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# Examination of Prediabetes and Diabetes Testing Among US Pediatric Patients with Overweight or Obesity Using an Electronic Health Record

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## Abstract

**Background:** Youth with excess weight are at risk of developing type 2 diabetes (T2DM). Guidelines recommend screening for prediabetes and/or T2DM after 10 years of age or after puberty in youth with excess weight who have ≥1 risk factor(s) for T2DM. Electronic health records (EHRs) offer an opportunity to study the use of tests to detect diabetes in youth.

**Methods:** We examined the frequency of (1) diabetes testing and (2) elevated test results among youth aged 10–19 years with at least one BMI measurement in an EHR from 2019 to 2021. We examined the presence of hemoglobin A1C (A1C), fasting plasma glucose (FPG), or oral glucose tolerance test (2-hour plasma glucose [2-hrPG]) results and, among those tested, the frequency of elevated values (A1C ≥6.5%, FPG ≥126mg/dL, or 2-hrPG ≥200mg/dL). Patients with pre-existing diabetes (*n* = 6793) were excluded.

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Authors' Contributions

B.B. conceptualization, investigation, original draft writing, and review and editing. E.M.K. conceptualization, methodology development, software utilization, data curation, validation, formal analysis, investigation, and original writing of the article. R.P. conceptualization, investigation, review and editing, and supervision. S.L.P. conceptualization, methodology development, software utilization, data curation, validation, formal analysis, investigation, and original writing. L.K. conceptualization software utilization, data curation, and review and editing. E.A.L. validation, formal analysis, visualization, and review and editing. G.I. investigation, validation, visualization and review and editing. H.M.B. conceptualization, visualization, supervision, and funding acquisition. A.B.G. conceptualization, visualization, supervision, and funding acquisition. *All authors approved* the final article as submitted and agreed to be accountable for all aspects of the work.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Author Disclosure Statement

No competing financial interests exist.

**Results:** Among 1,024,743 patients, 17% had overweight, 21% had obesity, including 8% with severe obesity. Among patients with excess weight, 10% had ≥1 glucose test result. Among those tested, elevated values were more common in patients with severe obesity (27%) and obesity (22%) than in those with healthy weight (8%), and among Black youth (30%) than White youth (13%). Among patients with excess weight, >80% of elevated values fell in the prediabetes range.

**Conclusions:** In youth with excess weight, the use of laboratory tests for prediabetes and T2DM was infrequent. Among youth with test results, elevated FPG, 2hrPG, or A1C levels were most common in those with severe obesity and Black youth.

### Keywords

body mass index; child obesity; diabetes; electronic health record; hyperglycemia; prediabetes

## Introduction

Type 2 diabetes mellitus (T2DM) prevalence and incidence in youth is rising.[1-3] The SEARCH for Diabetes in youth study (SEARCH) reported, from 2001 to 2017, a relative increase of 95% in the prevalence of T2DM in US youth.[1] From 2002 to 2015, the incidence of T2DM in youth increased 4.8% per year.[3] The recent trends in T2DM prevalence are linked to an increase in the number of youth with risk factors for T2DM, including excess weight.[2]

Prediabetes is an intermediate state of glucose homeostasis that can progress to T2DM.[4,5] Prediabetes is defined by the American Diabetes Association (ADA) and the American Academy of Pediatrics (AAP) as the presence of hyperglycemia, manifested by: elevated glycated hemoglobin A1C (A1C), impaired fasting glucose (IFG), or impaired glucose tolerance (IGT).[5,6] An analysis of 2606 adolescents in the National Health and Nutrition Examination Survey (NHANES) using A1C, IFG, and IGT found that 18% of adolescents 12–18 years old had prediabetes between 2005 and 2016, including 26% of adolescents with obesity.[7]

The ADA guidelines recommend screening for prediabetes and/or T2DM at or after 10 years of age or after puberty, whichever occurs earlier, in youth with overweight (BMI ≥85th percentile to <95th percentile) or obesity (BMI ≥95th percentile) and who have ≥1 risk factor(s) for T2DM (family history of type 2 diabetes, maternal gestational diabetes, signs of insulin resistance, or specific race and ethnicity groups, including Asian, Black, Hispanic, Native American, or Pacific Islander).[5,6] This screening approach allows the use of several different tests with specific elevation thresholds for prediabetes and T2DM.[4,5] Screening is done every 3 years if tests are normal, more frequently if BMI increases.[5] Because prediabetes can progress to overt diabetes, early detection is critical to T2DM prevention.[4,6] With one in five US youth with obesity,[8] determining best testing practices is critical.

Gaps remain in our understanding of testing practices among youth at risk for prediabetes and T2DM,[9] including the adoption of screening guidelines and screening variations by patient subgroup. Electronic health record (EHR) data that reflect real-world pediatric practice are a valuable data source to describe testing patterns and the epidemiology of prediabetes and T2DM. Using EHR data from January 2019 to November 2021, we conducted an exploratory analysis of youth aged 10–19 years to examine the frequency of prediabetes and T2DM testing and, among those tested, the proportion of patients with elevated glucose or A1C values.

## Methods

### Data Source

We used IQVIA's Ambulatory Electronic Medical Record (AEMR) (Observational Medical Outcomes Partnership version 5, released May 2022) database, which contains ~74 million patients treated by 100,000 health care providers across 800 ambulatory sites in the United States.[10] These data include year of birth, sex, race and ethnicity, encounter date, diagnostic codes, laboratory results, procedures, and medication orders. This analysis was reviewed and approved by the CDC IRB.

### Study Population

The IQVIA AEMR dataset included 1,283,640 youth aged 10–19 years with ≥1 valid measure of height and weight in 2019. Height and weight measurements were cleaned using growthcleanr[11,12]; an automated algorithm for detecting errors in height and weight data from EHRs. A total of 252,104 patients were removed due to extreme values or anthropometric data errors. Heights and weights were then used to calculate BMI and BMI percentile (Appendix A1);[13] if a patient had multiple BMI measurements in 2019, we selected the earliest BMI in 2019 to assign BMI category: underweight (<5th percentile), healthy weight (5th to <85th percentile), overweight (≥85th to <95th percentile), obesity (≥95th percentile), and severe obesity (≥120% of the 95th percentile). Severe obesity is a subset of obesity. After BMI cleaning, a total of 1,031,536 patients remained.

### Exclusion Criteria

Patients with markers of diabetes (type 1 or type 2) during the 2 years preceding the observation period (January 1, 2017–December 31, 2018) were excluded as these patients' laboratory test results are likely reflective of ongoing diabetes management. Diabetes was defined as having ≥1 diabetes ICD-10 diagnostic code, an order for a diabetes treatment medication, or procedure codes for insulin pumps or continuous glucose monitors during the 2-year exclusion period (Appendix A2).[14,15] Because metformin and glucagon-like peptide-1 receptor (GLP1) agonists are used to treat conditions other than diabetes, patients on metformin or GLP1s alone were not excluded. A total of 6793 patients with diabetes (<1%) were excluded from the study population, resulting in 1,024,743 patients in our analytic sample.

### Test Results

The ADA recommends screening for type 2 diabetes using A1C, fasting plasma glucose (FPG), or an oral glucose tolerance test (OGTT) in youth ≥10 years old or after the onset of puberty in youth with a BMI ≥85th percentile and ≥1 risk factor; estimates suggest that one in four US youth are screening-eligible.[16] Because these risk factors are difficult to identify in EHR data, we did not limit our sample to youth with excess weight and ≥1 risk factor. We refer to A1C, FPG, and OGTT collectively as *tests* for prediabetes and diabetes, and their results as *test results*. All patients with ≥1 test result were identified.

Test results were cleaned (Appendix A1) and categorized as being in the prediabetes range (A1C between 5.7% and 6.4%, FPG between 100 and 125 mg/dL, or 2 hour plasma glucose (2-hrPG) between 140 and 199 mg/dL, or in the diabetes range (A1C ≥6.5%, FPG ≥126 mg/dL, or 2-hrPG results between ≥200 mg/dL). Patients with elevated values were categorized as having ≥1 test result in the prediabetes or diabetes range. Patients with multiple elevated test results in both the prediabetes and diabetes range were flagged and analyzed. Null results (those with a missing or zero value) or extreme results (defined as A1C results <2% or >20%, FPG results >400 mg/dL, or 2-hrPG >400 mg/dL) were excluded from the elevation analysis. Null results suggest that a screening test was attempted or administered but that the result was unavailable; very high values could represent new onset of diabetes or errors.

### Statistical Analysis

Descriptive statistics for patients were summarized by age group, sex, racial/ethnic group (Asian, Black, Hispanic, Other, Unknown, and White), and BMI category. Because of the large sample size, we utilized descriptive statistics only. We estimated age based on the date of height or weight measurement and midpoint of the patient's birth year (*i.e.*, July 2). The patient's estimated age on the date of the sampled BMI was used throughout the analysis and assigned to the following age groups: 10–14 or 15–19 years. All analyses were conducted using the SAS software package, version 9.4 (SAS Institute, Cary, NC).

## Results

A total of 1,024,743 patients aged 10–19 years were included in the analysis; among them, 17% had overweight and 21% had obesity, including 8% with severe obesity (Table 1). Half (51%) were 10–14 years, and 52% were female. Among those with available data, 63% were White, 24% had other or unknown race/ethnicity, 9% were Black, 3% were Asian, and 1% was Hispanic.

Overall, 52,203 (5%) patients aged 10–19 years had ≥1 diabetes test result in the observation period (Table 2). The percent of patients with ≥1 test result did not differ by age group but was slightly higher for females (6%) compared to males (4%). By race and ethnicity, 9% of other, 8% of Black, 6% of Hispanic, and 5% each of Asian and White patients had ≥1 test result. By BMI category, the percent of patients with ≥1 test result was 2% of those with underweight or healthy weight, 5% of those with overweight, and 13% of those with obesity, including 19% of those with severe obesity.

Among those with ≥1 test result ($n$ = 52,203), nearly 7% ($n$ = 3525) were excluded because their test results were null, zero, or extreme values, leaving 48,678 patients to evaluate for elevation. Of those, 7915 patients (16%) had ≥1 elevated test result (Fig. 1). Elevated test results were more frequent among patients with severe obesity (27%) and obesity (22%) compared to those with overweight (12%), healthy weight (8%), or underweight (8%). More patients 10–14 years old (19%) had ≥1 elevated test result compared to patients 15–19 years old (14%). More males had ≥1 elevated test result (18%) compared with females (15%). Black patients had the highest proportion of elevated values (30%) compared to 19% among those of other race and ethnicity, 16% among Asian, 15% among Hispanic, and 13% among White patients.

Most patients with elevated test results were in the prediabetes range, and a small number of patients with excess weight ($n$ = 370, 5.5%) had multiple elevated test results in both the prediabetes and diabetes range (Fig. 2). Elevated test results in the diabetes range did not differ by sex but were slightly more common among children 15–19 years old compared to children 10–14 years. Elevated test results in the prediabetes range were more common among Hispanic patients with obesity (96%) or severe obesity (97%).

## Discussion

Our analysis leverages real-world EHR data to explore testing for prediabetes and diabetes in a very large patient population of US youth aged 10–19 years. The objective of the analysis was to assess the frequency of any testing and the frequency of elevated values among those tested by BMI status and demographics. Test results were uncommon in patients with overweight or obesity. This includes youth from specific racial and ethnic groups, who would be screening-eligible based on ADA recommendations.[4,6] Among patients with test results, one in five (22%) patients with obesity and over a quarter with severe obesity (27%) had ≥1 elevated value. Most elevated test results were in the prediabetes range. Among patients with overweight or obesity, elevated test results in the diabetes range were more common among those 15–19 years compared to 10–14 years.

Our analysis potentially missed test results. However, it is unclear what proportion of the large number of patients without tests in our analysis is due specifically to uncaptured test results. Our results indicate that testing for prediabetes and T2DM has value in prevention of disease progression, particularly among Black youth and youth with obesity or severe obesity. Our results should be balanced against the United States Preventive Services Task Force recommendation that there is insufficient evidence to assess the balance of benefits and harms of screening for prediabetes or type 2 diabetes in asymptomatic youth.[9] Our results add to the growing evidence base in favor of screening those at elevated risk.

Based on the ADA screening guidelines,[4,6] youth from specific racial and ethnic groups in our study with excess weight should have been tested and have ≥1 test result during the observation period. However, we found that only a small proportion of screening-eligible youth based on race and ethnicity (13%) received a test. Low testing in youth of specific racial and ethnic groups is concerning given the higher risk of complications[17,18]; in our analysis, ~1 in 3 (30%) Black youth who were tested had elevated values compared to 1 in 13 White youth (13%). Screening for prediabetes and diabetes in this population is a priority.[17,18] Finally, 19.8% of youth in our study had missing race and ethnicity data. Altogether, these findings highlight the importance of complete and high-quality reporting of race and ethnicity information in EHRs to help address disparities.[19]

In our analysis, A1C results comprised >90% of test results, suggesting that A1C is the primary test being used for testing among contributing providers. As a commonly used test, A1C has many practical advantages: it does not require fasting, has lower within-person variability than glucose tests, and is the basis for diabetes treatment and management decisions.[5,16] However, using A1C data alone to conduct surveillance may be limiting. One recent study found that, compared to FPG, A1C often detects a smaller cohort of youth with prediabetes or T2DM and that A1C has a stronger association with adverse health outcomes.[16] Our analysis did identify some youth with only elevated glucose values, either by FPG or 2-hrPG.

Some investigators have explored which subpopulations of youth are more or less likely to have elevated A1C or glucose results.[20,21] Risk factor associations have been consistently stronger for A1C-defined hyperglycemia suggesting that A1C-defined hyperglycemia identifies a smaller, but higher risk, population than FPG-defined hyperglycemia.[16]

Among patients with excess weight, elevated test results were common. Overall, most elevated values were A1C in the prediabetes range. However, there is no consensus in the field about the most appropriate A1C cutpoints for youth, as current A1C cut points are based on adult studies.[16,21,22] Although A1C may help identify youth with prediabetes, particularly those more likely to have other cardiometabolic risk factors, it remains unclear if different levels of elevated A1C are associated with differential cardiometabolic risk in youth.[16,21] Thus, different combinations of screening and/or confirmatory tests for prediabetes and T2DM may more appropriately identify youth with different risk factors and profiles. This may have important implications for how these youth will respond to any given therapy or intervention.[20] Nonetheless, laboratory testing is important to identify youth who might need additional monitoring.

Limited sample sizes in studies of youth limit the granularity and detail that NHANES can provide. Exploring complementary surveillance data sources is needed to detect rapid changes in incidence, explore progression from prediabetes to T2DM, and apply those findings to prevention. Our analysis does not provide prevalence estimates, but future EHR-based prevalence studies can build on our approach to further understand prediabetes and T2DM prevalence. In addition, this analysis uncovered several specific challenges with using EHR data that merit further exploration, including but not limited to, determining age, missing information for race, and ethnicity and the reliance on infrequently used laboratory tests to characterize prediabetes and T2DM. A more comprehensive EHR-based approach to prediabetes and diabetes prevalence would combine information from test results, medications, and diagnostic codes to identify cases. More work is needed to validate the best methods for generating prevalence estimates from EHR data across conditions, including prediabetes and diabetes.

Finally, our findings have important implications given the effects of the COVID-19 pandemic on weight gain[23-25] and T2DM incidence[26] in youth. Because the prevalence of obesity and T2DM may have increased, providers should be attentive to diabetes. Given the linkage between excess weight and T2DM risk, the pandemic may influence the trajectory of obesity in youth as well as the prevalence of and hospitalizations related to prediabetes and T2DM in coming years.[26] One study found a marked increase in the incidence of any new diabetes diagnosis, including T2DM among youth <18 years old, during the COVID-19 pandemic while another study found that hospitalizations related to new-onset T2DM doubled from 2019 to 2020.[26,27] It is possible that the burden of T2DM in youth increased substantially during the time period of this study.

### Limitations

This study has several limitations. First, this analysis is not necessarily representative of all providers and testing practices. In addition, because of the potential for missing data, this analysis may not be representative of the testing patterns for those providers who did submit data to IQVIA AEMR. Second, much of the data was collected during the COVID-19 pandemic and this may have affected testing rates since many children who had a BMI measurement in 2019 may not have sought care or received testing during our analytic period. Third, age was calculated from the date of visit and an estimated date of birth (*i.e*., the midpoint of year of birth). This could result in errors when calculating BMI percentile, classifying BMI category, and excluding some observations based on an estimated age. However, our large sample size and broad age range suggest that this would have little impact on our findings.

Fourth, this analysis relied heavily on laboratory test results rather than a full medical chart review, which makes it prone to several types of errors. Youth in this study may have had laboratory test results that were not accessible because the provider who ordered the test did not contribute data to IQVIA, the test result was not available in a structured or standardized format, or the test result could not be identified using the IQVIA search tools. These scenarios could result in incomplete test result information for prediabetes and T2DM test results. Current ADA guidelines recommend that if tests are normal, repeat testing should be performed at a minimum of 3-year intervals (or more frequently if BMI is increasing or the risk factor profile deteriorating). So, it is possible that testing may have occurred at a time not covered by the nearly 3-year study period.

Fifth, we did not assess testing for other risk factors related to prediabetes and T2DM because risk factor attributes are not consistently captured in clinical EHR data. As a result, we do not know how many youth in our analysis should have been tested based on current ADA guidelines. However, our study included many youth who would be screening-eligible because they were from specific racial and ethnic groups. Finally, this analysis did not explore confirmatory diagnostic testing. For youth with test results consistent with prediabetes, we could not determine progression to diabetes. This is an important question for future analyses.

## Conclusions

The IQVIA AEMR data offer a unique opportunity to study a large group of youth with overweight or obesity, including >80,000 youth with severe obesity. Test results for youth with excess weight were uncommon in our dataset. Based on ADA screening recommendations, in our study population, all the patients with BMI ≥85th percentile from specific racial and ethnic groups would be screening-eligible for prediabetes and

T2DM. However, test results were uncommon in these high-risk groups. Youth with severe obesity were most likely to have test results and had the highest proportion of elevated test results. Public health practitioners and clinicians should be aware of which youth need testing for prediabetes and T2DM and which youth should subsequently be referred to appropriate interventions. These findings highlight the opportunity to provide public health and clinical strategies to prevent disease progression. Important areas for future research include understanding of the low testing rates among youth from specific racial and ethnic groups, the impact and benefits of screening and progression of disease states, and the benefits or harms of treatment interventions, such as healthy weight programs and medications, in youth.

## Impact Statement

This article raises awareness of which youth need testing for prediabetes and type 2 diabetes mellitus and which youth should subsequently be referred to appropriate interventions. Clinical efforts may include how best to evaluate and support youth who are found to have elevated test results, and their families.

## Appendix 1.: Description of IQVIA AEMR Data Cleaning

## Height and Weight

Heights and weights that were likely to be errors were identified and excluded, using the growthcleanr algorithm for the longitudinal detection of extreme values. Then, we calculated the BMI, BMI percentile (BMI%), and BMI *Z* score for a patient's age and sex based on the CDC growth charts.[A1,A2] Finally, modified weight-for-age *Z* score (MWAZ), modified height-for-age *Z* score (MHAZ), and modified BMI-for-age *Z* score (MBMIZ) and a threshold for BMI values were used to exclude biologically implausible observations.[A3] Compared to the CDC-recommended BMI cleaning protocol, we used higher cut points so that fewer individuals with severe obesity were excluded. That is, observations were excluded if MWAZ ≥10 or MWAZ ≤−5, MHAZ ≥5 or MHAZ ≤−5, MBMIZ ≥10 or MBMIZ ≤−4, or BMI% ≥150th percentile for age and sex.

## Testing Results

From AEMR, a total of 363,889 A1C, 14,321 FPG, and 6442 OGTT laboratory test result observations occurring between January 1, 2019 and November 31, 2021 were extracted. Laboratory test names, distribution of result numeric values, and units were reviewed to confirm that nonfasting glucose results were not included as fasting glucose. No abnormalities were found in the FPG or OGTT results, but this review revealed that many estimated average glucose (EAG) results (13% of the A1C file) were present in the A1C file using different units. In order to systematically apply elevation thresholds, EAG results were converted from mmol/L and mg/dL to A1C values calculated as a percent.[A4]

Laboratory test results were then evaluated for biological plausibility based on the following thresholds:

| | Null and Extreme Values | Plausible | Extreme Values |
|---|---|---|---|
| AIC | 0, 1, and missing | 2–20 | >20 |
| FPG | 0 and missing | 1–400 | >400 |
| OGTT | 0 and missing | 1–400 | >400 |

A total of 8643 observations with a 0 or missing result and 1785 with a biologically high value were excluded from the elevation analysis. The process to identify OGTT and FPG from the larger group of glucose results highlighted the challenges of using glucose for prediabetes and diabetes. Plasma glucose testing is used as part of many clinical diagnostic tests and is highly sensitive to fasting status. From a glucose result, it is not possible to determine if a glucose test was screening for prediabetes, diabetes, or another condition. In addition, many glucose results did not have specified fasting status and were categorized as “glucose result” and could not be included in this analysis. Detailed coding of test type and patient status is important to understand the nature and purpose of glucose testing and results.

## Appendix 2.: List of Diabetes Exclusion Codes

## Diagnostic Codes

| Vocabulary | Diagnostic Code | Diagnostic Code Description | SNOMED-Equivalent Concept IDs |
|---|---|---|---|
| ICD-9 | 250.x | Diabetes mellitus and associated complications | 4196141, 37016767, 37016768, 4225656, 4221495, 43531578, 443735, 442793, 45769832, 43531616, 201820, 45757674, 45757474, 4096666, 4008576, 443238, 443727, 4009303, 373999, 435216, 443732, 443767, 42538169, 443733, 192279, 443730, 377821, 376065, 4202383, 43530690, 4223303, 4222876, 37016348, 37016349, 443592, 4226238, 201531, 201530, 45769876, 45757363, 4228112, 36714116, 439770, 443734, 4224254, 4228443, 4143857, 4140466, 45770830, 380097, 37016179, 45757435, 37016180, 45770881, 4225055, 4222415, 45769830, 45763583, 43530656, 4131908, 318712, 443729, 321822, 37017431, 37017432, 45763584, 43530685, 200687, 443731, 4227210, 376114, 4290822, 45773064, 201254, 40484648, 4152858, 4096668, 4099214, 443412, 201826, 4099217, 4151282, 4198296, 4200875, 4099651, 4193704, 40482801, 45770902 |
| ICD-10 | E08.X | | |
| | E09.X | | |
| | E10.x | Type 1 diabetes and associated complications | |
| | E11.x | Type 2 diabetes and associated complications | |
| | E13.X | | |

## Medication Ingredients

In AEMR, Medications are searchable multiple ways. Several diabetes treatment medications exist, which led us to use a search by 24 distinct ingredients.

| **Diabetes medications, by ingredient** |
|---|
| Acarbose |

| Diabetes medications, by ingredient |
|---|
| Alogliptin |
| Bromocriptine |
| Canagliflozin |
| Chlorpropamide |
| Dapagliflozin |
| Empagliflozin |
| Ertugliflozin |
| Glimepiride |
| Glipizide |
| Glyburide |
| Insulin |
| Linagliptin |
| Metformin |
| Miglitol |
| Nateglinide |
| Pioglitazone |
| Repaglinide |
| Rosiglitazone |
| Saxagliptin |
| Semaglutide |
| Sitagliptin |
| Tolazamide |
| Tolbutamide |

## Other Markers of Diabetes

The following procedure, device, and observation codes were used to identify patients with an insulin pump or continuous glucose monitor, which reflects diabetes treatment.

| Vocabulary | Procedure, Device, or Observation Code | Description |
|---|---|---|
| CPT4 | 95249, 95250, 95251 | Ambulatory continuous glucose monitoring |
| HCPCS | A9276, A9277, A9278, K0553 | Supplies for continuous glucose monitor, including sensor and receiver |
| HCPCS | S5565, S5566, A4230, A4231, A4232, A4255, E0784 | Supplies for insulin pump, including insulin cartridge and infusion set |
| HCPCS | S1034 | Artificial pancreas device system |
| HCPCS | J1817 | Insulin for administration through DME (i.e., insulin pump) per 50 U |
| SNOMED | 180178009, 443263006 | Continuous subcutaneous infusion of insulin or insertion of insulin pump |
| SNOMED | 69805005, 767696004, 767697008, 463326009, 470153003, 701419004, 701718008, 469277009, 468217005, 770744007 | Insulin pump, ambulatory insulin infusion pump supplies, and related devices |

| Vocabulary | Procedure, Device, or Observation Code | Description |
|---|---|---|
| NDC | 15630004884, 15630005235, 15630088435-15630088443, 38384300100, 65781012410, 65781025001, 65781025101, 65781025201, 65781037001, 65781037101, 65781037201, 65781118110, 76300012201, 76300022201, 76300032610, 76300033210, 76300039710, 76300039910, 76300052201, 89110512304, 89110512704, 89110514304, 89110514704, 89110522604, 89110522904, 89110524604, 89110524904, 89110711101, 89110711102, 89152338005, 89152462901 | Insulin pump kit, cartridge, infusion set, insulin pump controllers, and related devices |
| ICD-9 | V53.91 | Fitting and adjustment of insulin pump |
| ICD-10 | Z96.41 | Presence of insulin pump |
| ICD-9 | 996.57, T85.614x, T85.624x, T85.633x, T85.694x, T85.72x | Breakdown, leakage, displacement, other mechanical complication of, or infection and inflammatory reaction due to insulin pump |
| ICD-10 | | |

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## Key Findings

**What Is Already Known on This Subject?**

Excess weight in youth is associated with increased risk of developing type 2 diabetes mellitus (T2DM).

**What Are the New Findings in Your Article?**

This exploratory analysis of 2019–2021 electronic health record data found that recommended laboratory tests for prediabetes and T2DM detection were used infrequently in youth with overweight or obesity, including among youth from specific racial and ethnic groups who are screening eligible. Most of the youth with excess weight (90%) had no recorded diabetes laboratory tests. Among those with laboratory tests, 1 in 4 youth with severe obesity had elevated results, compared to 1 in 12 youth with healthy weight; nearly 1 in 3 Black youth who were tested had elevated results, compared to 1 in 8 White youth.

**How Might Your Results Change the Direction of Research or the Focus of Clinical Practice?**

Health care professionals should be aware of which youth need testing for prediabetes and T2DM and which youth should subsequently be referred to appropriate interventions. Public health and clinical efforts may include how best to evaluate and support youth who are found to have elevated test results, and their families.

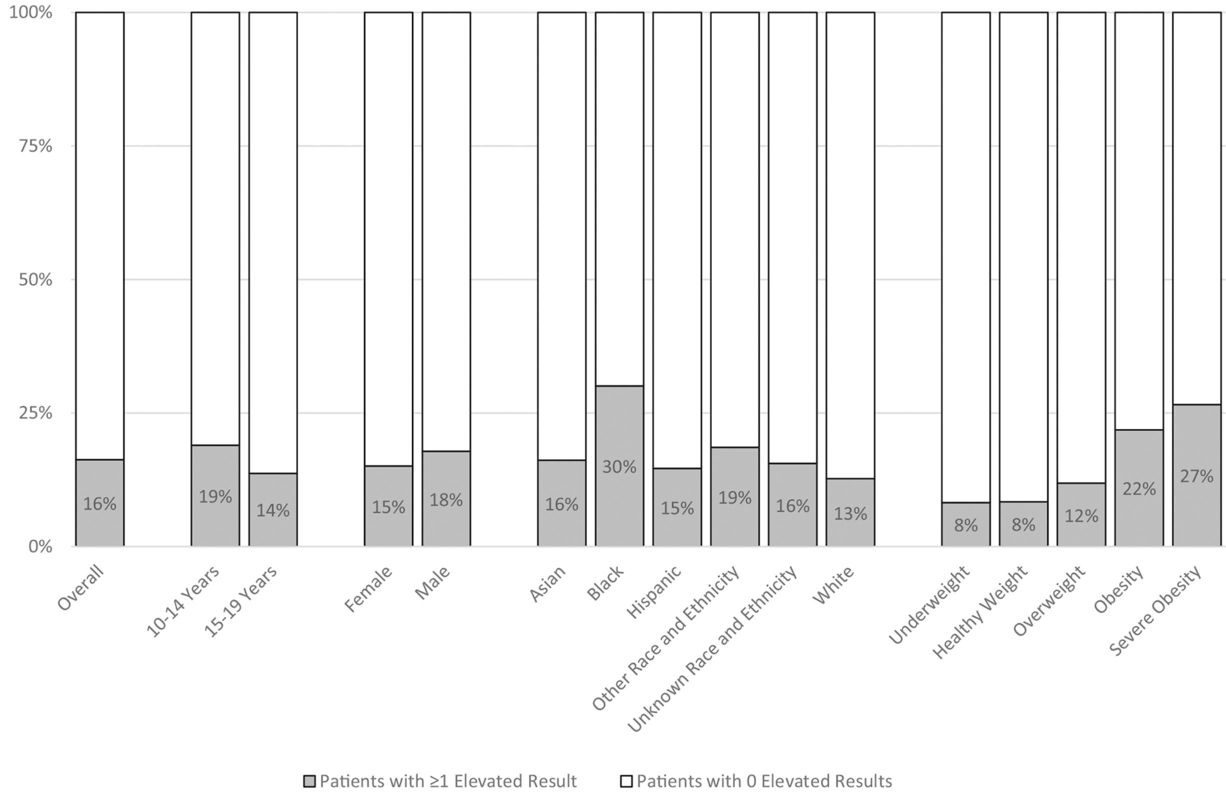


**Figure 1.**

BMI category assigned based on earliest 2019 BMI observation. BMI category defined as overweight (≥85th to <95th percentile), obesity (≥95th percentile), and severe obesity (≥120% of the 95th percentile). Severe obesity is a subset of obesity. IQVIA combines race and ethnicity into one field which may cause loss of true racial or ethnic identity data at the patient level. [a]Hemoglobin A1C, Fasting Blood Glucose and Oral Glucose Tolerance Test are referred to as *tests* for prediabetes and diabetes. AEMR, Ambulatory Electronic Medical Record.

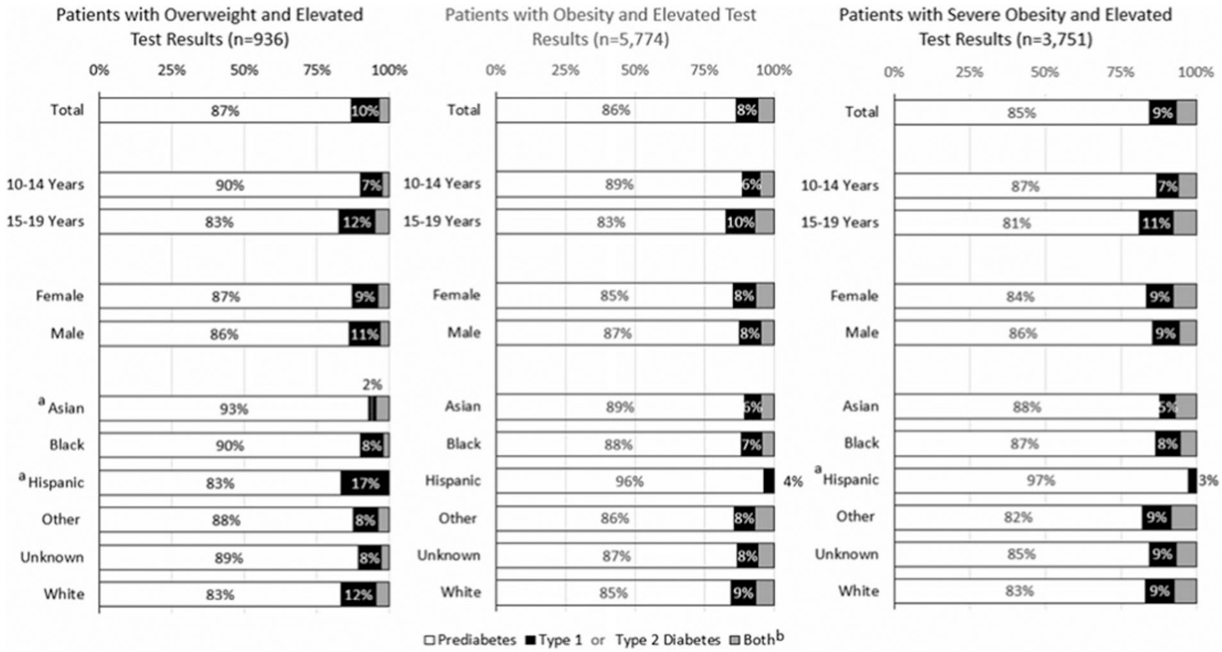


**Figure 2.**

Testing result elevation among patients with overweight, obesity and severe obesity by demographic attribute, IQVIA AEMR 2019–2021. BMI category assigned based on earliest 2019 BMI observation. BMI category defined as overweight (≥85th to <95th percentile), obesity (≥95th percentile), and severe obesity (≥120% of the 95th percentile). Severe obesity is a subset of obesity. IQVIA combines race and ethnicity in one field which may cause loss of true racial ethnic identity data at the patient level. Hemoglobin A1C, Fasting Blood Glucose and Oral Glucose Tolerance Test are referred to as *tests* for prediabetes and diabetes. IQVIA combines race and ethnicity in one field which may cause loss of true racial ethnic identity data at the patient level. “Proportions calculated based on <50 patients and may be unstable. [b]35 patients with overweight and 335 patients with obesity had multiple screening results that were in both the prediabetes and diabetes ranges.

**Table 1.**

Study Population by BMI Category and Demographic Group, IQVIA AEMR 2019

| | | BMI category,[a] *n* (%) | | | | |
|---|---|---|---|---|---|---|
| | **Overall** | **Underweight** | **Healthy** | **Overweight** | **Obesity** | **Severe obesity** |
| Total | 1,024,743 | 34,081 (3) | 607,274 (59) | 171,683 (17) | 211,705 (21) | 81,163 (8) |
| Age group | | | | | | |
| 10–14 Years | 519,406 | 16,775 (3) | 301,351 (58) | 89,552 (17) | 111,728 (22) | 41,006 (8) |
| 15–19 Years | 505,337 | 17,306 (3) | 305,923 (61) | 82,131 (16) | 99,977 (20) | 40,157 (8) |
| Sex | | | | | | |
| Female | 528,435 | 13,297 (3) | 319,201 (60) | 94,654 (18) | 101,283 (19) | 38,340 (7) |
| Male | 496,308 | 20,784 (4) | 288,073 (58) | 77,029 (16) | 110,422 (22) | 42,823 (9) |
| Race and ethnicity[b] | | | | | | |
| Asian | 26,962 | 1495 (6) | 18,819 (70) | 3816 (14) | 2832 (11) | 692 (3) |
| Black | 96,587 | 2280 (2) | 50,830 (53) | 17,032 (18) | 26,445 (27) | 12,332 (13) |
| Hispanic | 8262 | 231 (3) | 3984 (48) | 1647 (20) | 2400 (29) | 999 (12) |
| Other | 44,913 | 1381 (3) | 23,848 (53) | 8145 (18) | 11,539 (26) | 4682 (10) |
| Unknown | 202,542 | 6611 (3) | 119,698 (59) | 34,541 (17) | 41,692 (21) | 15,550 (8) |
| White | 645,477 | 22,083 (3) | 390,095 (60) | 106,502 (16) | 126,797 (20) | 46,908 (7) |

[a] BMI category assigned based on earliest 2019 BMI observation. BMI category defined as underweight (<5th percentile), healthy (5th to <85th percentile), overweight (≥85th to <95th percentile), obesity (≥95th percentile), and severe obesity (≥120% of the 95th percentile). Severe obesity is a subset of obesity.

[b] IQVIA combines race and ethnicity in one field which may cause loss of true race and ethnicity identity data at the patient level.

AEMR, Ambulatory Electronic Medical Records.

## Table 2.

Frequency of Diabetes Test Results[a] Among Youth with ≥1 Test Result, by Demographic Attribute and BMI Category,[b] IQVIA AEMR 2019

| | Patients with ≥1 test result[a] | | | | | |
|---|---|---|---|---|---|---|
| | | BMI category,[b] *n* (%) | | | | |
| | **Overall** | **Underweight** | **Healthy** | **Overweight** | **Obesity** | **Severe obesity** |
| Total | 52,203 (5%) | 818 (2%) | 14,629 (2%) | 8489 (5%) | 28,267 (13%) | 15,075 (19%) |
| Age group | | | | | | |
| 10–14 Years | 24,948 (5%) | 243 (1%) | 5140 (2%) | 3848 (4%) | 15,717 (14%) | 8313 (20%) |
| 15–19 Years | 27,255 (5%) | 575 (3%) | 9489 (3%) | 4641 (6%) | 12,550 (13%) | 6762 (17%) |
| Sex | | | | | | |
| Female | 29,915 (6%) | 372 (3%) | 8944 (3%) | 5448 (6%) | 15,151 (15%) | 7700 (20%) |
| Male | 22,288 (4%) | 446 (2%) | 5685 (2%) | 3041 (4%) | 13,116 (12%) | 7375 (17%) |
| Race and ethnicity[c] | | | | | | |
| Asian | 1466 (5%) | 37 (2%) | 600 (3%) | 267 (7%) | 562 (20%) | 195 (28%) |
| Black | 7257 (8%) | 69 (3%) | 1356 (3%) | 1082 (6%) | 4750 (18%) | 2867 (23%) |
| Hispanic | 467 (6%) | 6 (3%) | 81 (2%) | 76 (5%) | 304 (13%) | 163 (16%) |
| Other | 4120 (9%) | 45 (3%) | 992 (4%) | 651 (8%) | 2432 (21%) | 1318 (28%) |
| Unknown | 9324 (5%) | 133 (2%) | 2706 (2%) | 1651 (5%) | 4834 (12%) | 2405 (15%) |
| White | 29,569 (5%) | 528 (2%) | 8894 (2%) | 4762 (4%) | 15,385 (12%) | 8127 (17%) |

[a] Percents are calculated as a proportion among youth in each category with ≥1 test result. Hemoglobin AIC, Fasting Blood Glucose and Oral Glucose Tolerance Test are referred to as *tests* for prediabetes and diabetes.

[b] BMI category assigned based on earliest 2019 BMI observation. BMI category defined as overweight (≥85th to <95th percentile), obesity (≥95th percentile), and severe obesity (≥120% of the 95th percentile). Severe obesity is a subset of obesity.

[c] IQVIA combines race and ethnicity in one field which may cause loss of true race and ethnic identity data at the patient level.

AEMR, Ambulatory Electronic Medical Records.