# Prevalence of type 2 diabetes risk factors, including overweight and obesity, among youth attending hospital-based paediatric care in Western Melbourne

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## Abstract

*Aim*

To determine the prevalence of risk factors for type 2 diabetes in overweight and obese adolescents attending hospital-based paediatric care in Western Melbourne.

*Methods*

100 overweight and obese adolescents (aged 10-17 years) who attended an outpatient clinic at Sunshine Hospital between May 2019 and May 2020 were randomly selected following a retrospective chart review of 10–17-year-olds for whom a height and weight had been documented. Additional risk factors for type 2 diabetes were ascertained via structured telephone interview. Data was analysed to determine overall prevalence of risk factors for type 2 diabetes, and to evaluate for associations between each parameter with body mass index and the number of risk factors.

*Results*

Of the 487 adolescents who had height and weight data recorded, 45% were overweight or obese. 77% of those who were interviewed had an additional risk factor for type 2 diabetes. No association between the number of risk factors and body mass index standard deviation score was found. Additionally there was no association between the number of risk factors for type 2 diabetes and either family history of type 2 diabetes or ethnicity.

*Conclusions*



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This paediatric subpopulation had a high rate of risk factors for type 2 diabetes in addition to overweight and obesity, and are at risk of premature mortality and chronic morbidity should they develop type 2 diabetes.

*What is already known*

- The prevalence of youth type 2 diabetes is increasing in Australia, particularly in areas of socioeconomic disadvantage
- Current guidelines recommend type 2 diabetes screening in youth over the age of 10 years who are overweight or obese and have any additional risk factors
- Youth type 2 diabetes is associated with a significant risk of complications, and thus prevention and early detection strategies are essential

*What this paper adds*

- High rates of overweight and obesity in our population, and 77% had an additional risk factor for type 2 diabetes
- Those from an ethnicity at increased risk or with a family history did not have additional risk factors for type 2 diabetes
- Given similar findings may be seen among other socially disadvantaged youth in Australia, there is a need for an increased focus on preventative strategies to mitigate risk in these populations

## INTRODUCTION

Paediatric overweight and obesity has increased internationally over the last 40 years(1). In Australia, one quarter of the population aged 5-17 years were overweight (17%) or obese (8.1%) in 2017-2018(2). The prevalence of youth type 2 diabetes mellitus (T2D), a sequelae of overweight and obesity, is also increasing. Youth T2D is associated with a greater and earlier risk of cardiovascular and renal complications compared to youth with type 1 diabetes mellitus (T1D)(3).

Given the increasing prevalence of youth T2D, and the potential future healthcare burden, screening those at risk for developing T2D is imperative to improve health outcomes. Australian and North American guidelines recommend screening for T2D in youth (post-puberty onset or from age 10, whichever occurs earlier) who are overweight or obese with one or more risk factor(s) via two-hour oral glucose tolerance test, fasting plasma glucose, or HbA1c test(4,5).

In developed countries, the rate of youth T2D is higher among youth who experience socioeconomic disadvantage and among individuals with an ethnic background that is associated with increased risk of T2D(6). Sunshine Hospital, within Western Health, is located in the western suburbs of Melbourne and services a culturally diverse population with significant socioeconomic disadvantage, as shown in the Index of Relative Socio-Economic Disadvantage(7,8). Data from the National Diabetes Services Scheme (NDSS) demonstrates that Brimbank, a local government area in the western suburbs of Melbourne, experiences a disproportionately high burden of T2D compared to other metropolitan LGAs, with 7.4% of its residents experiencing T2D(9). Additionally, the two major campuses of Western Health experience the highest rates of inpatients with T2D in Melbourne's public hospital network(10). Given the increased risk of youth T2D among children with a family history of T2D, it is important to identify these children and youth to allow implementation of prevention strategies.

We aim to determine the prevalence of additional T2D risk factors in patients affected by overweight and obesity attending outpatient clinic appointments at Sunshine Hospital. This information will inform the development of a youth T2D prevention multi-disciplinary clinic within our health service.

## METHODS

### Participants

A retrospective review of Western Health's electronic medical records (EMR) was conducted to randomly identify 100 youth, aged 10 to 17 years, with a BMI in the overweight or obese range who attended a Sunshine Hospital paediatric outpatient clinic appointment between

May 2019 and May 2020. Youth that had height and weight recorded and had a BMI in the overweight or obese range were then randomly selected for interview using a random number generator. Overweight and obesity were defined according to the Center for Disease Control's definition of overweight as body mass index (BMI) above the 85$^{th}$ centile on BMI-for-age percentile charts, and obesity as BMI above 95$^{th}$ centile on BMI-for-age centile charts(11). Exclusion criteria included pre-existing diabetes mellitus, use of glucocorticoid medication or need for interpreter.

Data Collection

Eligible youth and their guardians were interviewed via telephone using a structured script to provide information about the study, obtain verbal consent for participation, and collect data on T2D risk factors. The risk factors evaluated were: ethnicity, maternal gestational diabetes mellitus (GDM) during gestation with participant, first or second degree relatives with T2D, birth weight and gestational age at birth, and participant history of dyslipidaemia, polycystic ovarian syndrome (PCOS) or hypertension. Based on published guidelines, participants with the following ethnicities were considered to be at higher risk for T2D: Pacific Islander, Māori, Aboriginal or Torres Strait Islander, Asian and South Asian, Middle Eastern and African(5,6). Adolescents identified as having one or more additional T2D risk factors were provided with a letter to discuss with their general practitioner. This letter outlined: their T2D risk factor/s, the American Diabetes Association (ADA) screening guidelines, healthy lifestyle change recommendations, and referral instructions if follow-up HbA1c was 6% or above.

Statistical Analysis

Data is presented as median and interquartile range (25-75 IQR) unless otherwise stated. Analysis of variance was used to compare BMI standard deviation scores (SDS) and age with the number of T2D risk factors, and BMI SDS amongst participants with or without a family history of T2D, in either first or second degree relatives. Mann-Whitney U tests were performed to compare BMI SDS in the presence and absence of T2D risk factors, and BMI SDS amongst participants with an ethnicity at and not at increased risk of T2D. Pearson's $\chi^2$ test was used to compare number of T2D risk factors with sex and ethnicity, and Fisher-Freeman-Halton exact test was used to compare number of risk factors with family history of T2D. A P value of $<0.05$ was considered statistically significant. Statistical analysis was performed using SPSS software version 27 (SPSS Inc., Chicago, IL, USA).

## RESULTS

A total of 1196 files were reviewed. BMI data was recorded for 487 patients who did not have a diagnosis of T1D or T2D documented on their EMR and of these, 45.17% (n=220) were identified to have a BMI in the overweight or obese range. 43 selected adolescents were unable to be contacted, 18 did not consent, 17 were excluded due to steroid medication and 1

adolescent withdrew consent. 100 youth with BMI in the overweight or obese range aged 10-17 years old were interviewed regarding risk factors for T2D. Demographic data is presented in Table 1. There were similar numbers of male and female participants, with a higher proportion of younger participants, compared to older age groups. Sixty percent of the participants had a BMI in the obese range and an overall median BMI SDS of 1.78. There was no significant difference in the sex (p=0.21) or age (p=0.99) of patients included in the study compared to those excluded.

Overall, 77% of participants had at least one additional risk factor for T2D (Table 2). Approximately half (49%) of the participants had an ethnicity associated with increased risk. Of the 100 participants, 54 had a first or second degree relative with T2D. Two participants had been diagnosed with pre-hypertension, three with dyslipidaemia and two with PCOs, however these clinical features had not been systematically documented in the study participants. Of those with birthweight data available, 9.3% were born small for gestational age (SGA).

Of the 77 participants with T2D risk factors, 48% had one risk factor, 43% had two risk factors and 9% had three risk factors. There was no significant difference in BMI SDS among those who had additional risk factors for T2D, or among participants who had zero, one, or two or more T2D risk factors (Table 3). Sex, the presence of family members with T2D and belonging to an at-risk ethnicity were not associated with a statistical difference in BMI SDS.

Similarly, there was no association found between the closeness of familial link to T2D and the individuals' number of other risk factors (excluding family history of T2D) for T2D (Supplementary Table 1). Moreover, there was no association found between ethnicity and the individual's number of risk factors for T2D (Supplementary Table 2).

**DISCUSSION**

This study reports four key findings about the youth, aged 10 to 17, who attended Sunshine Hospital paediatric outpatient clinics between May 2019 and May 2020. Firstly, 45% of patients that had BMI data recorded, and who did not have a documented diagnosis of T1D or T2D, had a BMI in the overweight or obese range. Secondly, 77% of those interviewed had at least one risk factor for T2D in addition being affected by overweight or obesity. Thirdly, there was no association between BMI SDS and the number of T2D risk factors. Finally, there was no association between either family history of T2D or ethnicity the number of additional risk factors for T2D.

Of those with recorded data, 45% of the youth attending outpatients were overweight or obese. This is higher than both the Australian prevalence (24.9% of children aged 5-17 years in 2017-2018 with BMI in the overweight and obese range)(3), and national prevalence in the United States (in 2017-2018, 35.4% of children aged 2-19 years had BMI in the overweight or

obese range)(12). Among a population of overweight or obese, referred to a tertiary paediatric weight management clinic in the US, Saleh *et al* reported that 23.1% of youth with one additional risk factor for T2D, and 35% of youth with two additional risk factors for T2D had dysglycaemia at presentation(13).

It was found that 77% of study participants had at least one risk factor for T2D in addition to overweight and obesity, which is consistent with studies in North America(14,15). Two of these studies have assessed the number of T2D risk factors among young people and found similar prevalence of T2D risk factor in Edmonton, Canada (70% had two or more risk factors for T2D)(14), and rural Alabama (73.7% had one or more risk factor for T2D)(15). In an Australian study focusing on Indigenous children aged 7-18 years, 75% of participants with T2D had the additional risk factor of family history of T2D(16). Our study only considered youth who already had the risk factor of overweight and obesity, which may distort risk factor prevalence when compared to the general population.

In contrast to other research, this study did not find an association between the presence or number of T2D risk factors and BMI SDS. Studies have suggested that there is a dose-response risk of developing T2D with increasing BMI(17,18). It is known that there is a link between obesity and insulin resistance(19), and youth who subsequently develop T2D have impaired insulin regulation and loss of pancreatic beta cell function compared to peers matched for age and weight(20), suggesting there are factors in addition to obesity driving the metabolic derangement that results in T2D. This may explain our finding that increasing BMI did not correlate to the number of T2D risk factors in our population.

We found that a family history of T2D was not associated with the number of additional risk factors for T2D, when the risk factor of family history of T2D was excluded. Other studies have demonstrated an increased risk of developing T2D when there is a family history of diabetes and an individual is overweight or obese(21). Overall, 54% of study participants had a family history of T2D. Family history is a non-modifiable T2D risk factor, but it has been suggested that the diabetes risk associated with a positive family history could be modified by prevention and management of overweight/obesity(21), indicating that early detection of risk factors, including family history, is an important component of diabetes prevention.

Our study also found individuals with an ethnicity that is known to be associated with increased risk of T2D, did not have additional risk factors for T2D or a significantly higher BMI SDS than those from non-at-risk ethnicities when ethnicity as a risk factor was excluded. Zhu *et* al. reported that individuals from ethnic minorities had a higher prevalence of both prediabetes and diabetes at lower BMI values than Caucasian adults(18). Additionally, BMI may not be a useful discriminator for higher risk populations. Consideration of other factors rather than BMI, or implementation of age determined screening may be important in those who have a family history of T2D.

The following limitations to this study are important to consider. Firstly, the sample size in our study was small which limited the ability to perform statistical analysis on subgroups and may reduce the generalisability of the results. However, the participants were representative of those not assessed in terms of demographic factors such as sex and age. Secondly, determination of risk factors, other than BMI in the overweight or obese range, was reliant on participant answers and may be influenced by recall bias. While this is more likely to have resulted in underreporting of risk factors (such as maternal GDM), overreporting may also have occurred. Other risk factors, including physical activity level and diet(14), and protective factors, including breast feeding, were not evaluated in this study.

This is the first study to examine T2D risk factors in this specific paediatric population, and to have completed a comprehensive survey of known risk factors. The increasing prevalence of youth T2D globally(4) necessitates targeted screening programs to identify at-risk youth. Undiagnosed and untreated, youth T2D will increase adolescent morbidity and mortality now and in the future(4), with research demonstrating high rates of early microvascular complications in this population(22). Early identification of risk factors for T2D would reduce the burden of disease associated with undiagnosed youth T2D.

Given the morbidity and mortality associated with youth-onset type 2 diabetes, our findings of a high prevalence of youth affected by obesity and overweight, with additional risk factors for T2D, is highly concerning. The high rate of at-risk youth identified in our cohort may be indicative of the risk for youth in similar populations who experience social disadvantage. Socioeconomic status, education, and access to affordable health services all have an influence on the risk of obesity and type 2 diabetes. Addressing these factors is fundamental for achieving equitable and improved health outcomes. Health professionals should be aware of this risk and ensure appropriate screening of at risk youth. It is imperative that preventative measures are further developed to mitigate the risk for T2D particularly among youth in high risk populations.

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**Table 1. Demographic and anthropometric information**

| | All (n, N=100) | Males (n, N=49) | Females (n, N=51) |
|---|---|---|---|
| **Age (years)** | | | |
| 10-11 | 35 | 19 | 16 |
| 12-13 | 26 | 11 | 15 |
| 14-15 | 23 | 13 | 10 |
| 16-17 | 16 | 6 | 10 |
| **BMI** | | | |
| Overweight | 40 | 13 (26.5%) | 27 (52.9%) |
| Obese | 60 | 36 (73.5%) | 24 (47.1%) |
| **BMI ($kg/m^2$)** **Median (25-75 IQR)** | 26.92 (24.36 – 31.01) | 27.55 (25.07 – 31.17) | 26.32 (24.15 – 29.88) |
| SDS | 1.78 (1.35 – 2.25) | 2.04 (1.57 – 2.36) | 1.62 (1.29 – 1.99) |
| Centile (%) | 96.19 (91.03 – 98.77) | 97.92 (94.17 – 99.08) | 94.72 (90.20 – 97.70) |

**Table 2. Prevalence of T2D Risk Factors**

| | %, n=100 |
|---|---|
| **Ethnicity** | |
| Pacific Islander | 7 |
| Māori | 0 |

| | |
|---|---|
| South Asian | 16 |
| Middle Eastern | 11 |
| Asian | 9 |
| African | 6 |
| Aboriginal or Torres Strait Islander | 0 |
| **Family history of T2D** | |
| First degree relative | 10 |
| Second degree relative | 44 |
| **Maternal GDM** | 6 |
| **Hypertension** | |
| Pre-hypertensive | 2 |
| Hypertensive | 0 |
| **Dyslipidaemia** | 3 |
| **PCOS** | 2 |
| **SGA** | 8 (n=86) |
| **Overall risk factor presence** | |
| None | 23 |
| ≥1 | 77 |

**Table 3. Risk Factor Analysis**

| | **Number (n=100)** | **Median (25-75 IQR)** | **p value** |
|---|---|---|---|
| **BMI SDS** | | | |
| T2D risk factors absent | 23 | 1.76 (1.32 – 2.33) | 0.89 |
| T2D risk factors present | 77 | 1.79 (1.35 – 2.25) | |

| | | | |
|---|---|---|---|
| **BMI SDS** | | | |
| No T2D risk factors | 23 | 1.76 (1.32 – 2.33) | 0.67 |
| One T2D risk factor | 37 | 1.71 (1.33 – 2.34) | |
| Two or more T2D risk factors | 40 | 1.94 (1.46 – 2.24) | |
| **BMI SDS – family history of T2D** | | | |
| No family history | 46 | 1.72 (1.31 – 2.22) | 0.37 |
| First degree relative | 10 | 1.80 (1.54 – 2.43) | |
| Second degree relative | 44 | 1.95 (1.39 – 2.24) | |
| **BMI SDS** | | | |
| Ethnicity at increased risk | 49 | 1.73 (1.31 – 2.13) | 0.19 |
| Ethnicity not at increased risk | 51 | 1.95 (1.37 – 2.35) | |
| **Age (years)** | | | |
| No T2D risk factors | 23 | 13 (11-14) | 0.43 |
| One T2D risk factor | 37 | 13 (11-15) | |
| Two or more T2D risk factors | 40 | 12 (11-14) | |

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