Just Living With Obese Family Members Increases Your Risk of Type 2 Diabetes

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IN BRIEF In this new era of accountable care and population health, large provider organizations are looking for new ways to predict diseases in their population, especially for people with diabetes. Although diabetes has been associated with the incidence of obesity, many diabetes patients are not obese. However, we find that just living in a household with one or more obese biologically related family members is a major risk factor for diabetes, even after accounting for all the other traditional risk factors.

With the rise of the accountable care movement, population health has become a very important topic. Health care provider organizations such as large hospital systems and medical groups—once only concerned with providing acute care—must now find new ways to manage the whole spectrum of health care for their patients. Invariably, this involves finding new and better ways of proactively predicting diseases and episodes within their population. One such example is diabetes, a leading cause of mortality in the United States, affecting ~29 million Americans and costing $245 billion in 2012 (1). More than 33% of American adults are estimated to have prediabetes. About 28% of people with diabetes are undiagnosed (1).

Much of the effort in the accountable care movement has been to look for new, nontraditional risk factors that have not been used before to predict diseases such as diabetes. There are a few traditional risk factors for diabetes. Existing research suggests that both obesity and physical inactivity are major nongenetic risk factors for type 2 diabetes (2–7). A causal relationship between obesity and type 2 diabetes has been well documented in the existing literature (8–11). Interactions between genetic predisposition and environmental risk factors increase the risk of type 2 diabetes and obesity (12). Evidence suggests that the identified genes contribute only modestly to the risk for each of the two diseases, indicating a more important role for environmental factors in the risk of disease (13). Family health history captures the effects of inherited genes and of exposure to similar environments among close relatives (14,15). A number of studies have examined the relationship between family history of type 2 diabetes and individual risk for type 2 diabetes (16–24). However, none have looked at the relationship between living with obese biologically related family members and an individual's risk of type 2 diabetes. In this study, we find that just living in a household with one or more obese biologically related family members is a major risk factor for diabetes, even after accounting for all the other traditional risk factors.

Methods

Data Sample

The Medical Expenditure Panel Survey (MEPS) is an annual national-

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ly representative survey from the federal Agency for Healthcare Research and Quality, interviewing about 16,000 new people and their households every year to get a nationally representative sample of the roughly 298 million members of the civilian, noninstitutionalized U.S. population. The survey collects health status, health care expenditures, and health insurance coverage information for each household for 2 years. This study uses MEPS data for the years 2002–2013. We narrowed the sample to people who did not have diabetes in the first-year interview. We further reduced the sample to people who had at least one blood relative living in the household. There were 40,724 individuals who met these criteria. We examined whether these individuals were newly diagnosed with diabetes in the year 2 interviews. To include only cases of recently diagnosed type 2 diabetes, we excluded individuals who were <30 years of age and who reported taking insulin. With the exclusion of 19 individuals with potential type 1 diabetes, our final sample had 40,707 individuals. This final sample was a nationally representative sample of the U.S. population who lived with a blood relative and did not have a prior diagnosis of diabetes. We then examined the predictive relationship between family obesity (versus self-obesity) and the onset of diabetes. Sample characteristics can be found in Table 1. In particular, 0.9% of the population was newly diagnosed with diabetes in year 2.

Measures

The measures below are prefaced either by "self" or "family." "Self" indicates that the person himself or herself had the reported condition (e.g., diabetes). "Family" indicates that another person in the family had the condition.

Self Diabetes

Anyone who reported a diabetes diagnosis in the second year of the survey but not in the first year was categorized as a new case of diabetes.

TABLE 1. Characteristics of the Study Sample (n = 40,707)

	Sample Size	Percentage of Total	
		Raw	Weighted
Diabetes in second year			
Yes	420	1.03	0.89
No	40,287	98.97	99.11
Mean age (years)		39.72	39.75
Baseline obesity			
Low to normal weight (BMI <25 kg/m^2)	16,026	39.37	42.25
Overweight (25 ≤ BMI <30 kg/m^2)	13,794	33.89	32.82
Obese (BMI ≥30 kg/m^2)	10,887	26.74	24.93
Weight gain in 1 year			
>5% of weight	11,427	28.07	26.32
≤5% of weight	29,280	71.93	73.68
Sex			
Male	18,566	45.61	48.58
Female	22,141	54.39	51.42
Race/ethnicity			
White	16,106	39.57	60.52
Hispanic	13,395	32.91	18.98
Asian	2,998	7.36	6.16
African American	8,208	20.16	14.34
Household income			
Low-to-high	31,830	78.19	85.16
Near-poor	2,351	5.78	3.98
Poor	6,526	16.03	10.86
Current smoker			
Yes	6,881	16.90	17.86
No	33,826	83.10	82.14
Ever advised to avoid fat foods			
Yes	10,552	25.92	25.74
No	30,155	74.08	74.26
Ever diagnosed as having high blood pressure other than during pregnancy			
Yes	8,290	20.38	19.78
No	32,417	79.62	80.22
At least three-fourths of biologically related family members living in the household are obese			
Yes	18,686	45.90	43.46
No	22,021	54.10	56.54
At least one biologically related family member living in the household has diabetes			
Yes	4,773	11.73	10.28
No	35,934	88.27	89.72

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TABLE 1. Characteristics of the Study Sample (n = 40,707), *continued from p. 306*

	Sample Size	Percentage of Total	
		Raw	Weighted
Of the biologically related family members living in the household:			
At least one has diabetes	4,773	11.73	10.28
None have diabetes but at least 75% are obese	15,718	38.61	37.04
None have diabetes and <75% are obese	20,216	49.66	52.68

Self Obesity

We used BMI reported in the first year as a way to categorize an individual's baseline weight using three dummy variables—low-to-normal weight (BMI <25 kg/m^2), overweight (BMI 25 to <30 kg/m^2), and obese (BMI ≥30 kg/m^2).

Self Weight Gain

A dichotomous indicator variable indicating an increase of ≥5% in BMI between the first and second year was constructed.

Next, using diabetes and obesity statuses of other biologically related family members living in the household, three family indicator variables were constructed.

Family Diabetes

Family diabetes indicates that one or more other members had diabetes.

Family Obesity

Family obesity indicates whether more than three-fourths of the other members were obese (BMI ≥30 kg/m^2).

Family Diabetes and Family Obesity

This category encompasses a hierarchal combination of obesity and diabetes statuses among other family members. This indicator variable contains the following three categories: *1*) family members were neither obese nor had diabetes (less than three-fourths of the family members were obese), *2*) three-fourths of the family members were obese but did not have diabetes, and *3*) one or more family members had diabetes. This variable was used to tease out and isolate the impact of family obesity from the effect of family diabetes on estimating the probability of being newly diagnosed with diabetes.

An individual's family income level and applicable poverty criteria were used to account for socioeconomic status via a three-category variable: poor (income <100% of the poverty line), near-poor (100–125% of the poverty line), and low-to-high income (>125% of the poverty line). Next, a binary variable was constructed to indicate whether a participant was ever advised to reduce intake of high-fat or high-cholesterol food. Other indicator variables included current smoking status, hypertension, sex, and race/ethnicity (Asian, African American, and other ethnicities). An indicator variable for each panel (cohort of interviewees) was used to account for cohort-specific fixed effects (11 cohorts).

Statistical Analysis

This study used Stata SE 14.1 (StataCorp, College Station, Tex.) to predict the onset of diabetes using a logistic regression model that accounted for the MEPS complex survey design. In the analysis, we used longitudinal weights for each panel. To assess model fit, we used the goodness-of-fit test, accounting for survey design suggested by Archer and Lemeshow (25). We investigated two models in our analysis. The first model included the family obesity and family diabetes statuses of an individual's family members as two separate predictor variables. The second model combined family members' obesity and family diabetes statuses into the three-category single predictor variable ("family diabetes and family obesity," as defined in the prevous section). Next, because about 3.5% (1,421 individuals) of the sampled individuals had missing BMI values, we used a multiple imputation method to impute the missing values of these two variables. To test robustness, the third model used all the predictors from the second model but included individuals without imputed BMI.

Results

A total of 40,707 individuals living with blood relatives and without a prior diabetes diagnosis formed our study sample. A total of 0.89% of the weighted sample had a diabetes diagnosis in the second year, 24.9% (10,887 sample individuals) were obese, 32.8% were overweight, 26.3% had a >5% weight gain (BMI), 48.6% were males, 60.5% were white, 19% were Hispanics, 6.2% were Asian, and 17.9% were current smokers (Table 1). Individuals categorized as being poor and near-poor comprised about 4% and 10.9% of the sample, respectively. Individuals who reported being ever diagnosed with hypertension represented 19.8% of the sample. A total of 25.7% of the sampled individuals reported receiving medical advice to cut down on high-fat or high-cholesterol foods. Among the sampled individuals, 10.3% had at least one biologically related family member with diabetes, 43.5% had obese biologically related relatives comprising at least three-fourths of their households, and 37% had obese relatives comprising at least three-fourths of their households but with no diabetes.

Table 2 presents the results of two logistic regression models. The goodness-of-fit test indicated that each model was a good fit (P = 0.784 for model 1 and P = 0.755 for model 2). As stated earlier, with the

TABLE 2. Logistic Regression Results Predicting the Likelihood of a Person Being Diagnosed With Diabetes at the End of 1 Year From Baseline

Predictors	Model 1 Coefficient	Model 2 Coefficient	Model 3 Coefficient
Age	**0.157*** **	**0.157*** **	**0.159*** **
Age × age	**−0.001*** **	**−0.001*** **	**−0.001*** **
Baseline obesity			
Low to normal weight (BMI <25 kg/m²)	**−0.374* **	**−0.374* **	−0.336
Overweight (25 ≤BMI <30 kg/m²)	Ref.	Ref.	Ref.
Obese (BMI ≥30 kg/m²)	**0.893*** **	**0.892*** **	**0.919*** **
Weight gain in 1 year			
>5% of weight	**0.452** **	**0.452** **	**0.457** **
≤5% of weight	Ref.	Ref.	Ref.
Sex			
Male	−0.091	−0.091	−0.090
Female	Ref.	Ref.	Ref.
Race/ethnicity			
White	Ref.	Ref.	Ref.
Hispanic	0.264	0.262	0.205
Asian	**0.752** **	**0.746** **	**0.747** **
African American	0.116	0.114	0.090
Household income			
Low-to-high	Ref.	Ref.	Ref.
Near-poor	**0.594* **	**0.594* **	**0.609** **
Poor	**0.552** **	**0.553** **	**0.493** **
Current smoker			
Yes	−0.180	−0.183	−0.193
No	Ref.	Ref.	Ref.
Ever advised to avoid fat foods			
Yes	0.260	0.26	0.250
No	Ref.	Ref.	Ref.
Ever diagnosed as having high blood pressure other than during pregnancy			
Yes	**0.573*** **	**0.572*** **	**0.601*** **
No	Ref.	Ref.	Ref.
At least three-fourths of biologically related family members living in the household are obese			
Yes	**0.270* **		
No	Ref.		

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exception of the obesity and diabetes statuses of an individual's family members, the remaining predictor covariates were the same in both models. The size, directionality, and significance level of each of these common predictor variable coefficients were commensurate across the two models. The incidence of diabetes was positively correlated with age (P <0.001) and negatively with age squared (P <0.001), suggesting that the likelihood of diabetes incidence increases with age but at a decreasing rate. Both higher weight (BMI) and weight gain (BMI gain) were positively associated with diabetes incidence (P <0.05). Diabetes incidence was positively associated with any diagnosis of high blood pressure (P <0.05). Relative to whites, other races had a higher chance of being diagnosed with diabetes, but the relationship was significant only for Asian subjects (P <0.001). Poor and near-poor individuals had a higher risk of diabetes diagnosis than low-to-high income individuals (P <0.05 for near-poor and P <0.01 for poor). Receipt of advice to reduce fat or cholesterol intake was weakly but positively associated with the incidence of diabetes (P <0.07). The presence of one or more biologically related family members with diabetes in the household increased the risk of diabetes incidence (P <0.05). While model 1 showed that living in a household in which at least three-fourths of an individual's biological family members were obese was positively and independently related to diabetes incidence (P <0.05), model 2 indicated that this relationship holds even in the absence of any other family members with diabetes (P <0.05).

Table 3 presents probabilities and marginal probabilities of diabetes incidence from model 2. Less than 1% (0.89%) of individuals who were without diabetes in the first year and had at least one biologically related person living in the same household were diagnosed with diabetes in the second year (P <0.001). The likeli-

TABLE 2. Logistic Regression Results Predicting the Likelihood of a Person Being Diagnosed With Diabetes at the End of 1 Year From Baseline, *continued from p. 308*

Predictors	Model 1 Coefficient	Model 2 Coefficient	Model 3 Coefficient
At least one biologically related family member living in the household has diabetes			
Yes	**0.418***		
No	Ref.		
Of the biologically related family members living in the household:			
At least one has diabetes		**0.620****	**0.641****
None have diabetes but at least 75% are obese		**0.294***	**0.298***
None have diabetes and <75% are obese	Ref.	Ref.	Ref.
Constant	**–10.703*****	**–10.712*****	**–10.752*****

**P <0.05; **P <0.01; ***P <0.001. Bold type indicates statistical significance. Model goodness-of-fit tests: P = 0.784 for Model 1 and P = 0.755 for Model 2; Model 3 presents the results of Model 2 rerun on individuals without imputed BMI. Ref., omitted reference category.*

TABLE 3. Predicted Probabilities and Predicted Marginal Differences From Logistic Regression Model Results

	Probability	Marginal Difference	Marginal Difference-in-Difference
Overall	**0.0089*****		
Sex			
Male	**0.0085*****	–0.0008	
Female	**0.0093*****	Ref.	
Baseline obesity			
Low to normal weight (BMI <25 kg/m²)	**0.0047*****	**-0.0021***	Ref.
Over weight (25 ≤BMI <30 kg/m²)	**0.0067*****	Ref.	
Obese (BMI ≥30 kg/m²)	**0.0160*****	**0.0093*****	**0.0114*****
Weight gain in 1 year			
>5% of weight	**0.0124*****	**0.0044****	
≤5% of weight	**0.0081*****	Ref.	
Race/ethnicity			
White	**0.0080*****	Ref.	
Hispanic	**0.0103*****	0.0023	–0.0061
Asian	**0.0164*****	**0.0084***	Ref.
African American	**0.0089*****	0.0009	**–0.0075***

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hood of diabetes incidence increased with BMI. Compared to the incidence of diabetes among overweight individuals, the incidence of diabetes was 0.2 percentage points lower among individuals of low-to-normal weight (P <0.05) and 0.9 percentage points higher among obese (BMI ≥30 kg/m^2) individuals (P <0.001). Further, the probability of new diabetes cases was 1.1 percentage points higher among obese individuals than among those of low-to-normal weight (P <0.001). Individuals who saw a gain in their weight (BMI) of >5% were 0.4 percentage points more likely to report diabetes than those who did not gain >5% (P <0.01). Compared to the incidence of diabetes among Asians, the incidence was lower among other groups: 0.8 percentage points less among whites (P <0.01), 0.6 percentage points less among Hispanics (P <0.07), and 0.7 percentage points less among African Americans (P <0.05). Compared to the incidence among individuals with low-to-high household incomes, the risk of diabetes incidence among poor and near-poor individuals increased by 0.58 percentage points (P <0.05) and 0.63 percentage points (P <0.10), respectively. Having any diagnosis of high blood pressure increased the risk of diabetes. Individuals who had been diagnosed as having high blood pressure were 0.5 percentage points more likely to report diabetes than people who were never diagnosed (P <0.001). For an individual living with biologically related family members without any diabetes history and with <75% being obese, that individual's predicted risk of diabetes was 0.75%. However, for an individual living with at least one biologically related family member with diabetes, risk increased by 0.6 percentage points (P <0.01), from 0.75% to about 1.35%. If an individual was living in a household without diabetes but where at least 75% of the family were obese, then that individual's risk of diabetes increased by 0.24 percentage points (P <0.05) from 0.75% to

TABLE 3. Predicted Probabilities and Predicted Marginal Differences From Logistic Regression Model Results, ***continued from p. 309***

	Probability	Marginal Difference	Marginal Difference-in-Difference
Household Income			
Low-to-high	**0.0081*** **	Ref.	
Near-poor	**0.0145*** **	**0.0063***	
Poor	**0.0139*** **	**0.0058** **	
Ever advised to avoid fat foods			
Yes	**0.0102*** **	0.0023	
No	**0.0079*** **	Ref.	
Current smoker			
Yes	**0.0077*** **	-0.0015	
No	**0.0091*** **	Ref.	
Ever diagnosed as having high blood pressure other than during pregnancy			
Yes	**0.0120*** **	**0.0051*** **	
No	**0.0069*** **	Ref.	
Of the biologically related family members living in the household:			
At least one has diabetes	**0.0136*** **	**0.0061** **	
None have diabetes but at least 75% are obese	**0.0099*** **	**0.0025***	
None have diabetes and <75% are obese	**0.0075*** **	Ref.	

**P <0.05; **P <0.01; ***P <0.001. Bold type indicates statistical significance. Ref., omitted reference category.*

0.99%. Nationally, this last estimate amounts to ~238,000 people per year in the United States who can be predicted to be newly diagnosed with type 2 diabetes based solely on family obesity.

Discussion

Using nationally representative survey data, we found that 0.89% of adults without diabetes in year 1 who were living with at least one blood-related family member were newly diagnosed with type 2 diabetes at the end of year 2. To our knowledge this is the first study that examined the relationship between the obesity status of biologically related family members and an individual's risk of diabetes. We showed that the prevalence of obesity among biologically related family members is positively related to an individual's risk of diabetes. Family members' obesity statuses predict an individual's risk of diabetes, not only in the presence of other predictors such as family members' diabetes statuses, individual's BMI, and weight gain, but also in the absence of any family household members with diabetes. The American Diabetes Association recommends screening for family history of diabetes (26); however, we recommend using prevalence of obesity among family members as a criterion for diabetes screening when the family diabetes history is not available or when no one in the family has diabetes. In addition, family history of obesity can be used as a prevention tool to guide individuals toward adopting healthy lifestyles. Moreover, because accountable care organizations and primary care medical homes seek to implement population health analytics to reduce acute medical care use, this article shows that there are additional, nontraditional measures that can be added to their predictive analytics arsenal to improve prediction in a cost-effective way. This result is important because the cost-effectiveness and business case for population health currently hangs in the balance.

Our study has some limitations. First, BMI information was missing in <5% of the sample. We used a multiple-imputation method to impute the missing BMI values. The results of our model did not change when individuals with missing BMIs were excluded from the analysis (see Model 3, Table 2). Second, the family information we used in our analysis was restricted only to family members living in the same household; therefore, our analysis does not include a comprehensive family history. Our proposed relationship between household obesity prevalence and the risk of diabetes may be confounded by the lack of complete family diabetes history, since lifestyle and behaviors are shaped during early childhood. For that reason, we recommend the use of complete family diabetes histories in future studies to examine the effect of household obesity status on individual risk of diabetes. We also recommend future research augmenting our survey data (family self-reports) with actual measurements and medical records. Lack of self-reported information about the family might not mean the absence of disease or obesity. Whether more complete medical information would bias our results upward or downward is unknown and is a subject for future research. Our current research merely indicates that there may be fruitful, evidence-based pathways to using nontraditional metrics and indicators to uncover population health early on to better target diabetes prevention efforts.

Disclaimer

The views herein do not represent the views of the Agency for Healthcare Research and Quality or the Department of Health and Human Services.

Duality of Interest

No potential conflicts of interest relevant to this article were reported.

Author Contributions

V.K. researched data and wrote the manuscript. W.E., K.T., and H.T. contributed to discussion and reviewed/edited the manuscript. V.K. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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