FEATURE ARTICLE

Benchmarking Diabetes Technology Use Among 21 U.S. Pediatric Diabetes Centers

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The American Diabetes Association's *Standards of Care in Diabetes* recommends the use of diabetes technology such as continuous glucose monitoring systems and insulin pumps for people living with type 1 diabetes. Unfortunately, there are multiple barriers to uptake of these devices, including local diabetes center practices. This study aimed to examine overall change and center-to-center variation in uptake of diabetes technology across 21 pediatric centers in the T1D Exchange Quality Improvement Collaborative. It found an overall increase in diabetes technology use for most centers from 2021 to 2022 with significant variation.

The use of diabetes technology, including continuous glucose monitoring (CGM) systems and insulin pumps, is associated with improved clinical outcomes and improved quality of life (1–16). The American Diabetes Association's (ADA's) *Standards of Care in Diabetes—2023* recommends the use of technology for all youth with type 1 diabetes, with an individualized approach (17,18). Although CGM and pump use is increasing worldwide, usage rates in the United States lag behind other high-income nations (19). Individuals of lower socioeconomic status and individuals from minority groups have decreased utilization of technology and poorer outcomes (4,19,20).

Barriers to technology adoption can occur at the patient, provider, and structural levels. Patient-level barriers can include a reluctance to wear diabetes devices, concerns over the device adhesive not working or causing allergic reactions, worsening of diabetes distress, or inadequate information regarding the benefits of technology use (21,22). Provider-level barriers to technology can include inadequate time for staff education, paperwork requirements, or implicit bias (23–25). Structural barriers include a lack of or inadequate insurance coverage, overly burdensome eligibility criteria to qualify for technology, or high out-of-pocket costs (22).

The T1D Exchange Quality Improvement Collaborative (T1DX-QI) is a learning health network created in 2016 in the United States. Pediatric and adult diabetes centers in the T1DX-QI use continuous quality improvement (QI) methodology and real-world electronic health record (EHR) data to improve the health of people with type 1 diabetes at the population level (26). The Collaborative allows for benchmarking of data and provides opportunities for participating centers to share best practices. As the T1DX-QI has grown from 10 original centers to 55 centers across the United States, it is important to understand differences in technology use across these centers' populations, identify opportunities for improvement, and determine the need for advocacy to decrease structural barriers.

Research Design and Methods

Data Collection

Participating centers in the T1DX-QI share data on population-based metrics, which are updated monthly. The data are shared from the EHR systems at each institution to the T1DX-QI data registry. For this study, data on CGM and insulin pump use, excluding automated insulin delivery

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(AID) systems, from 21 pediatric diabetes centers that had a complete dataset available during the study dates were analyzed over 6-month periods from January to June 2021 and from January to June 2022 (Supplementary Table S1). Average CGM and pump use during that time was determined at the center level. Centers were located throughout the United States to ensure that all regions of the country were represented and were grouped according to geographical location (Figure 1). Centers were de-identified and randomly assigned letters for this study.

Statistical Analysis

Medians and interquartile ranges (IQRs) were calculated for CGM and pump use at the center level and at the Collaborative level.

Results

The T1DX-QI Includes a Heterogenous Group of Centers

A total of 21 pediatric centers across four geographical regions contributed data to this analysis (Table 1). One-fourth of centers served fewer than <1,000 patients with type 1 diabetes, whereas 29% served >2,000 patients with type 1 diabetes per year. In 19% of the centers, more than half of the patients were publicly insured.

CGM Use Is Highly Variable Among T1DX-QI Centers

Data on CGM use are summarized in Figures 2 and 3. CGM use in the 21 participating centers ranged from a low of 31% to a high of 90% in 2021 (Figure 2A) with a median of 66% (IQR 56.5–77%). During the same period in 2022, CGM use ranged from 23 to 90%, with a median of 81% (IQR 72.5–83%). Between 2021 and 2022, 20 of the 21 centers had an increase in CGM use, while one center did not have a change. Only one center was in a state that did not have public insurance coverage for CGM but was still above the median for CGM use (70% and 83% for 2021 and 2022, respectively). However, there was no statistically significant difference in CGM use between centers with and without CGM coverage by public insurance plans. Most

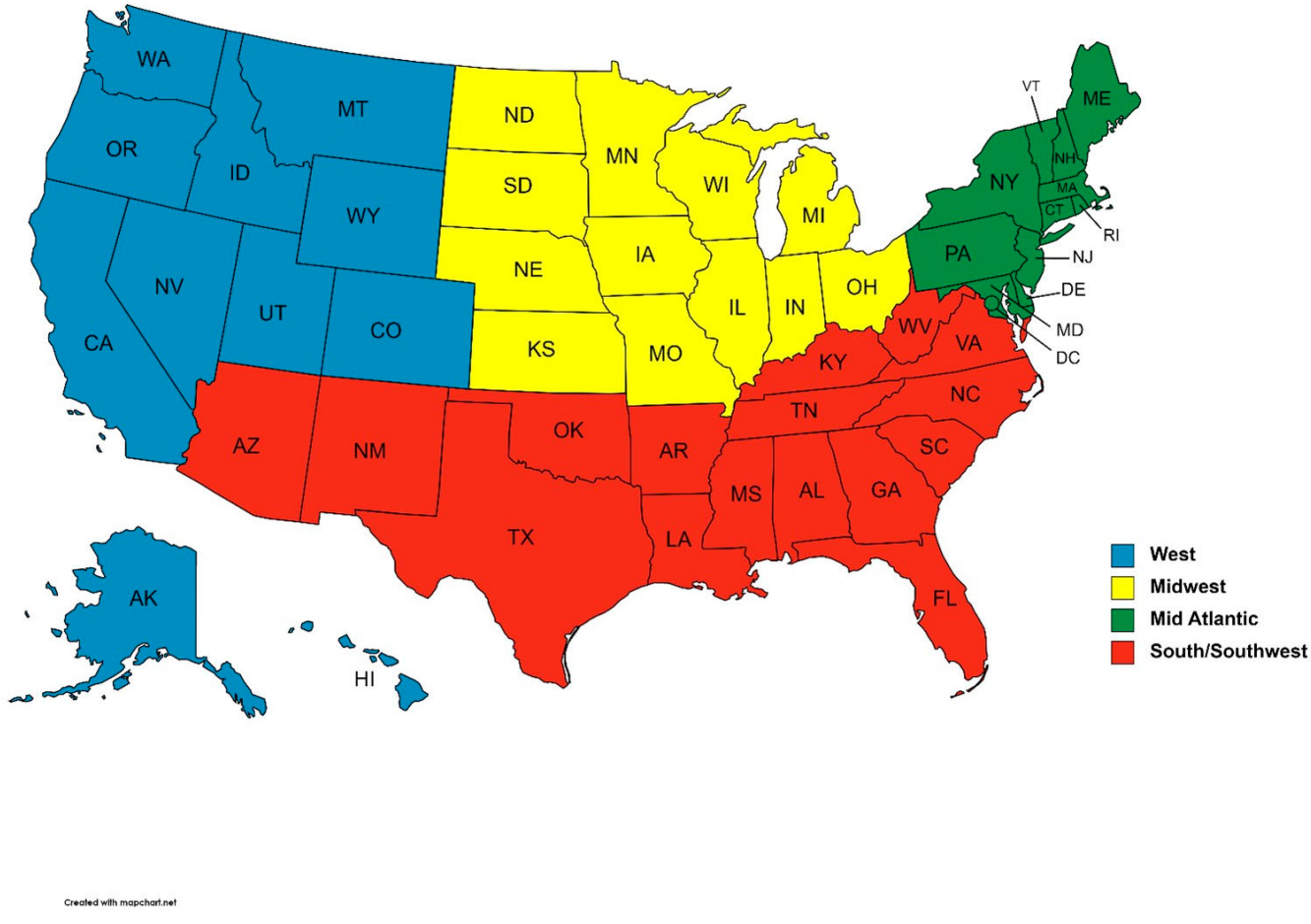

FIGURE 1 Geographical region distributions.

TABLE 1 Demographic Information for Participating Pediatric Centers (*N* = 21)

Characteristic	Centers
Center size (number of patients with type 1 diabetes served annually)	
<1,000	5 (24)
1,001–1,500	5 (24)
1,501–2,000	4 (19)
>2,001	7 (33)
Patients with public insurance, %	
≤35	6 (29)
36–50	11 (52)
>51	4 (19)

Data are *n* (%).

centers in the West (3 of 5) and Midwest (4 of 6) regions had GCM percentages above the median, whereas centers in the South and Southwest (2 of 6) and mid-Atlantic (2 of 4) regions fell below the median (Figure 3A).

Insulin Pump Use is Highly Variable in the T1DX-QI

Data on insulin pump use are summarized in Figures 2 and 3. Like CGM use, insulin pump use (excluding AID systems) among the centers in the T1DX-QI is also highly variable. In 2021, the median pump use was 51% (IQR 36–66.5%), with a range of 12–79% (Figure 2B). In 2022, the median pump use was 52% (IQR 41.5–69.5%), with a range of 17–81%. Between 2021 and 2022, 17 centers had an increase in pump use, ranging from 1 to 15%. Of the five centers experiencing a decrease in pump use, the decrease ranged from 1 to 5%. Centers from the West (3 of 5) and Midwest (5 of 6) trended above the median (Figure 3B). Most centers in the South and Southwest (5 of 6) and Mid-Atlantic (2 of 4) regions fell below the median in use of insulin pumps.

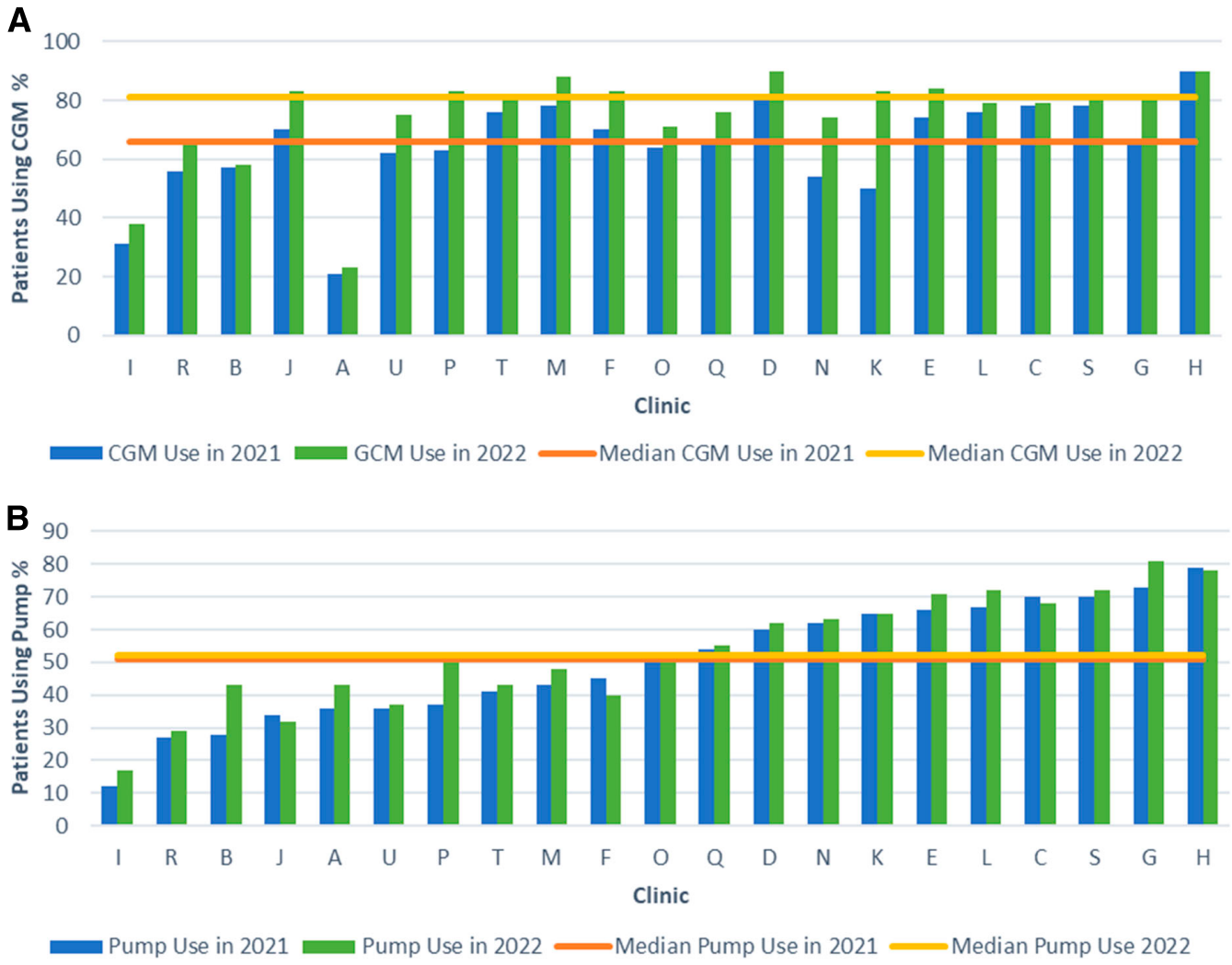

FIGURE 2 Median CGM (*A*) and insulin pump (*B*) use by clinic in 21 T1DX-QI sites in 2021 (blue) and 2022 (green).

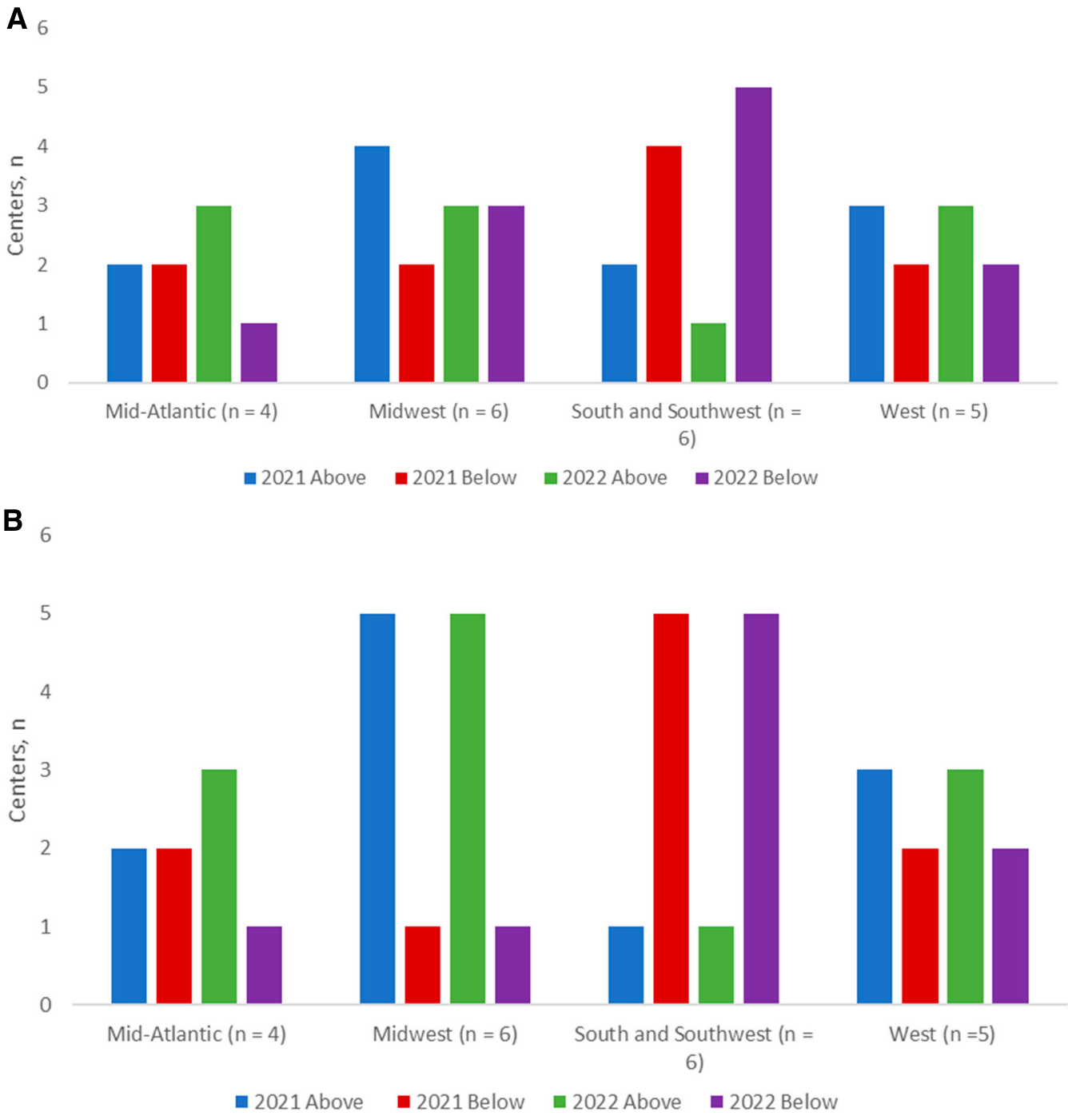

FIGURE 3 CGM (*A*) and insulin pump (*B*) use by region relative to the median usage of 21 clinics in the T1DX-QI. For each geographical region, the number of centers above and below the median are shown.

Rates of Pump and Sensor Use Are Not Always Related

To determine whether usage rates for insulin pumps and CGM are related, the use of pumps and CGM were compared against the median and characterized as "above" or "below" the median (Figure 3). The Midwest region showed little to no change in pump and CGM use between 2021 and 2022. The Mid-Atlantic region's improvement in the use of pumps mirrored that of CGM, with both increasing from 50% in 2021% to 75% in 2022. The South and Southwest regions trended down in CGM use from 2021 to 2022 and showed no change in pump use during that time period. The West's use of CGM and pumps remained constant at 60% each in 2021 and 2022.

Discussion

The use of diabetes technology is varied across the centers in the T1DX-QI. Among sites in 2021, CGM use varied from 21 to 90%, while pump use varied from 12 to 79%. In 2022, CGM use across the Collaborative increased, while pump use was relatively stable.

There appears to be some regional variations in technology use, with the highest rates found in the Midwest and West and the lowest rates the South and Southwest regions. Although insulin pumps have generally had coverage for patients on both private and public insurance, coverage for CGM use by youth with public insurance has only recently improved. This improved coverage may, in part, explain the larger increase seen in CGM uptake versus pump uptake.

Structural barriers may be contributing, in part, to some of the differences we found in technology use. Insulin pumps are typically covered by both public and private insurers, but CGM coverage is only available in a subset of centers for individuals with public insurance. In addition, youth with public insurance may have to meet certain strict criteria for CGM and/or pump coverage in some states (27–30). For example, some public insurers require that a person perform at least four blood glucose checks per day for 30 days before being eligible for CGM coverage. These requirements often make it extremely difficult for high-risk patients to access technology, which can further worsen disparities. Although we saw lower rates of technology use in individuals with public insurance, these differences were not statistically significant, which may, in part, have been the result of our small sample size. However, structural barriers do not appear to be the only factor contributing to differences in technology use across centers.

Provider-level barriers also may be contributing to some of the variation in technology use within the T1DX-QI. In previous years, the time needed to learn about new technology, educate patients about it, and complete paperwork to secure insurance coverage of CGM was associated with decreased CGM use (31). It may be important for members of the diabetes care team to have protected time to learn about new diabetes technology, train patients, and perform follow-up visits. It is also important to have enough support staff available to assist with the paperwork and authorization process. In this analysis, we were unable to assess other barriers, but there is work suggesting that providers' implicit bias may also affect diabetes technology adoption (25,32,33).

In addition to provider-level barriers, there may be patient-level factors that could be contributing to variations in technology use. We were unable to assess for these in our analyses, but it is important to address patient-level barriers in QI efforts.

As diabetes technology advances AID systems become more accessible, concerted QI efforts by motivated teams with adequate support staff will likely be necessary to increase technology use and address barriers at the patient, provider, and structural levels (31,34). Clinics in the T1DX-QI have implemented various QI initiatives to increase technology access. Future work should evaluate these various QI initiatives and identify those that have had the most success for broader dissemination.

Strengths and Limitations

The data from this study were derived from the T1DX-QI, which is the largest type 1 diabetes registry in the United States. The strength of this study lies in the large number of participating centers, representing different regions and populations across the country.

These data have some limitations, which should be noted. The data presented here are from a subset of pediatric diabetes centers in the United States. There is likely a selective bias regarding which centers participate in the T1DX-QI and have the ability to share patient-level data. In addition, we only captured data on the use of diabetes technology and did not capture data on barriers to or facilitators of technology use at the various sites.

Conclusion

This study shows that diabetes technology use is varied across clinical centers in the United States. Closing gaps in technology adoption rates will be increasingly important as diabetes technology continues to evolve and advance. The ADA and the International Society of Pediatric and Adolescent Diabetes recommend the use of AID systems, which combine an insulin pump and a CGM system, for all people with type 1 diabetes because of their demonstrated positive effects on glycemic control and quality of life measures. For this reason, it is important to use QI-based approaches to close gaps in technology access and use. In addition, it is important to engage in advocacy efforts to decrease disparities in technology access to provide the best possible care for all people with type 1 diabetes.

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DUALITY OF INTEREST

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AUTHOR CONTRIBUTIONS

P.P. wrote the manuscript. H.H. and O.E. analyzed the data and conceptualized the manuscript. P.P., O.O., S.L., M.A., A.N., B.M., K.C., S.H., D.E., A.R., and M.A.C. performed data collection. O.O., S.L., M.A., A.N., B.M., K.C., S.H., D.E., A.R., and M.A.C. reviewed and edited the manuscript. O.E. is the guarantor of this work and, as such, had access to all of the data and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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