Basic Statistics Using ARCGIS And SPSS For Pediatric Diabetes CASE STUDY: THE TIARET REGION.

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Abstract— The healthcare sector has become a field of interest in the last decade due to the effectiveness of added values in helping people find helpful information for improving their well-being. Diabetes is one of the most illnesses that threaten human life and negatively affect the quality of life. Diabetes may appear for several reasons at any age, even in childhood; pediatric diabetes has become more popular recently. Our study case was applied to children in the primary school category to extract meaningful insights and find relations between the geographic region and the affected category of children. This paper also aims to analyze the global epidemiology of diabetes in primary school children in the region of Tiaret as a use case for this study. Challenging that region's lack of medical data, we collected 327 student profiles from 10 primary schools. The collected data was analyzed using Statistical Package for the Social Sciences SPSS as a statistical tool to find the root of diabetes in the Tiaret region.

Keywords— Healthcare, Diabetes, ARCGIS, SPSS, Statistic.

I. INTRODUCTION

Diabetes is one of the most popular chronic diseases widespread in our society. Diabetes does not seem to be age-related. Even children in primary schools are susceptible to diabetes. A variety of internal and external factors can cause infection. Due to the extensive growth of food variety and busy lifestyles, people have been facing the issue of making healthy food decisions to reduce the risk of chronic diseases. [1] A recent study proved that diabetes and obesity are linked to each other this study on American culture characterized by the increasing consumption of sugar-sweetened drinks and food with high calory and fast food and sedentary behavior, targeting adults did not give positive results because of her naivety at this age, focusing on youth may lead to better results.[2] Children in Algeria spend about 8 hours at school daily and are supervised by their teachers, which is catastrophic for a child because one teacher in primary school cannot control more than 30 youth students in class in order to reduce the risks factors of diabetes type 2 which is mainly lifestyle-related and developed over time, the type 1 diabetes is considered as a genetic condition that appears early. Another study that targeted children in primary school proved that reducing the body mass index (BMI) could reduce childhood diabetes type 2.[3] A recent Diabetes UK survey examined the provision of diabetes care in primary schools in the UK and found that if children could not administer their insulin, 70% of schools expected a parent to come and give the injection. [4]. An international collaboration (DAWN Youth study) has provided preliminary data on providing diabetes care in schools, which underlines that this is not just a UK-based problem. [5]. Diabetes-specific legislation is not universal, and medical liability issues prevent school nurses and other school staff from helping children with diabetes in some countries. This report encouraged the development of realistic and practical solutions to the problems of managing diabetes within the school setting. Among other initiatives, the found in [6] is allocated to programs such as the Nutrition and Physical Activity Self-Assessment for Child Care, which seeks to increase the consumption of healthy food and participation in physical activity among children from birth to the age of 5 years old [7].

Type 2 pediatric diabetes is a major health issue and one of the most common endocrine disorders [8]. This type of diabetes has increased quickly over the last decades. A recent study in the USA shows that 190 per 100,000 students in primary school suffer from diabetes[9], about 109.5 per 100,000 in Saudi Arabia [9]. According to the International Diabetes Federation, the annual incidence of type 1 diabetes is 31.4 per 100,000[10].

Clay has played an increasingly important role in a variety of industries. with respect to its composition and structure which give it specific properties and make it useful in many different industrial applications such as artifacts, pharmaceuticals (Produced against the diabete), building materials,

electrochemical sciences, cosmetics, chemical products pharmaceuticals and earthenware, as well as clays playing a vital role in water purification technology. However, for a better use of these materials, it is necessary to eliminate the impurities that constitute them, where there are two main classes of clay purification methods which are: physical and chemical purification.

Clay is considered a particle and a mineral. Thanks to its soothing and healing properties, the clay has many benefits for our health and especially against the dibete,

This paper represents the first work on diabetes in the Tiaret region. 327 students' profile was collected and analyzed using SPSS. Primary results proved that males are more likely to be diagnosed with diabetes than females, and obesity is also related to diabetes. The Ministry of Education should give more priority to physical activities and sports classes in the academic program in primary school to improve child's health and avoid pediatric illnesses that may appear because of the lack of physical activities for the child. And we are also offering a strategy against diabete with the use of clay which is a natural and effective treatment.

The remainder of the article is structured as follows. In Section 2, we present the Use Case that contains a complete description of pediatric diabetes, SPSS, and ArcGIS tools, risk factors, and the data collected and methodology. In Section 3, we represent and discuss the results obtained. In section 4, we represent clay, its different characteristics and its importance against diabetes.

II. USE CASE

- PEDIATRIC DIABETES

The two most common forms of diabetes are type 1 and type 2 diabetes. Both forms can occur at any age, but children are more likely to be diagnosed with type 1 diabetes.

- Type 1 diabetes

Type 1 diabetes occurs when the pancreas does not produce enough of a hormone called insulin. This stops the body from being able to use sugar, which then builds up in the bloodstream. These sugars (also called glucose) that cannot be used by the body pass out in the urine and take water with them.

Type 1 diabetes is when your immune system destroy insulin-making cells in your pancreas. These are called beta cells. While type 1 diabetes can begin at any age, there is a peak period of this condition because it is usually diagnosed in children ***fig.1*** and young people from 5 to 6 and then again at ages 11 to 13. Type 1 diabetes, also called juvenile diabetes. [11]

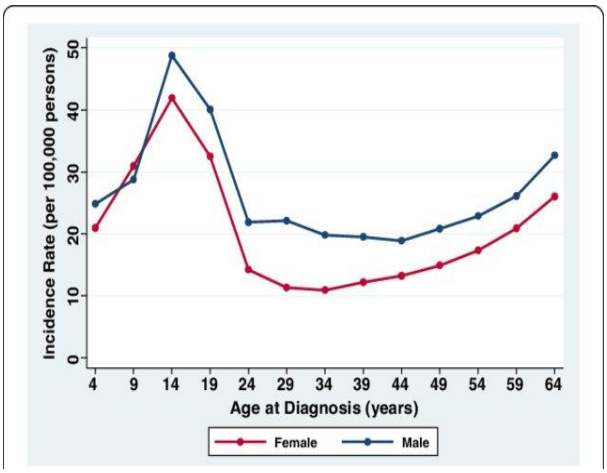

Fig. 1. Incidence rates for type 1 diabetes by age at diagnosis and sex, United States, 2001-2015

Often the first sign is an increase in how often a child urinates, especially at night, and may cause a child who is potty trained to start bedwetting again. There are other vital symptoms, for example, being very thirsty and tired, losing weight, and having an increased appetite. Identifying symptoms of type 1 diabetes early is important. High blood sugar levels and dehydration caused by uncontrolled diabetes are dangerous. They can cause children to need intravenous insulin and fluids in a pediatric emergency room or critical care unit.

- Type 2 diabetes

Type 2 diabetes was once called "adult-onset" diabetes because children hardly ever get it. With rising rates of childhood obesity, however, a growing number of children are being diagnosed with this form of the disease—some as young as ten years old. In addition to weight problems, other risk factors for type 2 diabetes in children include having a family member with the disease and being born to a mother with diabetes while pregnant (gestational diabetes) or other medical problems that affect the way the body handles insulin.

Symptoms are similar to type 1 diabetes and may show up gradually. Darkened areas of skin, especially around the neck or armpits, are also common.

Diabetic children (type 2) become a chronic disease that impacts the way your child's body processes sugar (glucose) for fuel. Without treatment, this disorder causes sugar to build up in the bloodstream, and a high level of glucose in the blood let to very serious long-term consequences. Plenty of studies confirmed that children rarely get infected by type 2 diabetes. [12] Fig.2.

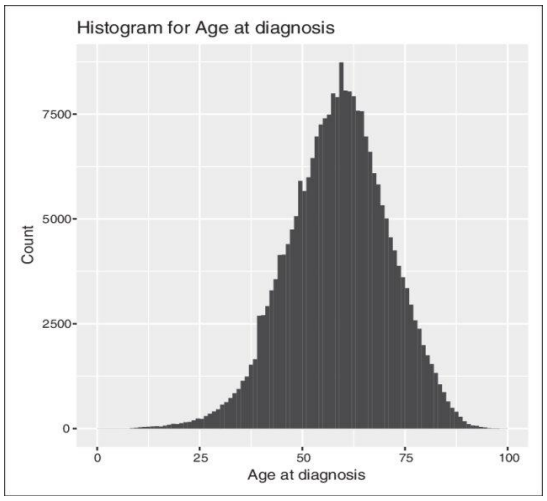

Fig. 2. Histogram of age at onset of type 2 diabetes mellitus in all those without previous cardiovascular disease.

There's plenty you can do to prevent and manage pediatric type 2 diabetes to help your child, including getting enough physical activity and maintaining a healthy weight by keeping your child in a safe BMI level to avoid obesity and thinness and prompt them to eat healthy food if exercises and diet aren't enough to handle and control type 2 diabetes, insulin or oral medication may be needed.

At the end of this section, we can resume the difference between diabetes type 1 and 2 in this table.

TABLE1
FOR THE DIFFERENCE BETWENN DIABETES TYPE 1 AND 2

	Type 1	**Type 2**
What is happening?	Your body attacks the cells in your pancreas, which means it cannot make any insulin.	Your body is unable to make enough insulin, or the insulin you do make doesn't work properly.
Symptoms	The symptoms of type 1 appear more quickly.	Type 2 symptoms can be easier to miss because they appear more slowly.
Management	Type 1 is managed by taking insulin to control your blood sugar.	You can manage type 2 diabetes in more ways than type 1. These include medication, exercise, and diet. People with type 2 can also be prescribed insulin.
Cure and Prevention	Currently, there is no cure for type 1, but research continues.	Type 2 cannot be cured, but there is evidence to say in many cases, it can be prevented and put into remission.

Either type 1 or 2 patients have too much glucose in their blood. This characteristic is the same for both types. The difference between them is how diabetes happens. Type 1 diabetes can be considered an autoimmune condition since the body has attacked and destroyed the cells that produce insulin, which means your body can't make insulin anymore.

- Risk Factors

Diabetes has a huge impact on children's life quality. It is very hard for a child to live and deal with diabetes condition. Children with type 1 diabetes may have many factors that contribute to issues with glycemic control, such as poor compliance with insulin therapy, obesity, obesity, and age. Other factors related to the treatment, like duration of living with the chronic condition of diabetes, the type of insulin therapy they get, and family support, when we talk about the psychological effect that children with chronic illnesses [13][14]. The glycemic control for children becomes a real challenge, especially in school. A child in primary school will never detect that his sugar level has decreased and he needs to raise it up or the reverse when the sugar level increase and he needs to get his insulin. This is one of the challenges that teachers face in primary school to protect their student life. Having high blood glucose (or sugar) levels can lead to serious health complications, no matter whether you have type 1 or type 2 diabetes. So, if you have either condition, you need to take the right steps to manage it [15].

- Statistical Package for the Social Sciences (SPSS)

Data analysis is one of the most flourishing domains right now. It represents the art of extracting meaning or knowledge from data; however, there are many data analysis tools available, and SPSS is one of them. SPSS was launched in 1968 by SPSS Inc. IBM acquired it in 2009. It is a suite of software programs that analyze scientific data related to the social sciences. It offers a fast-visual modeling environment that ranges both small and complex models. We called data obtained from SPSS a survey, data mining, market research, etc. It gained popularity because of the simplicity and the facilities of following command language and a well-documented user manual. It is used for Government entities, educational institutions, survey companies, market researchers, marketing organizations, health researchers, data miners, and many others use it for analyzing survey data.[16]

- ArcGIS

ArcGIS is geospatial software to view, edit and manage and analyze geographic data. ArcGIS, developed by Esri (Environmental Systems Research Institute), develops ArcGIS software in California for desktop, mobile, and web. Their motto is "Science of where" for the location intelligence and analytics it's used by a whole host of academic institutions and departments, both in the humanities and science, to develop and illustrate groundbreaking research. Further, it is used by serval governments and private/commercial institutions worldwide. The system has the capacity to create geographical information accessible throughout a company, privately or publicly, on the internet. Therefore, the software essentially works as a platform whereby geographical information can be linked, shared, and analyzed.

Like many GIS software, ArcGIS creates maps that require categories organized as layers. Each layer is registered spatially so that when overlaid one on top of another, the program lines them up properly to create a complex data map. The base layer is almost always a geographical map, pulled out of various sources depending upon the visualization needed (satellite, road map, etc.). This program has many of them available to users and contains live feed layers, including traffic details.

The first three layers are called feature or vector layers, each containing individual functions distinguished through the platform. These are points (like landmarks and buildings), lines (like roads and other 1D schemata), polygons (like political information and geographical census, called 2D data) raster images (a base vector layer like an aerial picture). Data can be correlated with at least one of these spatial layers and can be both mapped and analyzed, be it through features like demographic changes or via data tables. However, what sets this method apart from its competitors is the complex platform through this mapping, and data can be performed. Therefore, it's a vast-reaching program subject to the latest improvements and updates. It is currently available on Microsoft Windows desktops, although the online program is accessible on many operating systems. As it operates as a platform, users should not wade through pages of information and data; resources are available to decrease and extract specific information from much bigger geographical datasets.

In sum, it's a one-stop solution to data management and analysis as filtered through map construction.[17]

III. METHODOLOGY AND RESULTS

1- DATA SOURCE

Three hundred twenty-seven children's register was collected in this study. Among all registers, only six children were suffering from diabetes. Data were collected from 10 random primary schools in the Tiaret region. In our data-collecting process, we basically aim to determine and extract risk factors that may cause diabetes in other students in order to detect the main cause of diabetes for the six students. The content of our register contains basic information such as age, sex, and BMI values for each student:

$$BMI = \frac{weight(KG)}{hight(M) \times hight(M)}$$

A normal (healthy) BMI for child's generally between 5th and 85th percentile on the CDC growth charts [18].

2- METHODOLOGY

Because of the lack of time, this study was conducted between 15 September and 29 September 2022, with a representative sample of 326 children from 10 random primary schools in the region of Tiaret. The inclusion criteria were children of Tiaret aged younger than 12 years, the collected data included patients and normal cases, and data was collected manually. TABLE 2 represent the form of the collected.

TABLE 2
DATA STRUCTURE

GENDER
AGE
BMI
BREAKFAST
SNACKS
DISTANCE
ARRIVED BY CAR/BUS
SCHOOL LUNCH
CLASS
DIABETIC
OBESE

3- RESULTS

Data were analyzed using Statistical Package for Social Sciences, version 25.0 (SPSS, Inc., Chicago, IL, USA). Data were expressed using frequencies and percentages; analyses were performed using the chi-square test to assess the association between diabetes and its possible associated factors.

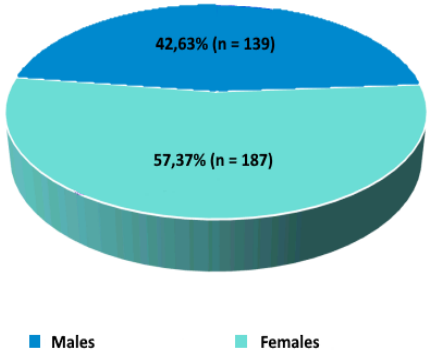

Fig. 3. Primary school children gender in our study.

The study included 326 primary school children. Their age ranged between 5 and 12 years. Approximately 42,63% of the children were males (n = 139), and 57,37% were females (n = 187) (Fig. 3). Children with diabetes represented 2,15% (n=7) of children (Fig. 4), 71,43% of them are males (n = 5) and 28,57% are females (n = 2) (Fig. 5).

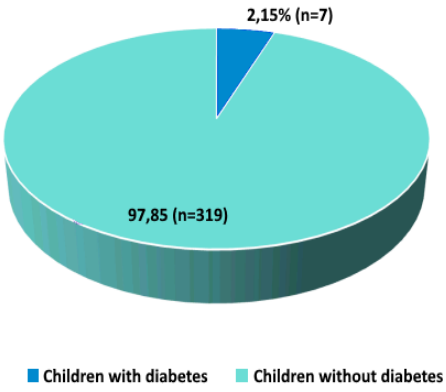

Fig. 4. Prevalence of diabetes among primary school children.

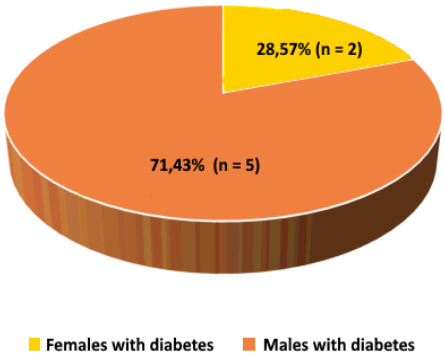

Fig. 5. Children with diabetes gender.

TABLE 3
CHI-SQUARE TEST RESULTS

	Children with diabetes	Children without diabetes	P_value
Gender			0,128
Male (n=139)	5 (3,5%)	136 (96,5%)	
Female (n=187)	2 (1,1%)	183 (98,9%)	
Age			**0,030**
5 (n=33)	0 (0%)	33 (100%)	**(1)**
6 (n=57)	1 (1,8%)	56 (98,2%)	
7 (n=39)	0 (0%)	39 (100%)	
8 (n=55)	1 (1,8%)	54 (98,2%)	
9 (n=43)	0 (0%)	43 (100%)	
10 (n=36)	1 (2,8%)	35 (97,2%)	
11 (n=51)	2 (3,9%)	49 (96,1%)	
12 (n=12)	2(16,7%)	10 (83,3%)	
Breakfast			0,667
No Breakfast (n=69)	1 (1,4%)	68 (98,6%)	
Milk (n=103)	2 (1,9%)	101 (98,1%)	
Milk + biscuit (n=77)	1 (1,3%)	76 (98,7%)	
Other (n=77)	3 (3,9%)	74 (96,1%)	
Distance			0,180
< 200m (n= 115)	4 (3,5%)	111 (96,5%)	
200m to 1km (n=108)	3 (2,8%)	105 (97,2%)	
> 1km (n=103)	0 (0%)	103 (100%)	
Arr. At by Car / Bus			0,235
Yes (n= 78)	3 (3,8%)	75 (96,2%)	
No (n=248)	4 (1,6%)	244 (98,4%)	
Snacks			0,429
No Snacks (n= 78)	2 (2,6%)	76 (97,4%)	
Fruits (n=84)	3 (3,6%)	81 (96,4%)	
Sandwich (n=80)	2 (2,5%)	78 (97,5%)	
Sugar (n=84)	0 (0%)	84 (100%)	
School meals			**0,000**
Yes (n= 277)	2 (0,7%)	275 (99,3%)	**(2)**
No (n=49)	5(10,2%)	44 (89,8%)	
Obesity			**0,001**
Yes (n= 45)	4(8,9%)	41 (91,1%)	**(3)**
No (n=281)	3(1,1%)	278 (98,9%)	

As shown in Table 2, none of the studied socio-demographic factors (Gender, Breakfast, Distance between home and school, Arriving at school by car or bus, and Snacks) were significantly associated or related to diabetes. Only Age, School meals, and Obesity appeared to be significant: (1) 71,43% of a student with diabetes ages range from 10 to 12 years old (p_value = 0,030); (2) 71,43% of students with diabetes avoid school meals (p_value = 0); and (3): 51,14% of students with diabetes are obese (p_value = 0).

Fig.6: Primary schools' distribution in Tiaret city

4- clay and diabete

Clay is one of the oldest materials used by humans. Harvested at even the earth in quarries, we do not find one but clays. On the one hand specific structure, as well as multiple properties, clays respond to many directions. Clay is deformable, transformable, adherent, flowing, slippery, fixing and thus has many capacities among which the transport, the capture, release of liquid, gaseous, but also solid, living substances, and dead[19].

The interest given in recent years to the study of clays by many laboratories in the world is justified by their abundance in nature, the importance of surfaces they develop, the presence of electrical charges on this surface and especially the exchangeability of inter-foliar cations. The latter, also called compensating cations, are the main elements responsible for hydration, swelling, plasticity and thixotropy. They thus give clays hydrophilic properties[20].

Clays belong to the family of silicates, and we will see it more precisely about phyllosilicates[21], where the term clay finds its origin in the Greek word argilos derived from argos which means white, then its translation into Latin: argilla. This nomination by the ancients is apparently due to the color of the material used in ceramics[20].

The use of clay requires purification where its process is normally performed to eliminate non-clay materials, such as

salts and non-soluble minerals, and non-suspended clay particles, serving to concentrate only the clay portion and make its rheological properties more stable and controllable. Purification is a necessary and critical stage that guarantees the reproducibility of results and give clay the characteristics that make it suitable for industrial applications[22][23].

A. Historical or theoretical uses of clay.

The clay was previously used for all the following situations:
Acidosis; animal bites; blood purification; cancer ; cardiovascular disorders; constipation ; detoxification; diarrhea ; dysentery; Eye disorders; Metabolic disorders - nervousness, insomnia, rheumatism, liver and biliary conditions, diabetes mellitus: clay baths and diluted clay to drink.

B. Physico-chemical properties of clays

1. **Load of clay surfaces**: Clay minerals carry a net electrical charge that must be compensated by the adsorption of ions of opposite sign from solution. Depending on its origin, this charge is either "permanent", that is to say independent of the physico-chemistry of the medium, or "variable" depending on the composition of the solution, particularly depending on the pH [24].
2. **The specific surface:** The specific surface represents the total surface (AS) per unit mass (M) and is generally expressed in m2/g [25]. The fine size of clay minerals gives them a large surface area relative to the volume of the particles[26].

The properties of clays are mainly controlled by their internal and external surface. The total surface includes the outer surface, between the clay particles, and the inner surface, corresponding to the interfoliar space[27].

- DISCUSSION & CONCLUSION

Only three factors were significates and associated with diabetes (Age, School meals, and Obesity). Several factors may also be related to such as Physical activities within schools or at home and family diabetes history (genetic factor).

Fig. 6 shows the primary-school distribution all over Tiaret city. It is conspicuous that schools are distributed all over the city, with an average distance between them estimated at hundreds of meters only, this is what makes most children attend their schools with less physical effort, besides the absence of sports class which means burning fewer calories, and thus directly affects their obesity factor.

What we also noticed is the spread of stores selling sweets that contain large quantities of sugar near schools, at a rate of two stores for each school. With most parents giving pocket money to their children, they tend to purchase sugar without their parent's supervision. For this reason, more efforts are needed to increase awareness among primary school teachers, staff, and parents to control sugar consumption.

Diabetes type one is almost impossible to avoid because it's related directly to genetic reasons, but controlling a child's activities and healthy nutrition such as drinking diluted clay will reduce the possibility of diabetes and many other diseases.

Further research with a large sample to extract more significant and associated factors to diabetes is needed.

IV. REFERENCES

[1] A. Robertson *et al.*, “Food and health in Europe: a new basis for action.,” *WHO Reg. Publ. Eur. Ser.*, no. 96, 2004.

[2] E. W. Gregg and D. Ph, “edi t or i a l s DoAre Children the Future of Type 2 Diabetes Prevention ?,” pp. 10–12, 2010.

[3] D. Foster *et al.*, “A School-Based Intervention for Diabetes Risk Reduction,” *N. Engl. J. Med.*, vol. 363, no. 5, pp. 443–453, 2010, doi: 10.1056/nejmoa1001933.

[4] F. MacMillan, A. Kirk, N. Mutrie, F. Moola, and K. Robertson, “Supporting participation in physical education at school in youth with type 1 diabetes: Perceptions of teachers, youth with type 1 diabetes, parents and diabetes professionals,” *Eur. Phys. Educ. Rev.*, vol. 21, no. 1, pp. 3–30, 2015, doi: 10.1177/1356336X14534367.

[5] K. Lange, C. Jackson, and L. Deeb, “Diabetes care in schools--the disturbing facts.,” *Pediatr. Diabetes*, vol. 10 Suppl 1, pp. 28–36, 2009, doi: 10.1111/j.1399-5448.2009.00613.x.

[6] N. Nurjannah, K. M. Baker, and D. P. Mashinini, “Spatiotemporal trends in diabetes-related mortality by school district in the state of Michigan, United States,” pp. 1–12, 2021.

[7] L. Gilmore, “Michigan Early Child Care: Improving Nutrition and Physical Activity Standards,” *CDC website*, 2016, [Online]. Available: https://www.cdc.gov/nccdphp/dnpao/state-local-programs/pdf/program-highlights/ece-mi.pdf

[8] T. Ngwiri, F. Were, B. Predieri, P. Ngugi, and L. Iughetti, “Glycemic Control in Kenyan Children and Adolescents with Type 1 Diabetes Mellitus,” *Int. J. Endocrinol.*, vol. 2015, 2015, doi: 10.1155/2015/761759.

[9] K. S. Aljabri and S. A. Bokhari, “Glycemic Control of Patients with Type 1 Diabetes Mellitus in Saudi Community,” *J. Diabetes Metab.*, vol. 04, no. 04, 2013, doi: 10.4172/2155-6156.1000256.

[10] S. Webber, *International Diabetes Federation*, vol. 102, no. 2. 2013. doi: 10.1016/j.diabres.2013.10.013.

[11] M. A. M. Rogers, C. Kim, T. Banerjee, and J. M. Lee, “Fluctuations in the incidence of type 1 diabetes in the United States from 2001 to 2015: A longitudinal study,” *BMC Med.*, vol. 15, no. 1, pp. 1–10, 2017, doi: 10.1186/s12916-017-0958-6.

[12] N. Sattar *et al.*, “Age at Diagnosis of Type 2 Diabetes Mellitus and Associations With Cardiovascular and Mortality Risks: Findings From the Swedish National Diabetes Registry,” *Circulation*, vol. 139, no. 19, pp. 2228–2237, 2019, doi: 10.1161/CIRCULATIONAHA.118.037885.

[13] N. M. Hamburg *et al.*, “Physical inactivity rapidly induces insulin resistance and microvascular dysfunction in healthy volunteers,” *Arterioscler. Thromb. Vasc. Biol.*, vol. 27, no. 12, pp. 2650–2656, 2007, doi: 10.1161/ATVBAHA.107.153288.

[14] U. Ekelund, S. Brage, S. J. Griffin, and N. J. Wareham, “Objectively measured moderate- and vigorous-intensity physical activity but not sedentary time predicts insulin resistance in high-risk individuals,” *Diabetes Care*, vol. 32, no. 6, pp.

1081–1086, 2009, doi: 10.2337/dc08-1895.
[15] M. I. Schmidt *et al.*, “Identifying individuals at high risk for diabetes: The Atherosclerosis Risk in Communities study,” *Diabetes Care*, vol. 28, no. 8, pp. 2013–2018, 2005, doi: 10.2337/diacare.28.8.2013.
[16] A. P. Field, *Discovering statistics using SPSS: and sex and drugs and rock “n” roll (2nd Edition)*. 2005.
[17] A. Fauzan, “Getting Started with Arc GIS GI S by ESRI”.
[18] D. M. B. Hall and T. J. Cole, “What use is the BMI?,” *Arch. Dis. Child.*, vol. 91, no. 4, pp. 283–286, 2006, doi: 10.1136/adc.2005.077339.
[19] F. Hernot, “L’argile, son utilisation à l’officine,” *Dépôt Univ. Nummérique des Étudiants (Université Angers)*, p. 139, 2016, [Online]. Available: http://dune.univ-angers.fr/fichiers/20073109/2016PPHA5426/fichier/5426F.pdf.
[20] M. C. Nassima, “Memoire de Magister Epuration des eaux usées: l’ élimination des micropolluants dans les eaux usées par un matériau argileux,” *Thèse*, pp. 1–138, 2012.
[21] L. Talc and J.-F. Robert, “Fiches détaillées,” pp. 2–4, 2011, [Online]. Available: www.lasim.org/images/doc_gratuite/argiles.pdf
[22] I. D. S. Pereira, V. C. Silva, J. F. Duarte Neto, G. A. Neves, H. C. Ferreira, and R. R. Menezes, “Influence of the purification of bentonite clay from new deposits in the state of Paraíba-Brazil for use in water-based drilling fluids,” *Ceramica*, vol. 64, no. 372, pp. 538–546, 2018, doi: 10.1590/0366-69132018643722402.
[23] M.-P. Teulade-Fichou, “Targeting quadruplex nucleic acids: From chemical biology tools to drug prototypes,” *J. Ind. Environ. Chem.*, vol. 03, p. 2019, 2019, doi: 10.4066/2591-7331-c1-008.
[24] L. Bouna. Fonctionnalisation des mineraux argileux d'origine marocaine par Tio2 en vue de l'élimination par photocatalyse de micropolluants organiques des milieux aqueux. Thèse de doctorat. Université de Toulouse (2012), 298 pages.
[25] F. Hubert. *Modélisation des diffractogrammes de minéraux argileux en assemblages complexes dans deux sols de climat tempère. Implications minéralogique et pédologique.* Thèse de doctorat, Université de Poitiers (2008), 223 pages.
[26] F. Valencia. *Caractérisations des particules fines d'un matériau granulaire de fondation par l'essai au bleu de méthylène.* Rapport GCT-2008-0, Département de génie civil faculté des sciences et de génie, Université LAVAL (Canada), 2008.
[27] B. Velde. *Chapter 2: Composition and Mineralogy of Clay Minerals, in "Origin and Mineralogy of Clays, Clays and Environment*" Ed Springer, (1995), 8 - 41p.