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Effects of Hypothetical Type 2 Diabetes Genetic Testing on Parents' Efforts to Prevent Diabetes in Children

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Abstract

Objective—To examine the effect of hypothetical genetic susceptibility test results on diabetic parents' intention to prevent type 2 diabetes (T2D) in their children.

Methods—Parents with T2D indicated their intention to prevent T2D in their youngest child at baseline and after a hypothetical positive and negative T2D genetic test result. We calculated mean/median “preventive intention scores” for each scenario and examined the association between parents' score change and parent/child characteristics.

Results—A total of 63% of parents reported that their child had “almost no risk” or “slight risk” of developing T2D. Parents' median baseline preventive intention score was 8. It increased to 10 after a positive test result and decreased to 5 after a negative test result.

Conclusions—Negative T2D genetic susceptibility test results may decrease diabetic parents' intentions to prevent T2D for their children. Future research studies in a real-life clinical context should examine this phenomenon.

Keywords

genetic testing; diabetes mellitus; type 2 diabetes; children; vignettes

INTRODUCTION

Parents can now order genetic susceptibility testing through direct-to-consumer online companies to assess their own and their children's risk of developing polygenic chronic diseases.^{1,2} Studies of genetic susceptibility testing for polygenic chronic disease have focused heavily on the effect of testing on adults' health behaviors.³⁻⁵ Relatively few have explored how genetic testing of children may influence parents' actions on behalf of their children's health,⁶ especially when parents already have the polygenic chronic disease being tested. Little is known about how these parents interpret and act on information from genetic susceptibility testing for their children within the context of this family history risk— one that is likely to become increasingly important as pediatrics confronts the genomic era. Type 2 diabetes (T2D) is an example of a chronic, multifactorial (e.g., genetic and environmental) polygenic disease whose prevalence is increasing in both children and adults.^{7,8} T2D can be

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prevented in adults,^{9,10} and parents can decrease their children's risk of developing T2D by encouraging an increase in physical activity and healthy eating habits.^{11,12} Children with diabetic parents are at increased risk to develop T2D as an adult.¹³ Given that genetic susceptibility testing to assess an individual's risk of developing T2D is both plausible and representative of the types of tests under development,¹ we sought to explore whether hypothetical results from genetic susceptibility testing change the stated intentions of diabetic parents to prevent T2D in their children.

MATERIALS AND METHODS

Study Design

Participants completed a mailed self-administered written survey. The data for these analyses were generated from questions that were added to one of the larger University of Michigan's Translating Research into Action for Diabetes (TRIAD) mail survey wave, which was approved by the University of Michigan institutional review board.

Participants and Procedures

We surveyed individuals who participated in TRIAD. TRIAD is a multicenter, prospective observational study of quality of care, costs, and outcomes for diabetes in US-managed care health plans. TRIAD study methods have been described previously.¹⁴ The initial survey (conducted in 2006) provided baseline demographic data for this analysis. Questions for this survey were completed in the second survey wave conducted in 2008 (overall survey response rate 80%) and were limited to those TRIAD participants from the Michigan TRIAD site. Because this was a study about parental intention to prevent diabetes in their children, we limited our analysis to parents with T2D who reported having a child under 18 living in their household at the time of the survey. The TRIAD study did not distinguish diabetes type among participants. To minimize the possibility of including individuals with type 1 diabetes in our analysis, we excluded parents who had been diagnosed with diabetes at ≥ 30 years of age and were treated with insulin alone. Previously published analyses of the TRIAD study have used these same criteria to identify individuals with T2D.¹⁵

Outcome: Parents' Intention to Prevent T2D—We used a 10-point scale to measure parents' level of intention to prevent T2D in their youngest child (which we refer to in this manuscript as "preventive intention score"; Figure 1). Parents were asked to provide their preventive intention score at baseline and then after a hypothetical positive and negative genetic testing vignette (Figure 1) presented in that order.

Independent Variables—Similar to previous studies of diabetes risk in adults,¹⁶ parents were asked to estimate their youngest child's risk of developing T2D using the following response choices: almost no risk, slight risk, moderate risk, and high risk. We also collected the following demographic information: parents' self-reported height and weight, parents' self-reported health status (excellent, very good, good, fair, and poor), parents' self-reported history of medical complications related to T2D, and parent-reported height and weight of his/her youngest child. We calculated BMIs for both parents and children. We classified parents' BMI as normal (BMI <25 kg/m²), overweight (BMI ≥ 25 and <30 kg/m²), and

obese (BMI ≥ 30 kg/m²) using adult standards; we classified children's BMI as normal or overweight (BMI percentile ≥ 85 th percentile) based on the 2000 CDC growth curves.¹⁷ We did not have information about the child's sex. Therefore, we calculated BMI assuming each of the most extreme end points of gender distribution in the population: first that all children of parents in the sample are girls and then that all children were boys. We appreciate that the actual distribution of gender among children will be somewhere between these 2 extreme assumptions. Given that, we were reassured that we found almost no differences in the proportion of overweight children using each for each extreme assumption (all boys, 56.4%, vs all girls, 55.4%; $\kappa = 0.96$). Nonetheless, we took a conservative approach and conducted separate analyses assuming all children to be boys and then girls.

Data Analysis

Parents' Assessment of Child's T2D Risk—We used ordered logistic regression to evaluate the association between parents' perception of child's risk of developing T2D and each of the following factors separately: child's weight status (reference, normal), parental weight status (reference, normal), the parent's number of T2D complications (0, 1, ≥ 2), and parent self-reported health status (categorized as “excellent”, “very good”, “good”, “fair,” or “poor”). We used a multivariate model that incorporated variables that were significant ($P < .05$) in the bivariate model.

Parents' Intention to Reduce Child's Risk of T2D: Baseline, After Positive Test, and After Negative Test—Given the skewed distribution of scores, we calculated the median and interquartile range of parents' preventive intention scores at baseline and after positive and negative genetic testing scenarios, respectively. We tested whether baseline scores increased with parents' report of a greater risk of the child developing T2D using a nonparametric trend test. We evaluated whether there was a difference between median preventive intention score at baseline and after the positive and negative testing vignettes, respectively, using the Wilcoxon signed-rank test for matched pairs and taking into account the Bonferroni correction for multiple comparisons.

Examining Change in Direction and Degree of Preventive Intention Scores—We then calculated the direction and degree of change in a parent's preventive intention score (preventive intention scores after each of the testing scenarios subtracted from baseline score). We categorized the score changes after each vignette as higher/lower/ identical to the baseline score. Using multinomial logistic regression, we examined the association between the directional change in score (eg, higher or lower; reference: no change in score) after each genetic test vignette and each of the following variables: parent's weight status (reference: normal), parent's self-report of health status (reference: very good/excellent), parent's estimate of child's T2D risk, and child's weight status (overweight vs not).

RESULTS

Of 824 respondents in the wave 2 TRIAD survey, 201 indicated that they were parents of a child ≥ 18 years old. Of these 201, 195 parents were categorized as having T2D (Figure 2).¹⁵ Characteristics of parent respondents and their children are listed in Table 1. In our study

population, 82% of parents were overweight (BMI ≥ 25 kg/m²), and more than half (56%) of parents' youngest children were overweight (BMI ≥ 85 th percentile).

Parents' Assessment of Child's T2D Risk

More than one-quarter of parents (29%) reported that their child had "almost no risk" of developing T2D whereas one-third (34%) reported their child to be at "slight risk." In addition, 26% of parents reported their child to be at "moderate risk," and 12% reported their child to be at "high risk." We did find a significant association between parents' perception of child's T2D risk and each of the following characteristics in a bivariate model (data not shown): parent's BMI (reference, normal; overweight, $P = .1$; obese, $P = .02$), child's BMI (boy percentiles: reference, normal; overweight, $P = .03$), and parent self-reported health status (reference, excellent/very good; good, $P = .001$; fair/poor, $P = .001$). However, in a multivariate model that included all these characteristics, only parents' health status remained significant. Parents who reported poor/fair or good health (vs excellent or very good) were more likely to report their child to be at a greater risk of developing diabetes (reference, excellent/very good; good, odds ratio [OR] = 3.9, 95% confidence interval [CI] = 2.0-7.8; fair/poor, OR = 3.7, 95% CI = 1.8-7.8).

Parents' Intention to Reduce Child's Risk of T2D: Baseline, After Positive Test, and After Negative Test

Preventive Intention Scores at Baseline—Figures 3 and 4 show box plots of parents' preventive intention scores. At baseline, the median preventive intention score was 8 (interquartile range [IQR] = 2-9), with 25% of parents reporting scores of 10. We found a significant trend between baseline preventive intention scores and parental perception of higher diabetes risk ($P < .001$ for the nonparametric trend test, Figure 3).

Preventive Intention Scores After Positive Genetic Test Result—After receiving a hypothetical positive genetic test for T2D, the median preventive intention score increased to 10 (IQR = 9-10; Figure 4). Scores after receipt of positive genetic test results were significantly different from baseline scores ($P < .0001$). The majority of parents (66%) reported higher intention scores after the positive genetic test vignette (Figure 4). The median score change for all parents was 2 with an IQR of 0 to 4. Of note, 77% ($n = 41$ of 53) of parents who had identical scores at baseline and after the positive genetic test result reported a score of 10. We did not find a significant association between parents who gave a higher or lower preventive intention score after a positive test result compared with baseline (reference, identical scores) and any of the following factors: parent's self-report of health status, parent's estimate of child's T2D risk, and child's weight status (data not shown). Our analysis with parent BMI was unstable because of the fact that no parents with a normal BMI had lower preventive intention scores.

Preventive Intention Scores After Negative Genetic Test Result—After receiving a hypothetical negative genetic test for T2D, the median parental preventive intention score decreased to 5 (IQR = 2-8; Figure 4). Scores after receipt of negative genetic test results were significantly different from baseline scores ($P < .0001$). More than one-third of parents (39%) reported a lower preventive intention score after receipt of a negative genetic test

result (Figure 5; median score change for all parents = 0, IQR = -2 to 0). We found that parents of overweight children were more likely to report a lower preventive intention score (reference, identical score) after receiving a hypothetical negative genetic test result (relative risk ratio [RRR] = 2.4; 95% CI = 1.3-4.5) when we assumed that all children were boys for BMI percentile assignment. The association remained significant when we assumed that all children were girls (RRR 2.1; 95% CI = 1.1-4.0). We did not find an association between a higher or lower preventive intention score after a negative test result (compared with baseline) and any of the following factors: parent's weight status, parent's self-report of health status, and parent's estimate of child's T2D risk (data not shown).

DISCUSSION

In this study, we found that a hypothetical positive genetic test result led almost two-thirds of diabetic parents to increase their intention to prevent T2D in their children. In contrast, we also found that a hypothetical negative genetic test result created a varied response from parents: almost half of parents did not change their preventive intention score, whereas more than one-third reported a lower preventive intention score after receiving a negative test result. Moreover, we found that diabetic parents of overweight children (i.e., those who had clinical risk factors that placed them at greater risk of developing T2D) were more likely to report a lower intention to prevent T2D in their children after receipt of a hypothetical negative genetic test result.

We acknowledge that any discussion of susceptibility testing in minors must be cognizant of the attendant ethical challenges and that such testing is not currently recommended by many professional organizations.^{18,19} However, many of these professional policy statements were published more than a decade ago in response to the prospect of genetic testing of children for untreatable adult-onset conditions. Now, we are confronting the prospect of genetic susceptibility testing for common and potentially preventable disorders, such as T2D. We do not support the introduction of genetic testing susceptibility into clinical pediatric medicine at this time. Yet we believe it prudent to anticipate potential communication challenges and to examine the benefits and harms of testing in a controlled research setting before clinical introduction.

Against this backdrop, our results raise a number of interesting issues about the potential effect of pediatric genetic susceptibility testing for complex genetic conditions, such as T2D, on parents' understanding of genetic risk and the effect of such testing on parents' behavior. Our study results suggest that genetic testing that indicates a child to have an increased disease risk may have the potential to serve as a useful adjunct to motivate diabetic parents to take greater preventive health actions for their child. The degree to which genetic fatalism may influence these actions is unclear. Although a recent systematic review and meta-analysis of the literature have failed to identify robust evidence that providing genetic risk information leads to lack of perceived control, or genetic fatalism,²⁰ we acknowledge that the number of studies that met criteria were small and did not focus on children.

A more complex and compelling situation arises when genetic testing results and other risk factors, such as family history and clinical risk factors, are discordant. Our current

understanding of the number of genetic mutations associated with complex diseases as well as their interaction with other genes and with the environment is woefully incomplete. Yet as our ability to screen widely for genetic risk factors for disease grows, it is very likely that such discordant results will become more commonplace. As this situation unfolds, we must take care to mitigate potential harms of such testing, such as falsely reassuring and/or demotivating individuals on the basis of a negative genetic susceptibility test result especially when they have clinical risk factors for a given disease. In addition, the potential use of this testing should not displace communication with and education of parents about healthy lifestyle choices and effective interventions.

Therefore, we find it concerning that a substantial minority of diabetic parents in our study reported a lower preventive intention score after a negative genetic test result vignette, despite the fact that their children are at elevated risk for T2D based on both their family history and/or weight status. There are a few potential explanations for this finding. It may be that parents are privileging genetic information above clinical risk factors (e.g., obesity) and family history and, as a result, are reassured by the negative genetic test result. Alternatively, parents may fail to understand that a negative genetic susceptibility test may not indicate that the patient has no genetic risk because the test may not include all disease-causing genetic variants. It is also possible that parents' responses to the vignettes may have been influenced by a demand effect because the vignette order was not randomized. However, a demand effect does not explain why parents of obese children were more likely to decrease their intention to prevent T2D in their children after a negative test result.

Study Limitations

There are limitations to this study that merit discussion. Because this study involved hypothetical vignettes, we measured intent and not behavior. In addition, we measured parents' report of their general intent to prevent the development of T2D in their children rather than parents' intent to engage in specific behaviors (e.g., encourage physical activity and healthy eating strategies). We also recognize that our measure of intent may not fully capture the complex nature of intention. In addition, given the constraints of the already established TRIAD study design,¹⁴ we could not randomize our scenarios to account for the possible influence of order effect on participants' responses. Future studies should account for this potential bias. Nevertheless, our goal with this study was to measure change in parents' thoughts about taking action to prevent T2D in their child and how hypothetical genetic testing scenarios can affect their thoughts about action.

In this study, we were unable to provide the participants with exact numerical risk estimates because we know of none that are currently available. Instead, we used the terms *negative* and *positive* in presenting the genetic test results. Some may disagree with the use of these terms. However, these terms are commonly used in everyday clinical practice and also used in publicly available genetic references guides provided by the National Institutes of Health.²¹

As with any self-administered information, it is possible that the participants had difficulty interpreting the risk information without a physician or genetic counselor. However, it should be noted that parents can access these tests outside of the medical field—without the

permission of a health care provider.¹ In such situations, parents will be left to interpret the information on their own, without the help of a knowledgeable professional. Finally, child weight and height were selfreported in this study. However, parent-reported height and weight have been found to be accurate for classifying the weight status of individuals.²²

All these issues limit our ability to generalize our results to clinical situations and predict specific aspects of parents' behavior (e.g., encourage physical activity and healthy eating strategies). As testing technology becomes more widely available, future studies will need to examine these issues in real-life clinical settings—albeit with careful attention to the potential for genetic testing to falsely reassure parents about their child's disease risk.

Clinical Practice Implications

How parents process and act on information (both genetic and nongenetic) about their child's risk of chronic disease, including potential harmful consequences of learning this risk information, merits exploration in future studies that incorporate numerical risk estimates as they become available. Although studies have assessed children's risk for developing T2D as an adult based on clinical and family history factors,¹³ no predictions involving genetic test risks exist for children. Admittedly, the exploration of parents' interpretation of their child's genetic risk is in its infancy. In spite of these limitations, we believe that this study offers an important first step in understanding how parents with T2D interpret genetic risk information about their children. Future studies should address the effect of pediatric genetic susceptibility testing on parental behavior with actual tests in controlled research settings.

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Baseline Question*

Each rung on the ladder below represents where parents are in their thinking about taking action to reduce their child's risk of developing type 2 diabetes (T2D).

Circle the number on the ladder (0-10) that indicates where you are now in your thinking about your youngest child.

Positive Genetic Test Result Showing Increased Risk of Type 2 Diabetes*

If your youngest child had a genetic test which was **positive** for specific genes that increase his/her chance of developing T2D, what number on the ladder would you be at in your thinking about taking action to reduce your youngest child's risk of developing T2D? (Circle the number)

Negative Genetic Test Result Showing Increased Risk of Type 2 Diabetes*

If your youngest child had a genetic test which was **negative** for specific genes that increase his/her chance of developing T2D, what number on the ladder would you be at in your thinking about taking action to reduce your youngest child's risk of developing T2D? (Circle the number)

* **Bolded text was not included in the original survey instrument.**

Figure 1.
Survey Questions

Figure 2.
Study Sample

^aTop edge of the box represents the 75th percentile, and the lower edge represents the 25th percentile (interquartile range = 75th percentile – 25th percentile). The middle line dividing dark and light shading represents the 50th percentile. The ends of the error bars represent the maximum and minimum values.

Figure 3.

Box Plot of Scores for Baseline Intent to Act by Child's Risk.^a

^aTop edge of the box represents 75th percentile and the lower edge represents the 25th percentile (interquartile range = 75th percentile – 25th percentile). The middle line dividing dark and light shading represents the 50th percentile. The ends of the error bars represent the maximum and minimum values.

Figure 4.

Box Plot of Scores for Intent to Act: Baseline, Positive Test, and Negative Test.^a

Figure 5.
Change in Parents' Score after Receipt of Hypothetical Genetic Test Results

Table 1

Parent and Child Characteristics (n = 195).

	Percentage (n)
Parent	
Mean age in years at survey $\pm$ SD	48.4 $\pm$ 8.3
Female	52.3 (102)
Parent weight status	
Normal (BMI <25 kg/m ²)	18.0 (35)
Overweight (BMI $\geq$ 25 and <30 kg/m ²)	26.6 (52)
Obese (BMI $\geq$ 30 kg/m ²)	55.4 (108)
Self-reported ethnicity	
White	69.2 (135)
Black	16.4 (32)
Hispanic	4.6 (9)
Other	9.8 (19)
Education	
High school or less	16.1 (31)
Some college or trade	35.2 (68)
College or more	48.7 (94)
Medical complications	
None	16.4 (32)
1	33.9 (66)
2	49.7 (97)
Self-reported health	
Excellent/Very good	29.4 (57)
Good	43.3 (84)
Fair/Poor	27.3 (53)
Child	
Mean age in years at survey $\pm$ SD	10.5 $\pm$ 4.9
Child weight status ^a	
Normal (BMI <85th percentile)	43.6 (85)
Overweight (BMI $\geq$ 85th percentile)	56.4 (110)

Abbreviation: SD, standard deviation.

^aBMI percentiles based on male gender.