic patients with no family history that attended Alimosho and Isolo General Hospitals, Lagos, during January–October 2020 was conducted. The patients' health records were checked, and relevant information was collected using a structured checklist. The checklist has three sections, namely Section A, B, and C. Section A contains socio-demographic variables, such as age, gender, religion, education levels, marital status, and ethnicity. Section B contains anthropometric variables, mainly weight. Section C contains medical/health variables, such as ABO blood groups, rhesus blood groups, and the severity of T2DM among various blood groups. The severity of DM was scored based on the number of diabetes-related complications and frequency of hospital visits (Zghebi et al. 2019). DM was considered severe if the patient had at least one diabetes-related complication and visited the hospital monthly.

Determination of sample size

The sample size for the study was calculated from the formula: $n = \frac{N}{1 + N(e)^2}$ (Yamane 1967).

In the formula above, n represents the sample size, N is the population size, and e shows the level of precision, which is usually between 0.10 and 0.01 (i.e., 10% to 1%). N was gotten from the number of diabetic patients that attended the two hospitals between January and October 2020.

Using a level of precision of 3% and the population size of 865,

$$n = \frac{865}{1 + 865(0.03)^2}$$

$n = 486.3$ and thus $n \sim 486$.

Therefore, the sample size used was 486.

Data analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS), version 24, and findings were presented using percentages and frequency distribution tables. The relationship between variables was tested using the Chi-square test at the significant level of 5% ($p \leq 0.05$).

Results

Influence of demographic characteristics on the prevalence of T2DM

The prevalence of T2DM increased with age and reached its peak at age class 50–59 years (35.8%) after which it declined to 21.4% at age class 60–69 years (Fig. 1). To sum it up, most of the diabetic patients were between 50 and 69 years of age. Figure 2 shows that more females (56.8%) than males (43.2%) had T2DM. As shown in Fig. 3, most of the diabetic patients were Christians (69.5%), followed by Muslims (21.4%) and traditional worshippers (9.1%). Information from Fig. 4 shows that Yoruba were the most diabetic (61.3%), followed by Igbo (15.6%) and Hausa (2.9%). The demographic characteristics of the study population also show that T2DM was least prevalent among singles (9.5%), while married people had the highest (55.6%) (Fig. 5). Furthermore, it is observed from Fig. 6 that people with no formal education (16.0%) and primary education (9.9%) were the least diabetic, while secondary school leavers (41.6%) and graduates of tertiary education (32.5%) were the most diabetic.

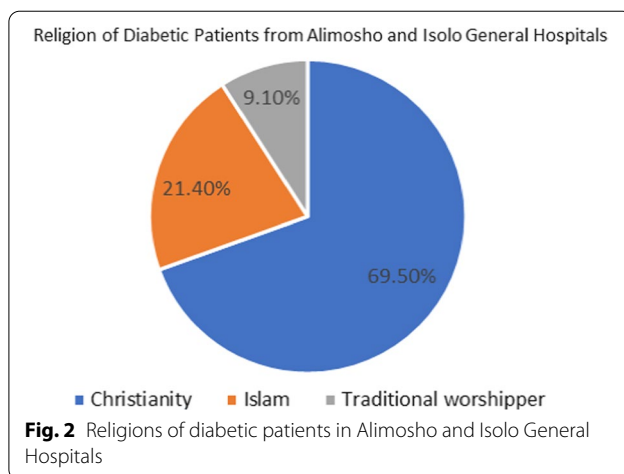


Fig. 2 Religions of diabetic patients in Alimosho and Isolo General Hospitals

Influence of body weight on the prevalence of T2DM

Table 1 shows that 59.05% of the diabetic patients were overweight (39.30% weighed between 25 and 29 kg/m² and 19.75% > 30 kg/m²), while 5.35% were underweight. This inferred that more than half of the diabetic patients were overweight.

Influence of ABO/rhesus blood groups on the prevalence of T2DM

Group O positive was the most prevalent (38.5%) blood group among diabetics, followed by A positive (20.2%), while the least was AB negative (4.5%) (Table 2). A significant difference ($p < 0.05$) was found between group O positive and other blood groups and also between group A positive and other blood groups.

Discussion

This study was conceptualized to determine the influence of ABO blood groups and demographic characteristics on the prevalence of T2DM in Lagos, Nigeria. The

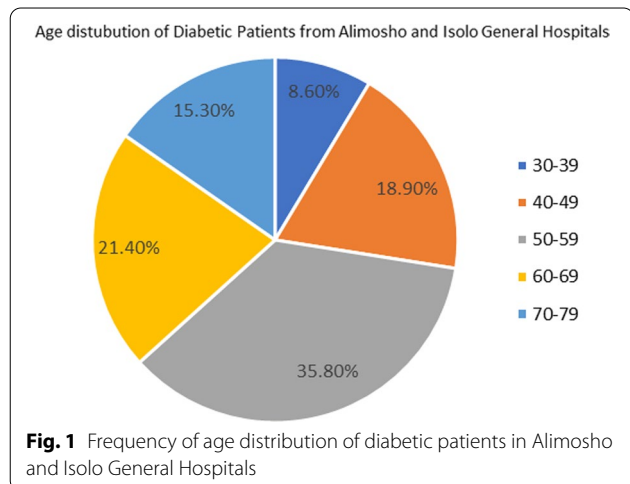


Fig. 1 Frequency of age distribution of diabetic patients in Alimosho and Isolo General Hospitals

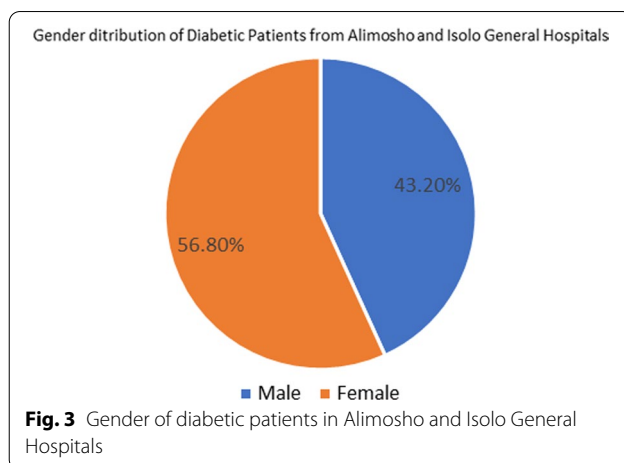
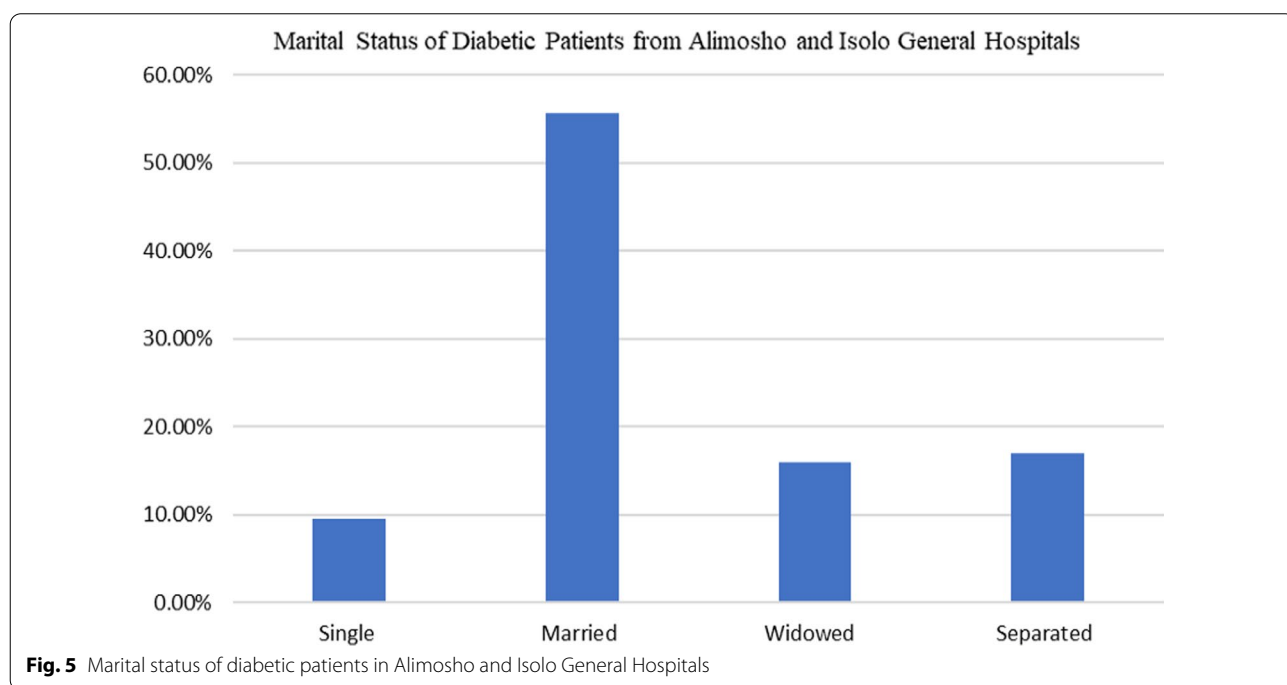
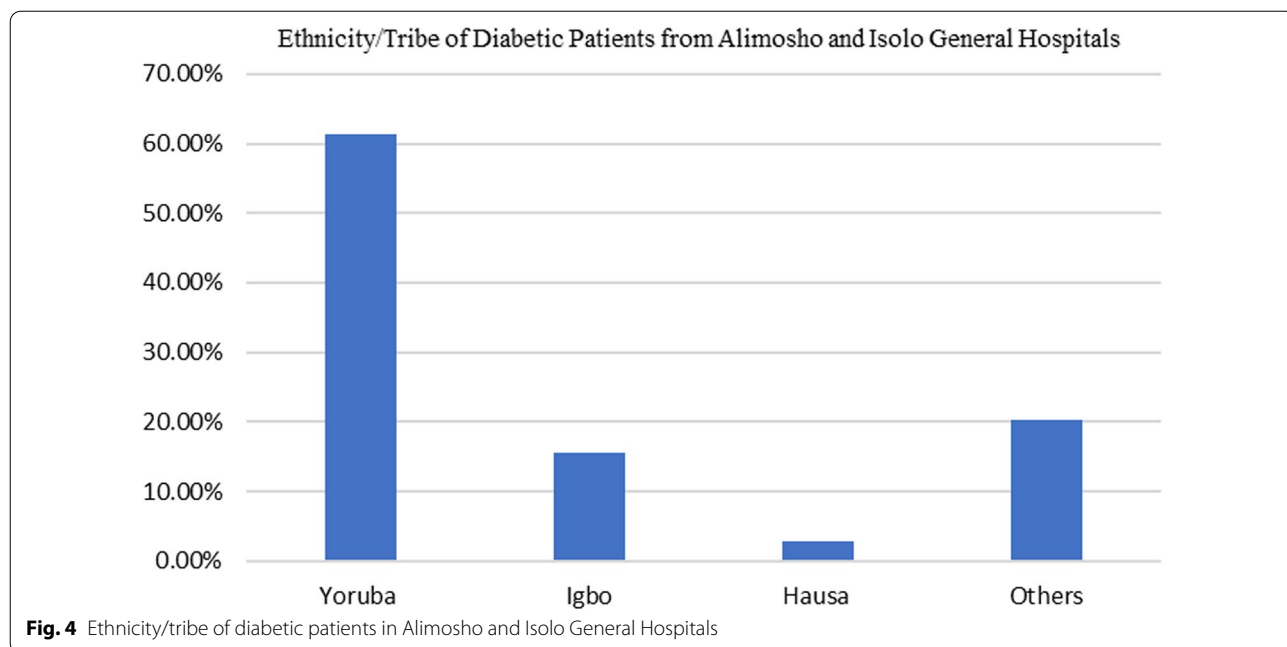


Fig. 3 Gender of diabetic patients in Alimosho and Isolo General Hospitals



increasing prevalence of T2DM with age and dominance of age class 50–69 years among the diabetics (Fig. 1) is consistent with the result of Shittu et al. (2017), who reported the prevalence of 36–60-year age class among type 2 diabetics in southwest Nigeria. Muhammad et al. (2019) also reported a similar result to the current study in which the age group 50–69 years was the most susceptible group to T2DM in the northwest of Nigeria.

Aging increases free fatty acid, which increases the risk of insulin resistance, hyperinsulinemia, and DM (Hardy et al. 2002; Einstein et al. 2010; Mandal et al. 2012). Aging also reduces lean body mass and increases visceral fat, which predisposes to insulin resistance (Ketut et al. 2012). Additionally, mitochondrial function and beta-cell proliferation decline with age, increasing the risks of insulin resistance (Ketut et al. 2012). The decline

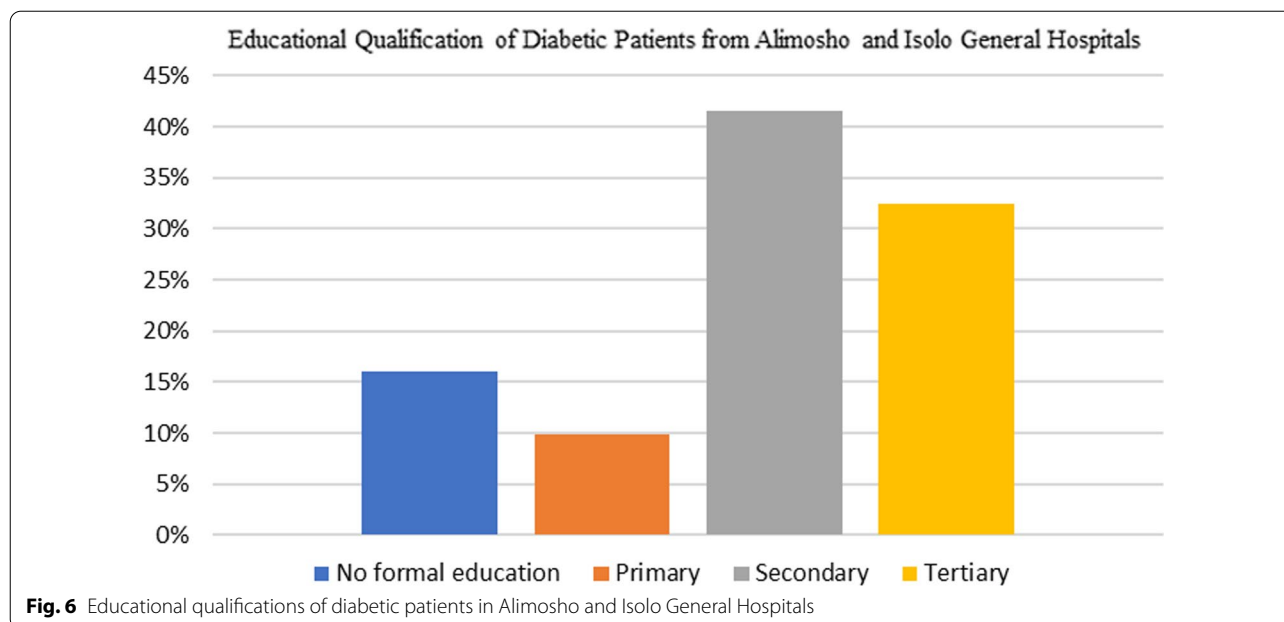


Table 1 Body weight of diabetic patients in Alimosho and Isolo General Hospitals, Lagos

Body mass index (kg/M ²)	Frequency	Percentage (%)
Underweight (< 18)	26	5.35
Normal weight (18.1–24.9)	173	35.60
Overweight (25.0–29.0)	191	39.30
Overweight (> 30)	96	19.75
Total	486	100

in the prevalence of DM at advanced ages (>60 years) noticed in this study could have resulted from the ability of some elderly adults to effectively put DM in check or survive it (Rockwood et al. 1998). Alternatively, glucose intolerance, which increases the risk of several diseases, increases with age and so some elderly adults may die of

other diseases before expressing DM (Rockwood et al. 1998).

The high prevalence of T2DM among females compared to males (Fig. 2) is consistent with the reports of Scavini et al. (2002), Mandal et al. (2012), and Shittu et al. (2017). As stated earlier, aging increases free fatty acid. However, it is more pronounced in females than in males, which may be responsible for the increased prevalence of T2DM among females (Mandal et al. 2012). Hormonal imbalance before and during the menstrual cycle may also increase the risk of some women (CDC 2018). In particular, longer or heavier menstruations may increase food cravings, increasing the risk or worsening T2DM (CDC 2018). Furthermore, females have relatively high estrogen and progesterone which, coupled with their less muscular mass, limits the uptake of glucose (Machado-Alba et al. 2016). Many females compared to males also perform less exercise, thereby unable to burn

Table 2 Distribution of ABO/rhesus blood groups among diabetic patients in Alimosho and Isolo General Hospitals, Lagos

Blood group types	Frequency n (%)	p values	Severe cases n (%)	p values
O Positive	187 (38.5)		64 (34.22)	
O Negative	49 (10.1)	<.00001*	36 (73.47)	<.00001*
A Positive	98 (20.2)		35 (35.71)	
A Negative	29 (6.0)	<.00001*	19 (65.51)	<.00001*
B Positive	41 (8.4)	<.00001*	21 (51.21)	<.00001*
B Negative	27 (5.6)	<.00001*	17 (62.96)	<.00001*
AB Positive	33 (6.8)	<.00001*	18 (54.55)	<.00001*
AB Negative	22 (4.5)	<.00001*	12 (54.55)	<.00001*

Values with an asterisk (*) are significantly different from O and A positive at $p < 0.05$ (Chi-square test)

excess fat, which, coupled with unhealthy diets such as energy-dense diets, increases their risk of T2DM (Bommer et al. 2018). However, the result of the present study contradicts the results of Grant et al. (2009) and Nordström et al. (2016), who reported a higher prevalence of T2DM among males compared to females. Generally, gender differential predisposition to T2DM varied globally, probably due to diverse lifestyle, environmental and socioeconomic factors as well as genetic and epigenetic factors (Kautzky-Willer et al. 2016).

There is a dearth of literature to compare the high prevalence of T2DM noticed among Christians than Muslims and traditional worshippers in this study (Fig. 3). However, a systematic review by Uloko et al. (2018) reported a lower prevalence of T2DM in the Muslim-dominated northern Nigeria compared to the Christian-dominated southern region. A systematic review by Adeloye et al. (2017) also reported a lower T2DM prevalence in the Muslim-dominated Sokoto city in northern Nigeria compared with Christian-dominated Uyo city in southern Nigeria. Rural dwelling and nomadic lifestyle of northern Muslims could be responsible for the relatively low prevalence of T2DM in the region (Adeloye et al. 2017). Rural dwellers often eat traditional foods, which are less energy dense and may reduce the risk of DM. Also, a nomadic lifestyle promotes the shedding of excess fat, reducing the risk of T2DM. On the other hand, urbanization, which is increasing more rapidly in the southern region of Nigeria, is associated with energy-dense Western diets, which increase the risk of DM. The very low number of diabetic traditional worshippers in this study could be due to the relatively low population of traditional worshippers in Nigeria.

There is also a dearth of the literature to compare the high prevalence of T2DM among Yoruba with Igbo and Hausa in the study (Fig. 4). However, Adeloye et al. (2017) showed that the southwest, which contains mainly Yoruba, has 3.2% DM prevalence compared to the northwest (3.0%) and southeast (3.7%), which contain mainly Hausa and Igbo, respectively. In the same vein, Uloko et al. (2018) reported a 4.6% prevalence of DM in the southwest, 5.9% in the northwest, and 9.8% in the northeast. This clearly indicates that Igbo are the most diabetic in Nigeria. Therefore, the relatively high prevalence of T2DM recorded among Yoruba in this study could be due to the high population of Yoruba in Lagos (the study area) compared to other tribes. Genetics as well as environmental factors such as culture, diets, and lifestyle may be responsible for the ethnic differences in the prevalence of T2DM. In particular, Igbo have the highest prevalence (39%) of overweight/obesity in Nigeria compared to 36% and 14% of Yoruba and Hausa, respectively (Okoh 2013; Osayomi 2018).

The low prevalence of T2DM among singles compared to married people in this study (Fig. 5) is consistent with the results of Shittu et al. (2017) and Aldossari et al. (2018). According to Nelson et al. (2018), married couples share the risk of developing T2DM, especially if one is overweight, it is likely the other will have it because they share the same diets. Married men are particularly at risk of developing T2DM if their spouse is obese because most times the wife determines what they eat (Nielsen et al. 2018). Furthermore, the burden of caring for a spouse and the family, especially in places with a poor economy like Nigeria, may increase the risk of many diseases, including T2DM. The relief from this burden after divorce or the death of a spouse may lead to better control of health (Trevisan et al. 2016), including glycemic levels as seen in the relatively low prevalence of T2DM among widowers and divorcees in the current study. Moreover, in Nigeria, couples tend to have regular feeding habits, mostly energy-dense foods such as cassava, yam, and rice, which may increase the risk of T2DM (Aladeniyi et al. 2017). However, the present study is inconsistent with Haines et al. (2018) and de Oliveira et al. (2020) who reported a lower frequency of T2DM among married couples than singles.

The low prevalence of T2DM among people with no formal education and primary education compared with secondary school leavers and graduates of tertiary education (Fig. 6) contradicts all the literature retrieved on the influence of education on T2DM prevalence. Notably, Aladeniyi et al. (2017) observed that low level of education was a risk factor for T2DM in Akure, southwest of Nigeria. In Oke-Ogun, still in the southwest of Nigeria, Shittu et al. (2017) observed that low level of education was a risk factor for T2DM in the area. Aladeniyi et al. (2017) suggested that higher education comes with increasing knowledge of diseases, which informs dietary and lifestyle adjustments, culminating in improved health. Using data on identical twins, Lundborg (2008) observed that higher education levels increase the rate of self-reporting health conditions, which reduce the prevalence of chronic diseases. In another study that used identical female twins' database in the UK, schooling reduced overweight, an important risk factor for T2DM (Amin et al. 2014). Taken together, these showed that the high prevalence of T2DM among individuals with secondary education and above in this study could be an isolated case and can be explained with two hypotheses. One, compared to other studies mentioned above, Lagos (the study area) is a megacity and urbanization has been mentioned earlier as a risk factor for T2DM. Two, in Nigeria, sometimes, higher education is synonymous with high socioeconomic status, which is a predisposing factor for T2DM in the country. In a study of 2149

participants in Ibadan, southwest of Nigeria, increasing socioeconomic status was identified as a risk factor for T2DM (Balogun and Gureje 2013).

The high prevalence of overweight among the diabetics in this study (Table 1) is consistent with the study by Bello et al. (2016), which indicated that the prevalence of obesity (body mass index (BMI) > 30 kg/m²) in Lagos was 22.1%. The finding is also consistent with the study conducted in Oyo state, Nigeria, by Fadupin et al. (2004) in which a majority (83%) of the patients were either overweight or obese. Similarly, a systematic review by Chukwuonye et al. (2013) reported that the prevalence of overweight Nigerians ranged from 20.3% to 35.1%, while the prevalence of obesity ranged from 8.1% to 22.2%. These findings showed that overweight is a modifiable risk factor for T2DM and could have contributed significantly to the diabetic conditions of the population under study. Overweight increases fatty acids and inflammation, leading to insulin resistance and T2DM (Karpe et al. 2011). Overweight causes adiposity, which disrupts metabolism by secreting excess hormones, glycerol, and other substances including leptin, cytokines, adiponectin, and proinflammatory substances, resulting in insulin resistance (Karpe et al. 2011). Adiposity in the pancreas and some organs that utilize glucose worsens insulin resistance, resulting in hyperfunction and exhaustion of beta cells (Cerf 2013).

The dominance of blood group O positive and the least prevalence of AB negative among the diabetics (Table 2) are consistent with the study by Alagwu et al. (2016) who observed that rhesus positive and group O (78%) were the most common blood groups among type 2 diabetic patients in Asaba, Nigeria, followed by A (22%), and the least was AB. Ebeye et al. (2018) also reported a similar finding as the current study among diabetics in Ughelli, Nigeria, in which rhesus positive and blood group O were the most prevalent, followed by B, A, and AB. The less severe T2DM cases among type O and A positive suggest that the relatively high prevalence of T2DM among blood groups O and A positive could mean the two blood groups are protective. According to Fufa and Debelo (2019), the dominance of group O blood could indicate its resistance or protection from diseases, an evolutionary success. Furthermore, non-O blood group individuals often express rs505922 variant at the ABO locus (9q34), which predisposes them to pancreatic cancers and other diabetes-related complications (Amundadottir et al. 2009; Farias et al. 2020). However, some scientists suggest that group O blood is universally common because it is the ancestral ABO blood allele (Cserti and Dzik 2007). A and B alleles appeared in the last 20,000 years and have not spread as much as O in the population (Villazon 2020). Moreover, individuals with blood group O are

arguably more predisposed to being overweight (Shehin and Basila 2019), which is a risk factor for T2DM. In a study conducted in Saudi Arabia, the prevalence of obesity among individuals with O, A, B, and AB blood was 13.7%, 9%, 4.8%, and 2.2%, respectively (Alwasaidi et al. 2017). In another study, over 10% of A positive males had high visceral fat, while over 34% of O positive females had high visceral fat (Behera et al. 2016). This suggests that high body fat could be predisposing group O individuals to T2DM. Additionally, the blood group O allele overexpresses tumor necrosis factor (TNF)-alpha and soluble intercellular adhesion molecule-1 (Alkout et al. 2000; Aggarwal et al. 2018). Overexpression of TNF-alpha is associated with inflammation, which is a cause of insulin resistance and T2DM (Aggarwal et al. 2018). However, the result of the current study contradicts the result of Bener and Yousafzai (2014) who observed more B blood group and less O blood group among diabetic patients in Qatar, United Arab Emirate. Additionally, in a study conducted in France by Fagherazzi et al. (2014), individuals with blood group O had a lower risk of T2DM compared to other blood groups. These variations suggest that the association between ABO blood groups and T2DM is influenced by geographical location, ethnicity, and diversity in biology, among others.

Recommendations

Based on the findings of the current study, the following suggestions are proposed:

- Blood group O and A positive people in the areas need to pay special attention to T2DM because they are highly susceptible to the disease.
- People of other blood groups also need to pay special attention because they have high chances of developing complications from the disease.
- There is a need for public sensitization in the areas regarding the role of overweight in the pathogenesis of T2DM and the need to adopt a healthy lifestyle.

Limitation of the study

The major challenge encountered in this study was limited access to health records of diabetic patients in the selected hospitals. Access to a higher sample size would have boosted our findings.

Conclusion

The results showed that age influenced susceptibility to T2DM in the areas with age classes 50–59 and 60–69 years in that order being the most susceptible age classes. Gender differential predispositions were also observed as females were more diabetic

(56.8%) compared to males (43.2%). Most of the diabetic patients were Christians (69.5%), followed by Muslims (21.4%) and traditional worshippers (9.1%). Yoruba accounted for most of the diabetics (61.3%), followed by Igbo (15.6%) and Hausa (2.9%). However, this could be due to the high population of Yoruba in the study areas. Diabetes was less prevalent among single, widowed, and separated people, while married people were the most diabetic (55.6%). Individuals with no formal education (16.0%) and primary education (9.9%) were the least diabetic, while secondary school leavers (41.6%) and tertiary education (32.5%) were the most diabetic. Approximately 59.05% of the diabetic patients were overweight, suggesting that overweight could be a strong risk factor for T2DM in the area. ABO group O positive was the most prevalent (38.5%) blood group, followed by A positive (20.2%), while the least was AB negative (4.5%). However, severe T2DM was less common among individuals with blood group O and A positive compared to other blood groups. This suggests that the relatively high prevalence of T2DM among blood groups O and A could be a selective advantage by natural selection. This further showed that ABO blood groups influenced susceptibility to T2DM and the severity of the condition in the areas.

Abbreviations

CDC: Center for Diseases Control and Prevention; DM: Diabetes mellitus; IDF: International Diabetes Federations; T2DM: Type 2 diabetes mellitus; WHO: World Health Organization.

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Not applicable.

Authors' contributions

TOY was involved in conceptualization and did literature search, article writing, and correspondence. EOO and MBM did literature search and article writing. ODF and JN did material and data collection. MOS and BMDA did proofreading. All authors proofread and approved the final manuscript.

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Availability of data and materials

All data were analyzed and included in this published article.

Declarations

Ethics approval and consent to participate

The study was approved by the Office of the Study Center, National Open University of Nigeria, Lagos. However, we could not obtain the reference number because the office does not issue reference numbers. The guidelines for conducting research on humans as outlined by the center were strictly followed. Moreover, a written consent was obtained from each participant before recruitment into the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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References

- Abdel Ghafar MT, Shalaby KH, Okda HI, Rizk and F.H. (2020) Association of ABCA1 (C69T) gene polymorphism with dyslipidemia and type 2 diabetes among the Egyptian population. *Meta Gene* 25:100714. <https://doi.org/10.1016/j.mgene.2020.100714>
- Adeleoye D, Ige JO, Aderemi AV, Adeleye N, Amoo EO, Auta A, Oni G (2017) Estimating the prevalence, hospitalisation and mortality from type 2 diabetes mellitus in Nigeria: a systematic review and meta-analysis. *BMJ Open* 7(5):e015424. <https://doi.org/10.1136/bmjopen-2016-015424>
- Aggarwal T, Singh D, Sharma B, Siddiqui SS, Agarwal S (2018) Association of ABO and Rh blood groups with type 2 diabetes mellitus in Muzaffarnagar city. *Nat J Physiol Pharmacy Pharmacol* 8(2):167–170. <https://doi.org/10.5455/njppp.2018.8.0830324082017>
- Aladeniyi I, Adeniyi OV, Fawole O, Adeolu M, Ter Goon D, Ajayi AI, Iruedo J (2017) The prevalence and correlates of pre-diabetes and diabetes mellitus among public category workers in Akure, Nigeria. *Open Public Health J* 10:167–176. <https://doi.org/10.2174/1874944501710010167>
- Alagwu EA, Akukwu D, Ngwu EE, Uloneme GC (2016) ABO/rhesus blood group and correlation with sickle cell disease and type-II diabetes mellitus in south east and South-South of Nigeria. *UK J Pharm Biosci* 4(5):78–82
- Alkout AM, Blackwell CC, Weir DM (2000) Increased inflammatory responses of persons of blood group O to *Helicobacter pylori*. *J Infect Dis* 181(4):1364–1369. <https://doi.org/10.1086/315375>
- Alwasaidi AT, Alrasheed SK, Alhazmi AR, Alfraidi OB, Jameel MA, Alandijani AA (2017) Relation between ABO blood groups and obesity in a Saudi Arabian population. *J Taibah Univ Med Sci* 12(5):407–411. <https://doi.org/10.1016/j.jtumed.2017.05.011>
- Aldossari KK, Aldiab A, Al-Zahrani JM, Al-Ghamdi SM, Abdelrazik M, Batais MA, Javad S, Nooruddin S, Razzak HA, El-Metwally A (2018) Prevalence of prediabetes, diabetes, and its associated risk factors among males in Saudi Arabia: a population-based survey. *J Diabetes Res*. <https://doi.org/10.1155/2018/2194604>
- Amin V, Behrman JR, Spector TD (2013) Does more schooling improve health outcomes and health related behaviors? Evidence from U.K. Twins. *Econ of Educ Rev* 35:10. <https://doi.org/10.1016/j.econeduc.2013.04.004>
- Amundadottir L, Kraft P, Stolzenberg-Solomon RZ, Fuchs CS, Petersen GM, Arslan AA, Bueno-de-Mesquita HB, Gross M, Helzlsouer K, Jacobs EJ, LaCroix A, Zheng W, Albanes D, Bamlet W, Berg CD, Berrino F, Bingham S, Buring JE, Bracci PM, Canzian F, Hoover RN (2009) Genome-wide association study identifies variants in the ABO locus associated with susceptibility to pancreatic cancer. *Nat Genet* 41(9):986–990. <https://doi.org/10.1038/ng.429>
- Anifowoshe AT, Owolodun OB, Akinseye KM, Iyiola OA, Oyeyemi BF (2017) Gene frequencies of ABO and Rh blood groups in Nigeria: a review. *Egypt J Med Human Genetics* 18(3):205–210. <https://doi.org/10.1016/j.ejmhg.2016.10.004>
- Balogun WO, Gureje O (2013) Self-reported incident type 2 diabetes in the Ibadan study of ageing: relationship with urban residence and socio-economic status. *Gerontology* 59:3–7. <https://doi.org/10.1159/000340062>
- Behera S, Sahoo A, Satyanarayana P (2016) Relationship of blood group with body fat percentage, visceral fat, and waist-hip ratio. *Nat J Physiol Pharmacy Pharmacol* 6(6):591–595
- Bello BT, Amira CO, Braimoh RW, Nwizu CC (2016) Obesity among adult Nigerians: relationship with blood pressure, blood sugar, and proteinuria. *Saudi J Obes* 4:68–74

- Bener A, Yousafzai MT (2014) The distribution of the ABO blood groups among the diabetes mellitus patients in Qatar. *Niger J Clin Pract* 17:565–568. <https://doi.org/10.4103/1119-3077.141418>
- Bommer C, Sagalova V, Heesemann E, Manne-Goehler J, Atun R, Bärnighausen T, Davies J, Vollmer M (2018) Global economic burden of diabetes in adults: projections from 2015 to 2030. *Diabetes Care* 41(5):963–970. <https://doi.org/10.2337/dc17-1962>
- CDC (Centers for Disease Control and Prevention) (2018) Diabetes in women. <https://www.cdc.gov/diabetes/library/features/diabetes-and-women.html>. Accessed 3 Dec 2020
- Cerf ME (2013) Beta cell dysfunction and insulin resistance. *Front Endocrinol* 4:37. <https://doi.org/10.3389/fendo.2013.00037>
- Chukwuonye II, Chuku A, John C, Ohagwu KA, Imoh ME, Isa SE, Ogah OS, Oviyasu E (2013) Prevalence of overweight and obesity in adult Nigerians - a systematic review. *Diabetes Metabol Syndr Obes* 6:43–47. <https://doi.org/10.2147/DMSO.S38626>
- Cserti CM, Dzik WH (2007) The ABO blood group system and Plasmodium falciparum malaria. *Blood* 110(7):2250–2258. <https://doi.org/10.1182/blood-2007-03-077602>
- de Oliveira CM, Tureck LV, Alvares D, Liu C, Horimoto ARVR, Balcells M (2020) Relationship between marital status and incidence of type 2 diabetes mellitus in a Brazilian rural population: The Baependi Heart Study. *PLoS ONE* 15(8):e0236869. <https://doi.org/10.1371/journal.pone.0236869>
- Ebeye MO, Aigbiremolen AA, Esegbue PRC, Umom RE, Odigie MO, Igweh JC (2018) Association between ABO, rhesus blood groups, and type II diabetes mellitus among the Urhobos. *Asian Hematol Res J* 1(1):1–6. <https://doi.org/10.9734/AHRJ/2018/37954>
- Einstein HF, Huffman MD, Fishman S, Jerschow E, Heo H, Atzmon G (2010) Aging per se increases the susceptibility to free fatty acid-induced insulin resistance. *J Gerontol A Biol Sci Med Sci* 65(8):800–808. <https://doi.org/10.1093/gerona/glq078>
- Fadupin GT, Joseph EU, Keshinro OO (2004) Prevalence of obesity among type 2 diabetics in Nigeria a case study of patients in Ibadan, Oyo State, Nigeria. *Afr J Med Med Sci* 33(4):381–384
- Fagherazzi G, Gusto G, Clavel-Chapelon F, Balkau B, Bonnet F (2014) ABO and Rhesus blood groups and risk of type 2 diabetes: evidence from the large E3N cohort study. *Diabetologia* 58(3):519–522. <https://doi.org/10.1007/s00125-014-3472-9>
- Farias AJ, Wu AH, Porcel J, Le Marchand L, Wilkens LR, Monroe KR, Maskarinec G, Pandolfi SJ, Setiawan VW (2020) Diabetes-Related complications and pancreatic cancer incidence in the multiethnic cohort. *JNCI Cancer Spectrum* 4(5):pkaa035. <https://doi.org/10.1093/jncics/pkaa035>
- Fufa AW, Debelo DG (2019) Distribution of ABO and Rh (D) blood groups among students attending secondary and preparatory schools in Bote town, Oromia national regional state, Ethiopia. *Int J Sci Technol Educ Res* 10(1):1–8. <https://doi.org/10.5897/IJSTER2019.0448>
- Grant JF, Hicks N, Taylor AW, Chittleborough CR, Phillips PJ (2009) Gender-specific epidemiology of diabetes: a representative cross-sectional study. *Int J Equity Health* 8:6. <https://doi.org/10.1186/1475-2876-8-6>
- Haines L, Coppa N, Harris Y, Wisnivesky JP, Lin JJ (2018) The Impact of Partnership Status on Diabetes Control and Self-Management Behaviors. *Health Educ Behav* 45(5):668–671. <https://doi.org/10.1177/1090198117752783>
- Hardy WR, Meckling-Gill AK, Williford J, Desmond AR, Wei H (2002) Energy restriction reduces long-chain saturated fatty acids associated with plasma lipids in aging male rats. *J Nutr* 132(10):3172–3177. <https://doi.org/10.1093/jn/131.10.3172>
- IDF Africa (International Diabetes Federation) (2019) IDF Africa members: Nigeria. <https://idf.org/our-network/regions-members/africa/members/20-nigeria.html>. Accessed 31 Oct 2020
- IDF (International Diabetes Federation) (2019) Diabetes facts & figures. IDF Diabetes Atlas Ninth edition 2019. <https://www.idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html>. Accessed 31 Oct 2020
- Karpe F, Dickmann JR, Frayn KN (2011) Fatty acids, obesity, and insulin resistance: time for a reevaluation. *Diabetes* 60(10):2441–2449. <https://doi.org/10.2337/db11-0425>
- Kautzky-Willer A, Harreiter J, Pacini G (2016) Sex and gender differences in risk, pathophysiology and complications of type 2 diabetes mellitus. *Endocr Rev* 37(3):278–316. <https://doi.org/10.1210/er.2015-1137>
- Ketut S, Pande D, Semadi MS, Kuswardhani RAT (2012) Age is an important risk factor for type 2 diabetes mellitus and cardiovascular diseases, glucose tolerance, Sureka Chackrewarthy. *IntechOpen*. <https://doi.org/10.5772/52397>
- Lin X, Xu Y, Pan X, Xu J, Ding Y, Sun X, Song X, Ren Y, Sha P (2020) Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025. *Sci Rep* 10:14790. <https://doi.org/10.1038/s41598-020-71908-9>
- Lundborg P (2008) The health returns to education: What can we learn from twins? IZA. Discussion paper no. 3399. <http://ftp.iza.org/dp3399.pdf>. Accessed 11 Dec 2020
- Machado-Alba JE, Medina-Morales DA, Echeverri-Cataño LF (2016) Evaluation of the quality of life of patients with diabetes mellitus treated with conventional or analogue insulins. *Diabetes Res Clin Pract* 116(2):237–243. <https://doi.org/10.1016/j.diabres.2016.04.039>
- Mandal S, Čaušević A, Malenica M, Hadžidedić S, Prnjavorac B, Semiz S (2012) Age and gender related differences in free fatty acid levels in patients with type 2 diabetes mellitus. *J Health Sci* 2(3):184–191. <https://doi.org/10.17532/jhsci.2012.37>
- Muhammad UM, Jiadong R, Muhammad NS, Nawaz B (2019) Stratified diabetes mellitus prevalence for the Northwestern Nigerian states, a data mining approach. *Int J Environ Res Public Health* 16(21):4089. <https://doi.org/10.3390/ijerph16214089>
- Nielsen J, Hulman A, Daniel RW (2018) Spousal cardiometabolic risk factors and incidence of type 2 diabetes: a prospective analysis from the English Longitudinal Study of Ageing. *Diabetologia* 61(7):1572–1580. <https://doi.org/10.1007/s00125-018-4587-1>
- Nordström A, Hadrévi J, Olsson T, Franks PW, Nordström P (2016) Higher prevalence of type 2 diabetes in men than in women is associated with differences in visceral fat mass. *J Clin Endocrinol Metab* 101(10):3740–3746. <https://doi.org/10.1210/jc.2016-1915>
- Okoh M (2013) Socio-demographic correlates of overweight and obesity among women of reproductive age in Nigeria. *Afr J Reprod Health* 17(4):66–76
- Oladele EO, Yahaya TO, Adewunmi OO, David B, Oladipo AJ (2020) Distribution of ABO/rhesus blood groups among hepatitis B virus (HBV) positive patients in Lagos, South-Western, Nigeria. *FUDMA J Sci* 4(3):196–200
- Osayomi T (2019) The emergence of a diabetes pocket in Nigeria: the result of a spatial analysis. *GeoJournal* 84:1149–1164. <https://doi.org/10.1007/s10708-018-9911-2>
- Pastakia SD, Pekny CR, Manyara SM, Fischer L (2017) Diabetes in sub-Saharan Africa—from policy to practice to progress: targeting the existing gaps for future care for diabetes. *Diabetes Metab Syndr Obes* 10:247–263. <https://doi.org/10.2147/DMSO.S126314>
- Qi L, Cornelis MC, Kraft P, Jensen M, van Dam RM, Sun Q, Girman CJ, Laurie CC, Mirel DB, Hunter DJ, Rimm E, Hu FB (2010) Genetic variants in ABO blood group region, plasma soluble E-selectin levels and risk of type 2 diabetes. *Hum Mol Genet* 19(9):1856–1862. <https://doi.org/10.1093/hmg/ddq057>
- Qureshi MA, Bhatti R (2003) Frequency of ABO blood groups among the diabetes mellitus type 2 patients. *J Coll Phys Surg Pak* 13(8):453–455
- Rockwood K, Tan M-E, Phillips S, McDowell I (1998) Prevalence of diabetes mellitus in elderly people in Canada: report from the Canadian Study of Health and Aging. *Age Ageing* 27:573–577. <https://doi.org/10.1093/ageing/27.5.573>
- Scavin M, Stidley CA, Shah VO, Narva AS, Tentori F, Kessler DS (2003) Prevalence of diabetes is higher among female than male Zuni Indians. *Diabetes Care* 26(1):55–60. <https://doi.org/10.2337/diacare.26.1.55>
- Shehin M, Basila V (2019) Correlation between ABO blood groups and body mass index among medical students. *Int J Res Med Sci* 7(10):3878–3881. <https://doi.org/10.18203/2320-6012.ijrms20194325>
- Shittu RO, Kasali FO, Biliaminu SA, Odeigah LO, Sule AG, Musah Y (2017) Prevalence of diabetes and pre-diabetes in Oke-Ogun Region of Oyo State, Nigeria. *J Med Res Health Educ* 1:1
- Trevisan C, Veronese N, Maggi S, Baggio G, De Rui M, Bolzetta F, Zambon S, Sartori L, Perissinotto E, Crepaldi G, Manzato E, Sergi G (2016) Marital status and frailty in older people: gender differences in the Progetto Veneto Anziani longitudinal study. *J Women's Health (larchmt)* 25(6):630–637. <https://doi.org/10.1089/jwh.2015.5592>

- Ugwu E, Adeleye O, Gezawa I, Okpe I, Enamino M, Ezeani I (2019) Burden of diabetic foot ulcer in Nigeria: Current evidence from the multicenter evaluation of diabetic foot ulcer in Nigeria. *World J Diabetes* 10(3):200–211. <https://doi.org/10.4239/wjcd.v10.i3.200>
- Uloko AE, Musa BM, Ramalan MA, Gezawa ID, Puepet FH, Uloko AT, Borodo MM, Sada KB (2018) Prevalence and risk factors for diabetes mellitus in Nigeria: a systematic review and meta-analysis. *Diabetes Therapy Res Treat Educ Diabetes Relat Disord* 9(3):1307–1316. <https://doi.org/10.1007/s13300-018-0441-1>
- Villazon L (2020) Why is type O the most common blood type? *Science Focus*. <https://www.sciencefocus.com/the-human-body/why-is-type-o-the-most-common-blood-type/>. Accessed 25 Feb 2020
- World Health Organization (2013) Definition Diagnosis and Classification of Diabetes Mellitus and its complications. Report of a WHO Consultation. Geneva, WHO
- Yahaya T, Obaroh IO, Oladele EO (2017) The roles of environmental pollutants in the pathogenesis and prevalence of diabetes: a review. *J Appl Sci Environ Manag* 21(1):5–8. <https://doi.org/10.4314/jasem.v21i1.1>
- Yahaya T, Oladele E, Fatodu I, Abdulazeez A, Yeldu Y (2020) Concentrations and health risk evaluation of heavy metals and microorganisms in groundwater in Lagos, Southwest Nigeria. *Journal of Advances in Environmental Health Research* 8(3):234–242. <https://doi.org/10.22102/jaehr.2020.245629.1183>
- Yahaya T, Salisu T (2020) A review of type 2 diabetes mellitus predisposing genes. *Curr Diabetes Rev* 16(1):52–61. <https://doi.org/10.2174/1573399815666181204145806>
- Yahaya T, Shehu K, Isah H, Oladele E, Shemishere U (2019) Toxicological evaluation of the leaves of *Guiera senegalensis* (J.F. Gme), *Cassia occidentalis* (Linn), and *Ziziphus mauritiana* (Lam). *Beni-Suef Univ J Basic Appl Sci* 8:14. <https://doi.org/10.1186/s43088-019-0015-y>
- Yahaya T, Shemishere U (2020) Genetics and pathophysiology of maturity onset diabetes of the young (MODY): a review of current trends. *Oman Med J* 35(3):e126. <https://doi.org/10.5001/omj.2020.44>
- Yamane T (1967) *Statistics, an introductory analysis*, 2nd edn. Harper and Row, New York
- Zahid H, Yahyaoui A, Uwingabiye J, El Khazraji A, El Hadeif R, Messaoudi N (2016) Phenotypic and allelic distribution of ABO and Rh-D blood Groups in Blood Transfusion Center of Avicenna Military Hospital, Marrakech, Morocco. *Int J Med Health Res* 2(1):1–9
- Zghebi SS, Panagioti M, Rutter MK, Ashcroft DM, van Marwijk H, Salisbury C, Chew-Graham CA, Buchan I, Qureshi N, Peek N, Mallen C, Mamas M, Kontopantelis E (2019) Assessing the severity of Type 2 diabetes using clinical data-based measures: a systematic review. *Diabetic Med J B Diabetic Assoc* 36(6):688–701. <https://doi.org/10.1111/dme.13905>

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