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Racial Disparities with the HbA1c Screening Test for Type-2 Diabetes

Introduction

Diabetes is a disease that affects every 1 in 8 people. The same is true about the number of Black people with this disease. This might not seem shocking at first, but this means that the diabetes rate for Black Americans is 60% higher than that of White Americans. About 13% of Black people are diagnosed with diabetes compared to the 7% of non-Hispanic White Americans. I introduce these facts to show that statistically, Black people are more likely to have diabetes. It is also evident that Black people are extremely underrepresented during clinical trials and research. What are the consequences of underrepresentation and assumptions in the medical industry? Black patients have faced these consequences since before it was legal to operate on a Black individual.

There is an increasing number of studies that support the findings that the quantitative Hemoglobin A1c test is disproportionally misdiagnosing Black patients. A genetic variant most commonly found amongst Black patients is one reason why they are repeatedly underdiagnosed.

This variant causes the Glucose-6-phosphate dehydrogenase deficiency, the root of which is due to a failing enzymatic protein of the same name, which is found in 1 in 10 African American males in the United States. G6PD causes red blood cells to undergo hemolysis or prematurely break down. It artificially lowers the value of blood sugar in the HbA1c test, which specifically affects the diagnosis of patients with type 2 diabetes.

"We estimate that if we tested all Americans for diabetes using the HbA1c test, we would miss type 2 diabetes in around 650,000 African Americans. However, the HbA1c test remains a suitable test for diagnosing and monitoring diabetes for the majority of people," Says Dr. Inês Barroso

Dr. Barroso acknowledges the thousands of potentially undiscovered cases of type 2 diabetes but supports the test due to its overall effectiveness for the rest of the population. Many doctors and physicians agree with this reason, but there are flaws in the thinking that nothing can be done about it.

Though the HbA1c test is effective for many patients, this overlooks the hundreds of thousands of Black people who show the most cases of diabetes, while showing the least effectiveness through this test. This underlines how medical testing can reinforce healthcare inequality and disparities even if done unintentionally. It raises questions about racial equity in medicine from the lack of diversity in research, from the consequences of creating devices based on majority populations, and from ignoring said research that shows the ineffectiveness for minority populations who are most impacted. I am most interested in this topic because I want to pursue a career in developing medical devices and technology. Understanding the flaws within the medical industry and flaws impacting my community enlightens me as to why it is crucial

that we have professionals who care. We must create systems that work with accuracy for diverse populations rather than assuming or going along with the notion that one universal standard applies to everyone. I will catalog the biological and systemic factors that contribute to these inaccuracies, the consequences of improper diagnoses, and the ethical and moral responsibilities of the medical field to create better diagnostic screenings that work for everyone.

A Background on Diabetes

Type 2 diabetes is a metabolic disease in which the body cannot produce enough insulin or becomes resistant to insulin. The human body uses insulin to regulate the blood glucose levels, and it is extremely necessary to allow glucose to move from the bloodstream to cells to be used for energy and energy storage. Defects can lead to a metabolic imbalance responsible for diabetes. Type 2 diabetes is affected by the genetics of a person and the environment. Genetic factors can present when exposed to an environment fostered by a caloric diet or 'sedentary lifestyle'. It is also extremely important to note that patients with different ethnic backgrounds can have and present specific phenotypes that increase risk factors that include hypertension, insulin resistance, and dyslipidemia(an imbalance of lipids in the blood).

According to the World Health Organization (WHO), this chronic metabolic disease is triggered by deficient pancreatic islet β-cells' insulin release, which is 90% of cases, or by tissue insulin resistance and an inadequate compensatory insulin secretory response. Insulin resistance is a developing research topic with data suggesting that more than just pancreatic systems contribute to malfunctioning insulin β-cells and α-cells. Other organs involved can be the liver,

skeletal muscle, kidneys, and even the brain. Researchers are seeing dysregulation, inflammation, and more as important physiological factors of this disease. Improper insulin production and function lead to an accumulation of glucose in the blood. Eventually, elevated blood sugar levels damage blood vessels, organs, and nerves throughout the body. These factors can lead to neuropathy, heart disease, kidney failure, and loss of vision.

There are many different ways that doctors can diagnose diabetes. One of the earliest used methods is fasting plasma glucose testing, which requires fasting for hours before blood is drawn. Another is the glucose tolerance test, which measures blood sugar levels before and after drinking a glucose-heavy drink. Though sometimes these methods can be effective, they are inconvenient because they require fasting or multiple blood draws, which can be critical when facing a patient presenting complications of diabetes.

The “Glycemic Gap” is an acute or short-term glucose index level test upon patient admission, compared to the HbA1c test, which measures 2-3 months' average glucose levels. The difference is the immediate test that measures hemoglobin levels in the instant- the short term, and the HbA1c test, which measures levels over the course of 2 to 3 months- the long term. This is relevant in cases dealing with high red blood cell turnover count. When a patient has a High blood cell turnover rate, it can lower the value of their HbA1c due to the shortened lifespan. This can lead physicians, doctors, and researchers to underestimate the severity of an entire group of people's diabetes. Not only can the glycemic Gap represent a medical issue, it can manifest these systemic problems we face when discussing health accessibility, diversity, and research and clinical trials, but also unequal care all around.

The HbA1c Test As A Gold Standard

The HbA1c test is the most popular and ideal test because of its efficiency and simplicity. Hemoglobin is a protein inside red blood cells that carries oxygen throughout the body. Glucose naturally attaches to this hemoglobin protein over time and gets transported. The diagnostic test measures the percentage of hemoglobin coated with glucose, which allows doctors to estimate average blood sugar levels over 2-3 months, the lifespan of a red blood cell. When hemoglobin levels are above 6.5%, it means a patient is positive for diabetes.

There's a wide range of analytical techniques used to quantify hemoglobin levels. The International Federation of Clinical Chemistry and Laboratory Medicine has established two proposed reference methods: electrospray ionization mass spectrometry and capillary electrophoresis. Both of these methods target glycanated N-terminal valine of the referenced hemoglobin β chain. This meticulous analytical process utilizes enzymatic digestion with the protein Glu-C to release the N-terminal hexapeptide to separate and quantify the glycated and non-glycated hexapeptides. Hemoglobin is the ratio of glycated peptides to total hexapeptides. Though there's even a downside to these two methods. The IFCC methods are said to be 1.5% to 2% lower than other values due to the differences and the glycinated diffractions used. They even suggest that it's not used for routine clinical use but is a standard for commercial research and testing. By painting an image of the wider range of testing used from the same training test for the same disease, it is unnerving to see clear inaccuracies being the standard.

Dr. William Herman and Dr. Robert Cohen advocate for thorough screenings in the medical field. They and other physicians believe that using one system of diabetic screening can skyrocket the possibilities of a misclassification or misdiagnosis of diabetes or not having diabetes. Even the American Diabetes Association (ADA) has recognized numerous potential limitations of a diagnosis of diabetes using HbA1c. They leave the method of diagnosis up to the health care provider due to the wide array of factors that could interfere with HbA1c levels. This also changes some criteria left up in the air because of the unique patient background and conditions. An extremely important limitation of the diagnostic test for diabetes is that a lesser part of a third of the variance is explained by normal factors that vary day to day. Glycemia, age, sex, and body mass index (BMI) are all factors that contribute to HbA1c levels.

“This suggests that at or near normal glucose levels, where HbA1c has been recommended for the diagnosis of diabetes, glycemia is a less important determinant of hemoglobin glycation and other factors operate to produce consistent changes in HbA1c.” Dr. Herman and Cohen support this in their paper about the racial and ethnic implications for the diagnosis of diabetes, endorsed by PubMed Central and The Journal of Clinical Endocrinology & Metabolism.

The suggestion of a preliminary diagnosis assumes that all patients' red blood cell turnover rates are the same as the standard. With the same systems in place and the same diagnostic screening test as the universal standard, it is not a surprise that many black Americans slip through the cracks when it comes to being diagnosed, generally. In a field that systematically ignores the differences or similarities black people have anatomically with said standard, it is hard to advocate against the entire history of medicine.

Flawed Systems and Screenings

The timely efficiency of the test is not the only reason doctors use it. They also like to administer this test due to the cost-effectiveness compared with the timeliness, which argues a hard case for it to be the first and only test taken. It has significant meaning that the price is a large contributing influencer as to why patients don't receive full care. That would be all the difference between a diet or a diagnosis. Cost should never be a determining factor in whether a patient can have full care that should be rightfully allocated to them. Not only will the price affect their care and the accuracy of diagnosis, but it will also affect their quality of life after the diagnosis because this can place even greater burdens on people already facing healthcare inequality.

It was clear that racial and ethnic differences were always prevalent when screening HbA1c, yet this red flag was ignored due to assumptions that it was created by a lack of quality of care and access to care. The medical industry has failed Black Americans by making assumptions and conducting improper and inequitable research.

Under v.s. Over Diagnosed

Most commonly researched conditions are high altitude, pregnancy, and blood transfusion that result in falsely low HbA1c values. Any disease that involves red blood cells or hemoglobin/ glucose production can interfere with or mislead doctors about the result of the

standard screenings. Diseases such as sickle cell anemia, anemia, kidney failure, or liver disease can result in the longevity of a red blood cell dwindling and artificially lowering HbA1c levels. This is why professionals know that patients must be interpreted cautiously before fully confirming a diagnosis.

Oftentimes, a falsely high hemoglobin value can be linked back to insufficient or low iron in the blood. Lower or insufficient iron can result from an iron deficiency anemia, infection-induced or tumor-induced anemia. Other genetic deficiencies, hemoglobinopathies, Such as a B12 deficiency or thalassemia, can cause a falsely high level. Others are hypertriglyceridemia, organ transplantation, or hyperglycation, commonly found in mostly African ethnic groups.

Systemic Racism and Consistent Homogeneous Baselines in the Medical Field

Until recently, primarily White populations were being researched for clinical trials while excluding racial minorities. This clear exclusion of black people from research has developed many negative consequences in the medical field today. As a result, many medical standards were developed without fully considering the biological diversity of America. An example of not only exclusion but also exploitation was the Tuskegee Syphilis Study. This was when Black men with syphilis were intentionally left untreated without informed consent. This was a violation constructed by an industry that portrays itself as healing and protecting as its sworn duty. In 2026, not much has changed. We still face this failure to prioritize black patients

equally, represented in the disproportionality of Black people diagnosed with diabetes versus how many Black people are included in the clinical study and research of this disease.

It is good to acknowledge that Healthcare disparities are not always created intentionally by discrimination. Today, disparities occur because systems are constructed to follow patterns and assumptions that don't apply to everyone equally. Previously, I have studied how pulse oximeter is, and other diagnostic algorithms have performed differently across racial groups. Due to the light capture and melanin interference, the medical device is shown to overestimate oxygen levels in patients with more melanin, i.e., darker skin tones.

While the HbA1c test wasn't purposefully designed to harm Black patients, the assumption that the standard applies to further racial and ethnic groups than those tested on does not equate to helpful research specifically focusing on Black patients.

Author's Take on Real-Life Solutions

To make a medically significant change, clinicians dealing with type 2 diabetes should completely understand the significance of the HbA1c screening and what the values mean. It's also important to look not only at the values but also at the whole patient and their medical background. I am thankful to have the opportunity to discover this disparity so I can change it in the near future. Though proposing a higher accuracy test for Black patients will take many years of research and knowledge of technology, there are tools and devices to monitor diabetes that also need improving. At home, diabetic neuropathy screening tests can be improved with better

accessibility and mobility features for patients with peripheral neuropathy. These are consistent and gradual improvements that are attainable and can help thousands with diabetes.

Ethical Responsibility and A Moral Shift to Medical Innovation

Until the systems in place change and there is further research proving that disparities in Black patients, individual students, professionals, and researchers have to place the responsibility of being non-biased and aware of all possibilities that could shift their perspective of a diagnosis on them. My challenge to healthcare providers is to find a balance between individual and equitable public medicine and health standards. It is important to pinpoint racial disparities instead of breeding assumptions and ignorance because this is what allows systems of inequality to continue.

My perspective on medical technology and engineering has changed because the tools we develop are human-made. The devices do not account for the lack of diversity during development and testing. It is up to us as scientists and engineers to include all aspects of anatomy and biological differences so as not to unintentionally disadvantage certain populations. Our responsibility as engineers is not only to create functional tools but also to ask questions about who these tools are built for and who can benefit the most.