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Obesity and glycemic control in patients with diabetes mellitus: Analysis of physician electronic health records in the US from 2009–2011

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ABSTRACT

Aims: Examine the association between obesity and glycemic control among patients with type 1 (T1DM) or type 2 diabetes mellitus (T2DM).
Methods: Data from US physician electronic health records (Humedica®) from 2009–2011 were utilized. Patients were defined as having above–target glycemic control if they had an HbA1c ≥7% at any time during the study period. Multinomial logistic regressions were conducted separately for T1DM and T2DM patients, and examined associations between BMI categories and probability of having above–target glycemic control (≥7% and <8%, ≥8% and <9%, or ≥9%) while controlling for patient demographics, general health, comorbid conditions, and antihyperglycemic medication use.
Results: There were 14,028 T1DM and 248,567 T2DM patients; 47.8% of T1DM and 63.4% of T2DM were obese (BMI ≥30 kg/m^2). For T1DM, being overweight (BMI 25– < 30), obese class I (30– < 35), II (35– < 40), or III (≥40) was associated with a significantly higher probability of having HbA1c ≥ 8% and <9% or ≥9%, while being overweight was associated with a significantly higher probability of having HbA1c ≥7% and <8% compared to normal BMI (BMI ≥ 18.5 and < 25). For T2DM patients, being overweight, obese class I, II, or III was associated with a significantly higher probability of having HbA1c ≥7% and <8%, ≥8% and <9%, or ≥9%.
Conclusions: For both T1DM and T2DM patients, there were positive and statistically significant associations between being overweight or obese and having suboptimal glycemic control. These findings quantify the associations between obesity and glycemic control, and highlight the potential importance of individual characteristics on glycemic control.

1. Introduction

Diabetes mellitus currently affects 29.1 million Americans (Centers for Disease Control and Prevention, 2014b) and the United States (US) economy with $245 billion (2012) in treatment costs each year (American Diabetes Association, 2013). Obesity is also highly prevalent in the US, with more than one-third of the adult population classified as obese, indicated by a body mass index (BMI kg/m^2) of 30 or above (Centers for Disease Control and Prevention, 2014a). Being overweight or obese independently increases the risks of developing a large number of serious illnesses, including coronary heart disease, some cancers, stroke, liver and gallbladder disease, and osteoarthritis (Centers for Disease Control and Prevention, 2013; Hubert, Feinleib, McNamara, & Castelli, 1983; National Institutes of Health and National Heart, Lung, and Blood Institute, 1998). Because of these obesity-associated conditions, obese Americans have 42% higher yearly health care costs relative to those of normal weight, and the aggregate costs of obesity in the US have been estimated at $147 billion (2008 dollars) annually, or 9.1% of all medical spending (Finkelstein, Fiebelkorn, & Wang, 2003). The prevalence of obesity in the US has risen significantly over the past several decades (Centers for Disease Control and Prevention, 2014a) and has been a major driver of the nation's rapidly increasing health care costs (Finkelstein et al., 2003).

Excess body weight has been identified as an issue of concern for both type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus

Conflicts of Interest: Bae, Hoogwerf, Mo and Nelson completed this work as employees of Eli Lilly and Company, while Lage was compensated by Eli Lilly and Company for her work on this research.

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(T2DM). Obesity is a major risk factor for T2DM, (Ganz et al., 2014) and 80% of individuals with T2DM are overweight or obese (National Institutes of Health and National Institute of Diabetes and Digestive and Kidney Disease, 2004). Among patients with T2DM, obesity raises the odds of developing many common diabetic complications, including heart disease, retinopathy, dyslipidemia, and hypertension (American Diabetes Association, 2014). Previous studies have shown that the glycemic control of patients with T2DM tends to worsen with weight gain and to improve with weight loss, (Neiberg et al., 2012; Shantha, Kumar, Kahan, & Cheskin, 2012) while significant weight loss, such as that associated with gastric bypass surgery, has been shown to lead to a partial or total remission of T2DM (Scopinaro et al., 2014). Among individuals with T1DM, research has shown a 7-fold increase in the prevalence of obesity among patients with T1DM after 18-years follow up, with the amount of insulin used positively associated with weight gain (Conway et al., 2010). Furthermore, clinical trial evidence shows that weight gain among patients with T1DM is associated with an increased cardiovascular risk (Purnell et al., 1998) and that this risk is lower among patients with improved glycemic control (Williams, Erbey, Becker, & Orchard, 1999).

In addition to the research which has examined the relationship between glycemic control and changes in weight, there has been some research which has focused on the relationship between BMI categories and glycemic control. For example, a study using data from the National Health and Nutrition Examination Survey (NHANES) between 1999 and 2006 showed that mean HbA1c levels were highest for diabetes patients with BMI < 25 (Nguyen, Nguyen, Lane, & Wang, 2011). However, little research has focused on the relationship between BMI classifications and HbA1c among a large, insured population.

The goal of this research was to improve understanding of the association between obesity and glycemic control. Specifically, the analyses used a large, cross-national population of individuals with T1DM and T2DM to examine the association between BMI classes and the odds of having suboptimal glycemic control, as indicated by a hemoglobin A1c (HbA1c) value higher than <7%, given that such a target has been defined as reasonable for many non-pregnant adults (American Diabetes Association, 2014). Furthermore, the analyses examines a range of above target glycemic control (HbA1c ≥7% and <8%, ≥8% and <9%, and ≥9%) and also identifies other factors linked to suboptimal glycemic control.

2. Methods

An electronic health record (EHR) data base (Humedica®) was analyzed. The data were extracted from various health information technology systems in medical group practices and integrated delivery networks (IDNs), and contain laboratory results, radiology and pathology reports, physician and nurse notes, prescriptions written and dispensed, procedures, diagnoses, and other details of a patient's office visit. Humedica data are based upon a network of provider organizations that treat approximately 30 million patients who may be uninsured or insured via commercial insurance, Medicare, or Medicaid. The data come from 38 states, although the midwestern region of the US is overrepresented. The data are all de-identified and fully comply with Health Insurance Portability and Accountability Act (HIPAA) regulations.

To be included in this study, an individual was first identified as having T1DM or T2DM between January 1, 2009 and December 31, 2011. Patients were classified as having T1DM if they received at least two diagnoses of T1DM (250.x1 or 250.x3) during the study period and were classified as having T2DM if they received at least two diagnoses of T2DM (250.x0 or 250.x2) and were not in the T1DM cohort. Individuals were also required to have at least one BMI value and one HbA1c value recorded during this time period, and to be at least age 18 years in the year 2009. Individuals were excluded if they were diagnosed as pregnant at any time in the 3-year time period or if their first active record was after January 2009 or their last active record was before December 2011. Finally, patients identified as underweight were excluded since they represented less than 1% of the patients. These inclusion/exclusion criteria resulted in a sample size of 259,595 (248,567 with T2DM and 14,028 with T1DM). Fig. 1 illustrates how each inclusion/exclusion criterion affected sample size.

Descriptive statistics (mean and standard deviation or medians and interquartile ranges for continuous variables, and frequency and percentages for categorical variables) were used to characterize the sample. Student's t-tests and chi-square tests were used to assess differences between cohorts based upon glycemic control. Glycemic control was measured as the highest recorded HbA1c over the study period and patients were categorized into four groups depending upon whether their HbA1c was <7%, ≥7% and <8%, ≥8% and <9%, or ≥9%. These cutoffs were based upon clinical guidelines which recommend a treatment target of HbA1c <7% for many non-pregnant adults with diabetes and suggest that a target of <8% may be appropriate for patients with a history of severe hypoglycemia, limited life expectancy, or diabetic complications or comorbidities (American Diabetes Association, 2015). Furthermore, results from an observational study among the elderly suggest that a target HbA1c of 8 to 8.9% may be appropriate (Yau et al., 2012) and that an HbA1c value of > 9% is associated with increased mortality risk among patients with type 2 diabetes (Nicholas, Charlton, Dregan, & Gulliford, 2013).

Multinomial logistic regressions were then estimated in order to examine the relationship between glycemic control and BMI (kg/m^2) levels (normal - 18.5 to <25, overweight - 25 to <30, obesity I - 30 to <35, obesity II - 35 to <40, and obesity III - ≥40) (World Health

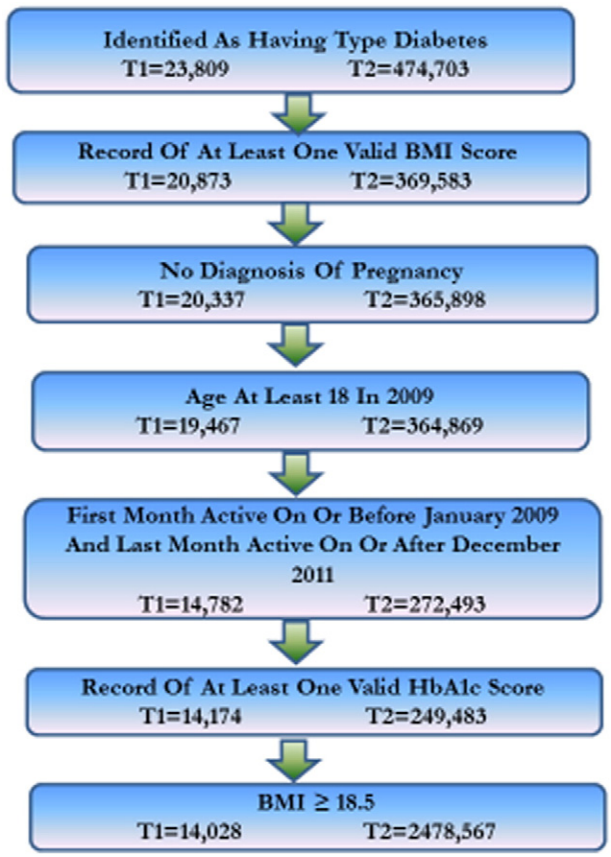

Fig. 1. Inclusion/Exclusion criteria and sample size.