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Diagnosing and Treating Diabetes in Rural Jamaica

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☒ By checking this box, I indicate that my mentor has read and reviewed my draft proposal prior to submission

Abstract

Objective: This research study was conducted to determine the correlation between finger stick glucose and finger stick hemoglobin A1c values in order to draw conclusions about the redundancy of the two tests in a rural Jamaican traveling clinic setting. *Methods:* This study was conducted using de-identified data from an electronic health record used in clinics in St. Mary's Parish, Jamaica. A correlational analysis was completed using the glucose and A1c variables to determine both the direction and strength of the correlation. *Results:* A positive correlation of 0.654549 was found in analysis. This correlation did not meet the set threshold for test redundancy of 0.8 which is of importance to clinical staff who must make decisions about resource distribution in the clinics of interest.

Key Words: diabetes mellitus, fingerstick A1c, Jamaica

Introduction/Literature Review

Diabetes mellitus is a condition that affects people worldwide. Diabetes manifests as hyperglycemia and, if not sufficiently diagnosed and treated, can lead to a host of health complications and financial burdens for both individuals and health systems. In developing nations, such as Jamaica, where healthcare may be delivered in low resource, clinic-based settings, it may be a challenge to provide gold standard diagnostic testing. For this reason, it is important to determine the best, feasible set of diagnostic testing.

As mentioned, diabetes is a disease whose prevalence is expanding worldwide. Ferguson, Tulloch-Reid, and Wilks[3] narrowed their research to just examine diabetes in the Caribbean. In their research, Ferguson, et al.[3] assessed epidemiological studies on diabetes across the Caribbean through a review of published literature and health and governmental reports. The authors cited that, currently, increasing prevalence of diabetes exists in Caribbean nations. Studies also project even greater prevalence in the coming years, which was the motivation for this literature review. Authors broke their findings down by nation as a way to assess country-specific reasons for increasing prevalence. They followed this with a report of implications for the Caribbean nations, as a whole. Authors of this study concluded that diabetes continues to be a public health issue in developing Caribbean nations. They commented on the implications this has on each country's finances now and in the future.

In a similar study, Dr. Micheal Boyne[2] examined factors involved in the increased prevalence of diabetes in only the English-speaking Caribbean nations. He performed an extensive literature review including 131 articles. He found that the prevalence of obesity and type II diabetes is higher in many of these Caribbean countries than in other developing nations. Boyne's summarized the findings in his literature review and postulated that this difference is a

result of genetics, lifestyle, early life factors like birth weight, and other metabolic factors. Increased rates of type II diabetes put residents of these nations at higher risk of other health complications, such as cardiovascular issues. He claims that this raises concern, not just for the health of the nation, but for the economic burdens that could be placed upon these developing nations that are losing productive members due to chronic illnesses, like diabetes. His overarching conclusion is these developing nations must come up with public health solutions to halt the progression of disease prevalence among their citizens.

Opinions differ on both the accuracy and validity of different tests used in the diagnosis of diabetes. Barrett, Huggman, and Johnson[1] sought to test several of these methods. In their study, they compared four different screening methods for the diagnosis of diabetes in an adolescent, Jamaican population. This study was born out of concern of increasing obesity and type II diabetes prevalence in Jamaica and the authors' belief that screening should begin earlier for these diseases because of Jamaica's lack of healthcare resources. This study included 59 high school students recruited randomly from schools across Jamaica. Each of these students underwent a finger stick glucose, finger stick cholesterol, and finger stick HbA1c test. The values of these tests were compared with the values collected from a venous blood draw. Barrett, et al. found high levels of agreement between finger stick glucose and the venous draw. In terms of finger stick HbA1c and finger stick cholesterol, researchers found that there was a significant deviation from the venous draw, however, they concluded that this difference is not enough to completely exclude the use of these tests. Overall, the authors believed that each of the three finger stick tests was found to be valid enough to be used as screening tests in this Jamaican adolescent population, especially in resource-poor areas. The authors did, however, warn that

finger stick HbA1c and cholesterol tests should be met with caution as they did show statistically significant deviations from the venous blood standards.

Beyond simply questioning the validity of HbA1c testing, some in the medical community have questioned whether the use of HbA1c for diagnosis and screening is even appropriate use of such testing. In his study, Higgins[4] reports the positive and negative view on HbA1c testing as both screening and diagnostic testing through an analysis of previous literature. He begins his analysis with a report on the traditional uses of HbA1c, which is monitoring and observation of glycemic control. Higgins first reviews reasons support for HbA1c testing in diagnosis and screening. The list includes no patient preparation for testing, the more forgiving nature of HbA1c measurements for biological variability and recent changes in a patient's physiological state (i.e. stress, diet, etc.), and that microvascular complications are better predicted by HbA1c values. He follows this discussion with objections to screening and diagnostic uses of HbA1c measurements. First, these objections state that glucose and HbA1c values do not correlate as well in non-diabetics as they do in diabetics. Second, critics claim that HbA1c testing is more expensive, and thus not always an option for low resource nations. Finally, Higgins includes the argument that biological variation in HbA1c is too high for diagnostic purposes. Overall, Higgins concludes that there is much disagreement about the effectiveness of HbA1c testing for diagnosis and screening. He supports the position that there may exist a need for more than one test for diagnostic purposes. This could include the use of both a glucose test and an HbA1c test for diagnosis.

Diabetes mellitus is a worldwide condition that Ferguson, Tulloch-Reid, & Wilks[3] project only increases in prevalence in coming years. It will, thus, be important to find appropriate diagnostic testing that will work within each healthcare setting to diagnose patients early and

avoid some of the complications and burdens described by Boyne[2]. In a developing nation, such as Jamaica, this setting is sometimes composed of low resource, traveling clinics. It is, thus, important to determine how much and what kind of testing is necessary for appropriate treatment of patients, while also remaining feasible in this setting that lacks resources. Finger stick glucose and finger stick HbA1c testing are two testing measures that have been used in these clinics previously. Barrett, Huggman, & Johnson[1] validated the use of these tests, especially in low-resource settings, but included some reservations about their accuracy. Unwin, et al.[5] shared a similar distrust in HbA1c values because, according to their research, there was too wide of a margin of error that could lead to undiagnosed diabetics or over-diagnosed pre-diabetics. Arguments of advocators and objectors to the use of HbA1c were summarized by Higgins[4] and exposed some of the same arguments. Overall, there still remains a gap in knowledge about appropriate care for this specific Jamaican clinic setting. Continuation of research in this area could provide healthcare professionals with a better solution for testing their patients.

Hypothesis/Specific Aims/Research Questions

The main research question is whether a correlation exists between random finger stick glucose measurements and HbA1c measurements taken in patients in a Jamaican clinical setting. For this research question, I hypothesize that if a patient's finger stick glucose and HbA1c values are compared, then there will be a positive correlation that exists. The second research question takes into consideration the practical implications of this correlation and asks how does this correlation impact the need for both types of diagnostic testing for hyperglycemia in a Jamaican clinical setting. For this question, I hypothesize that the correlation will not be above a threshold of 0.8, such that, it would not be necessary to use both finger stick glucose and HbA1c testing in the diagnosis of hyperglycemia in this Jamaican clinical setting

Methods

Context/Protocol/Data Collection

Before examining and analyzing the data, approval was sought for this project from the Wright State University IRB. The project was determined to be exempt from IRB research requirements. To answer both of the stated research questions, data was retrieved from a de-identified data set. This data set was originally acquired from OpenEMR, an electronic health record used in the setting of the rural Jamaican clinics of interest. Specific data points include age, sex, BMI, glucose readings, and HbA1c readings. The data reflect measurements of finger stick glucose and finger stick HbA1c values that have been collected and recorded into the OpenEMR electronic health record during trips made by students and health professionals with American Caribbean Experience, in coordination with the Ministry of Health. These measurements were obtained in clinics in St. Mary Parish in Jamaica from July 1, 2016 through July 31, 2018. The finger stick glucose measurements were acquired with blood glucose meters and the HbA1c measurements were taken with an HbA1c meter called the A1Cnow^{+} system. The data set includes measurements from only those patients with both glucose and HbA1c measurements taken at the same clinic visit, creating a sample size of data from thirty-four patients.

Data Analysis

The values of age, sex, and BMI are used to define the dataset and give more information about the population being tested. To answer the first research question, a quantitative analysis was employed to determine the correlation between finger stick glucose and HbA1c

measurements. This analysis took place in excel using the correlational analysis function. The findings were also used in the analysis of the second research question.

Results

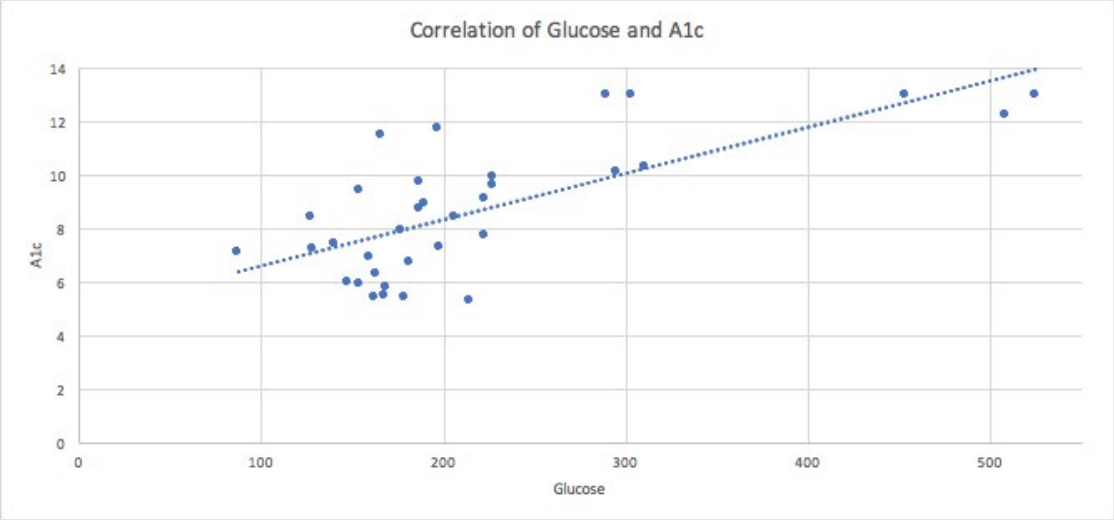
Data from thirty-four patients was analyzed. Twenty-three (67.65%) of the patients were female and eleven (32.35%) of the patients were male. The mean and median age of the patients in the data set was 57.1 years and 57.2 years respectively. Body Mass index was available for twenty-two of the patients, which had a mean value of 29.49, falling into the overweight category.

Patient ID	Finger stick glucose	Finger stick A1c
1	178	5.4
2	159	6.9
3	206	8.4
4	154	5.9
5	166	11.5
6	187	8.7
7	163	6.3
8	453	>13
9	289	>13
10	181	6.7
11	87	7.1
12	187	9.7

Patient ID	Finger stick glucose	Finger stick A1c
13	222	7.7
14	189	8.9
15	222	9.1
16	214	5.3
17	310	10.3
18	140	7.4
19	127	8.4
20	197	11.7
21	295	10.1
22	162	5.4
23	154	9.4
24	525	13

Patient ID	Finger stick glucose	Finger stick A1c
25	128	7.2
26	177	7.9
27	198	7.3
28	227	9.9
29	147	6
30	303	>13
31	167	5.5
32	168	5.8
33	508	12.2
34	227	9.6

The table above describes the data used in this study. It is important to note that the finger stick A1c meter identified values extending to 13.0. Measurements above this value were recorded as >13 by the A1Cnow^{+} system.



The graph above shows the relationship between finger stick glucose and finger stick hemoglobin A1c values. The correlation between these two values was found to be positive 0.654549.

Discussion

This study was built around the question of whether or not a positive correlation exists between finger stick glucose and finger stick hemoglobin A1c tests. I hypothesized that the correlational analysis would show that a positive correlation exists when these two values were collected from patients at the same visit. This hypothesis was based upon the idea that high levels of glucose in the bloodstream have increased ability to glycosylate hemoglobin which is the value read in the A1c test. Upon analysis of the data, the correlation was found to be a positive value, which was consistent with expectations.

The second research question was intended to extend upon the first question and potentially have practical implications on the testing that the clinics of interest will use moving forward, namely, whether the strength of correlation between the two variables is so strong as to render the use of both tests redundant. Correlations represent the relationship between two variables and can have a value between 0 and 1. The relationship is between two variables is found to be stronger when the correlation is closer to the value of 1. My hypothesis is that if the correlation is above the threshold of 0.8, then the tests show strong agreement and it would be redundant for patients to undergo both tests. The result of the analysis was a correlation of strength 0.654549. This value did not exceed the predetermined threshold. The conclusion is that the two variables do not have so strong a relationship to be considered redundant.

The question of redundancy is important in this clinical setting. These clinics are limited by the amount of resources available. Finger stick A1c testing, thus, presents challenges. First, finger stick A1c testing is more expensive than traditional finger stick glucose testing. In a resource limited setting, it is important to allocate resources to testing and materials that most benefit patients. Hence, the question of redundancy is one that has implications on whether or not resources should be allocated to running the finger stick A1c tests. Another issue with finger stick A1c is the challenge of running the test itself. The test has a specified temperature range, and the clinics of interest are often warmer than the upper limit of the temperature range. This leads to the challenge of cooling the tests and keeping them in the correct temperature range to be used. Given the outcome of the study, it would appear that, depending on the amount of resources able to be spared, finger stick A1c testing is worth some of the challenges that performing the test may pose.

These results are meaningful in the context of the specific patient population in which the data was collected. The calculated correlation was not an exact 1:1 correlation. An exact correlation is not expected because a finger stick glucose is a point in time measurement of the glucose whereas the A1c is an average over the previous three months. One challenge for the use of glucose, is that these clinics come into an area for one day only and the patients that visit stand in line, sometimes all day, to be seen by staff. This makes glucose testing particularly challenging in that patients are not guaranteed to be fasting when the measurements are taken. Glucose measurements may be significantly elevated above fasting levels depending on the timing and content of their last meal. Challenges may arise in using these measurements in treatment decisions. Thus, A1c testing is potentially a beneficial tool in this setting as A1c is thought to provide a better idea of glycemic control in a patient's recent past.

Previous research has implications on the current study. Dr. Micheal Boyne[2] explained that there is a need for changes in public health to occur in Caribbean nations in order to combat the increasing prevalence of diabetes. Other researchers have gone on to study some potential answers to this public health question. Barrett, Huggman, & Johnson[1], Higgins[4], Unwin, et al.[5] have all focused their studies on hemoglobin A1c testing which is the topic of the current study. Barrett, Huggman, & Johnson[1] and Higgins[4] both researched and then drew conclusions about using A1c tests in screening and diagnosis. The researchers supported the conclusion that there are several drawbacks to using hemoglobin A1c testing, but they concluded that, despite the issues posed by the testing, it may still be beneficial to continue to use A1c testing in screening and diagnosis. This supports the results of the current study which found that A1c testing may be indicated along with glucose testing. Unwin, et al.[5], on the other hand, supported the opposite conclusion. They concluded that A1c testing should be mistrusted due to the wide margin of

error of the test. They suggested that the testing could lead to over or underdiagnoses of diabetics. In the clinical setting of interest, this could be harmful. Both clinics and patients have low access to resources. It is important that patients are only being treated for the medical conditions that they have and resources are not wasted on medical conditions that are not severe enough to warrant treatment. Overall, previous research illustrates a need new public health measures in Caribbean nations like Jamaica, although there are ambiguous conclusions about the utility of hemoglobin A1c testing.

Conclusion

Limitations of this study exist. The first limitation of the study is the relatively small patient population. De-identified data from patients was only included in the study if they had both finger stick glucose and finger stick A1c done during the same clinic visit. Additionally, the data was only collected from patients who visited the clinics in the past two years. This timeframe has to do with the initiation of finger stick A1c testing in the clinics. While a larger sample size would likely not impact the positive nature of the correlation, the strength of the correlation between the two variables may be influenced.

Generalizability is also another potential limitation. This study was performed using data from traveling rural clinics in St. Mary Parish, Jamaica. This clinical environment has unique challenges that may differ from many other clinical environments. In the clinics, there is a lack of resources. On such is that the rural clinical settings do not provide the opportunity to run laboratory blood tests. This means that A1c measurements must be done by fingerstick. In previous research done by Barrett, Huggman, and Johnson[1], it was shown that there is a significant deviation of fingerstick A1c from venous blood values. However, the authors concluded that there was still utility in using the test results. Further, the A1Cnow^{+} system could

be a limitation of the study. This system reports fingerstick A1c measurements. The measurements are reported out in value up to 13.0. Any values of A1c read by the system as being above 13.0 are reported by the system as >13.0. This is a potential limitation because it alters the correlational analysis

In the future, this research could be furthered in a couple of ways. First, the research could be extended to adolescents. Current literature, such as, articles written by Barrett, Huggman, and Johnson[1] and Dr. Michael Boyne[2] explain the rising incidence and prevalence of type 2 diabetes mellitus in Caribbean nations like Jamaica. Barrett's article specifically talks about screening of adolescents and how this may impact the course of diabetes by diagnosing early or catching those at risk before diagnosis. Expanding the current study to include adolescents from the clinics of interest can give a better idea of what testing, if any, is beneficial for screening younger patients in this patient population. If a strong indication for this testing exists, adolescents at risk of diabetes as evidenced by high finger stick glucose and finger stick A1c, can have interventions early.

This study can be furthered to discuss medical management of patient's diabetes. Before finger stick A1c testing was implemented in the clinics, patients were only subjected to finger stick glucose. There are drawbacks to using only finger stick glucose for deciding upon medical management of diabetes, including, especially in this setting, the variability of values given type and timing of last meal. Hemoglobin A1c could be beneficial in this setting because it may give a better idea of what the patient's glycemic control is over a longer period of time. Research could continue to determine if there is a difference between the medical decision physicians make about pharmaceutical treatment based upon finger stick glucose alone versus both glucose and

A1c values. The outcomes of the study would have great impact on further diminishing redundant testing in clinic.

In conclusion, a positive correlation was found between finger stick glucose and finger stick hemoglobin A1c in this patient population, confirming that both glucose and A1c values rise together. When the strength of correlation was analyzed, it was found to not meet the set threshold of 0.8. This lead to the conclusion that the relationship between the two tests is so strong that the tests to be considered redundant in screening and diagnosing diabetes. This is an important consideration for the clinics of interest which have limited resources and need to decide how to distribute them. The results of the study suggest that it may be beneficial for resources to be allocated for both finger stick glucose and finger stick A1c testing to benefit patients seen in these rural Jamaican clinics.

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