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Obesity in hospitalized type 2 diabetes patients: A descriptive study

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Background: The association between obesity and type 2 diabetes has been well documented in epidemiological studies. Patients with type 2 diabetes have a higher body weight than control populations. Relatively few studies, however, have examined the prevalence of obesity in a cohort of hospitalized type 2 diabetes mellitus patients using an electronic health records database. This study measured the prevalence of obesity in hospitalized type 2 diabetes patients and described demographic and clinical characteristics using electronic health records from Convergence CT sites located in the southwestern United States.





Material/Methods: Hospitalized patients with type 2 diabetes mellitus were identified in electronic health records from the Convergence Global Research Network. Demographic and clinical characteristics were examined for hospitalized patients with type 2 diabetes. Comparisons were made between males and females across different clinical characteristics as well as between obese patients (BMI ≥ 30 kg/m²) and patients with BMI < 30 kg/m².

Results: Approximately 26.8% of hospitalized type 2 diabetes patients were overweight (BMI=25–29.9 kg/m²) and 57.7% were obese (BMI ≥ 30 kg/m²). A higher percentage of females (61.3%) were obese compared to males (54.6%) ($p=0.002$). Obese patients with type 2 diabetes were younger, appeared to have inadequate glycemic control, exhibited higher blood pressure, and had worse lipid profiles compared to type 2 diabetes patients with BMI < 30 kg/m².

Conclusions: Approximately 84.5% of the hospitalized type 2 diabetes patients identified in this study were overweight or obese (BMI ≥ 25 kg/m²), suggesting the need for effective weight loss intervention in this population.

Key words: **obesity • type 2 diabetes • hospitalization • weight loss**

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Background

There is extensive epidemiological evidence to illustrate the association between obesity and type 2 diabetes. Indeed, type 2 diabetics have a higher body weight than patients in a control population [1]. In a survey by the US Centers for Disease Control and Prevention, the prevalence of obesity among persons diagnosed with diabetes was 53% in men and 58% in women. Higher percentages were classified as overweight or obese (86% in men and 84% in women) [2].

Obesity represents a significant cost burden to the US health-care system, with nearly 50% of costs financed by Medicare and Medicaid [3]. An analysis of prescription spending for community-dwelling Medicare beneficiaries found that annual drug spending was significantly higher for obese Medicare beneficiaries compared to normal-weight beneficiaries. Obese individuals also had higher utilization rates for selected medications used to treat diabetes, hypertension, ischemic heart disease, heart failure, hyperlipidemia, and osteoarthritis [4].

A reduction in weight could potentially minimize the risk of type 2 diabetes. Studies have demonstrated a link between weight loss with enhanced glucose homeostasis and a reduction in the risk of developing type 2 diabetes. Interventions have included lifestyle changes in overweight subjects with impaired glucose tolerance [5–7], as well as a combination of lifestyle changes with drug therapy [8].

Patients hospitalized with type 2 diabetes may present with complications such as advanced cardiovascular disease. An increasing amount of evidence in the literature has shown that body mass index, triglycerides and high density lipoproteins are also independent predictors of hospitalization for diabetes complications [9]. Thus, the need for effective interventions, such as weight loss, to reduce the clinical and economic impact of hospitalization for complications related to type 2 diabetes. Moreover, the challenge to diabetes prevention on a population level involves collaboration from multiple parties including education providers, non-governmental organizations, the food industry, the media, urban planners, and politicians [10].

Relatively few studies, however, have specifically examined the prevalence of obesity in hospitalized type 2 diabetes patients in the United States. Our study measured the prevalence of obesity in a cohort of hospitalized type 2 diabetes patients identified in an electronic health records database from Convergence CT sites located in the southwestern United States.

Material and Methods

Electronic health records from Convergence CT sites located in the southwestern United States, part of the Convergence Global Research Network (CGRN), were used for analyses. CGRN includes a number of provider hospitals and healthcare systems in the United States and facilitates relationships between members of the CGRN and medical research organizations [11]. In compliance with the Health Insurance Portability and Accountability Act (HIPAA), patient data were deidentified. Thus, this study was exempt from the requirement for institutional review board approval.

Hospital inpatients 18–89 years of age and with a type 2 diabetes ICD-9 diagnosis (ICD-9 codes 250.x0 or 250.x2) were identified between January 1, 2010 and December 31, 2011. Information was collected on a patient's gender, age, body mass index, plasma glucose level, treatment, blood pressure, total cholesterol, triglyceride level, high density lipoprotein level, and low density lipoprotein level. Clinical characteristics were measured on or as close as possible to the hospital admission date.

Descriptive characteristics of the hospitalized type 2 diabetes population, including patient counts and frequencies, were tabulated and compared using the chi-square test. Patient distribution was stratified by gender and examined by age groups, body mass index categories, and treatments. Mean age; mean body mass index; mean plasma glucose; mean systolic and diastolic blood pressure; and mean total cholesterol, triglyceride, high density lipoprotein, and low density lipoprotein values were computed and compared between male and female type 2 diabetes patients using the *t*-test statistic.

Patients were also stratified into two categories: BMI <30 kg/m² and BMI ≥30 kg/m². Descriptive characteristics of male and female type 2 diabetics within the two BMI strata were tabulated and comparisons were made between patients in the obese category (BMI ≥30 kg/m²) vs. BMI <30 kg/m². Demographic and clinical characteristics included mean age; mean glucose; mean systolic and diastolic blood pressure; and mean total cholesterol, triglyceride, high density lipoprotein and low density lipoprotein values. Comparisons were made using the *t*-test statistic.

Results

A total of 2044 hospitalized type 2 diabetes patients were identified across Convergence CT sites in the southwestern United States (Figure 1). Approximately 53.3% of the population included males. As can be seen from Table 1, females were slightly older than males (mean age =63.8 years vs. 62.1 years, *p*=0.008). The prevalence of obesity (BMI ≥30 kg/m²) was 57.7% in this diabetic patient population. Females had a higher body

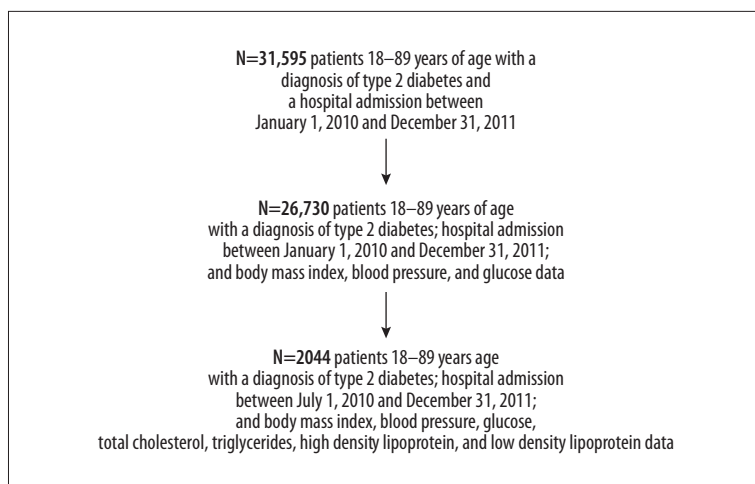


Figure 1. Number of hospitalized type 2 diabetes patients identified after requiring select inclusion criteria.

mass index relative to males (mean BMI=33.9 kg/m² vs. 32.0 kg/m², $p<0.0001$), and a higher percentage of females were obese (61.3% vs. 54.6%, $p=0.002$). Overall, glycemic control appeared to be inadequate. Male patients were observed to have a higher plasma glucose level compared to female patients (mean plasma glucose =185 mg/dL vs. 174 mg/dL, $p=0.02$). Only 17.7% of the hospitalized type 2 diabetics received insulin (19.1% of males and 16.0% of females), and 38.0% received antidiabetic medications (38.6% of males and 37.2% of females). The mean systolic blood pressure readings would suggest a prehypertension level (130–140 mmHg), and there was no statistically significant difference between males and females. Males, however, had small but significantly higher mean diastolic blood pressure levels relative to females (mean diastolic BP=72.5 mmHg vs. 69.5 mmHg, $p<0.0001$). Among lipid laboratory results, triglyceride levels were significantly higher among males (mean triglyceride =253 mg/dL vs. 183 mg/dL, $p<0.0001$); and females had significantly higher high density lipoprotein levels (mean HDL =37.2 mg/dL vs. 31.5 mg/dL, $p<0.0001$) and higher low density lipoprotein levels (mean LDL =88.3 mg/dL vs. 81.3 mg/dL, $p<0.0001$).

After stratifying hospitalized type 2 diabetes patients into two groups (BMI <30 kg/m² and BMI ≥30 kg/m²), it was noted that obese males and females each were significantly younger than males and females with BMI <30 kg/m² ($p<0.0001$) (Table 2). Only obese males had a significantly higher plasma glucose level compared to males with BMI <30 kg/m² (mean plasma glucose =193 mg/dL vs. 177 mg/dL, $p=0.03$). Similarly, obese males had significantly higher systolic and diastolic blood pressure values relative to males with BMI <30 kg/m² (mean systolic BP=133 mmHg vs. 129 mmHg, $p=0.002$; and mean diastolic BP=74.1 mmHg vs. 70.6 mmHg, $p<0.0001$). Obese females also had higher diastolic blood pressure readings relative to females with BMI <30 kg/m² (mean diastolic BP=70.3 mmHg vs. 68.2 mmHg, $p=0.008$). With respect to lipid levels, obese males had significantly higher total cholesterol values

compared to males with BMI <30 kg/m² (mean total cholesterol =162 mg/dL vs. 149 mg/dL, $p=0.002$). Triglyceride levels were higher for obese males relative to males with BMI <30 kg/m² and obese females relative to females with BMI <30 kg/m² (mean triglyceride =283 mg/dL vs. 217 mg/dL, $p=0.03$; and 195 mg/dL vs. 164 mg/dL, $p=0.03$, respectively). High density lipoprotein levels were lower for obese males and females (mean HDL=30.1 mg/dL vs. 33.1 mg/dL, $p<0.0001$; and 36.1 mg/dL vs. 39.0 mg/dL, $p=0.0003$, respectively), while obese males were observed to have a higher low density lipoprotein level relative to males with BMI <30 kg/m² (mean LDL=83.6 mg/dL vs. 78.5 mg/dL, $p=0.02$).

Discussion

The results of this study demonstrate that 84.5% of hospitalized type 2 diabetes patients were overweight or obese (BMI ≥25 kg/m²). In particular, obese patients (BMI ≥30 kg/m²) were younger, appeared to have inadequate glycemic control, demonstrated higher blood pressure, and had a suboptimal lipid profile compared to patients with BMI <30 kg/m². Based on 2009–2010 data from the US National Health and Nutrition Examination Survey, 35.7% of US adults were obese. The prevalence of obesity did not vary between males (35.5%) and females (35.8%) [12]. Obesity prevalence, however, has been shown to be higher among diabetic males and females (53% and 58%, respectively) [2]. An observational study of patients who attended a diabetes clinic in the United Kingdom noted that 47.0% of male type 2 diabetics were obese, while 54.3% of female type 2 diabetes patients were obese [13]. These findings are rather consistent with the results of our study which observed a prevalence of 54.6% among males hospitalized with type 2 diabetes and 61.3% among hospitalized female type 2 diabetics.

It appeared that glycemic control was inadequate in this patient population. Males and females had mean glucose levels

Table 1. Characteristics of hospitalized patients with type 2 diabetes.

Characteristic	Male type 2 diabetes patients (N=1090)		Female type 2 diabetes patients (N=954)		p-value
Age (years)					
Mean age (SD)	62.1	(14.0)	63.8	(14.2)	0.008
18–29 n (%)	10	(0.9%)	8	(0.8%)	NS
30–39 n (%)	56	(5.1%)	43	(4.5%)	NS
40–49 n (%)	160	(14.7%)	115	(12.1%)	NS
50–59 n (%)	227	(20.8%)	189	(19.8%)	NS
60–69 n (%)	287	(26.3%)	233	(24.4%)	NS
70–79 n (%)	217	(19.9%)	224	(23.5%)	0.05
80–89 n (%)	133	(12.2%)	142	(14.9%)	NS
Length of hospitalization (days)					
Mean length of hospitalization (SD)	4.9	(4.9)	4.8	(4.3)	NS
Body mass index (kg/m ²)					
Mean body mass index (SD)	32.0	(7.6)	33.9	(9.5)	<0.0001
<18.5 n (%)	9	(0.8%)	14	(1.5%)	NS
18.5–24.9 n (%)	164	(15.0%)	130	(13.6%)	NS
25–29.9 n (%)	322	(29.5%)	225	(23.6%)	0.002
≥30 n (%)	595	(54.6%)	585	(61.3%)	0.002
≥40 n (%)	140	(12.8%)	220	(23.1%)	<0.0001
Glucose (mg/dL)					
Mean glucose (SD)	185	(122)	174	(100)	0.02
Treatment (%)					
Insulin n (%)	208	(19.1%)	153	(16.0%)	NS
Antidiabetic medication n (%)	421	(38.6%)	355	(37.2%)	NS
Antidiabetic medication + insulin n (%)	223	(20.5%)	176	(18.4%)	NS
Blood pressure (mmHg)					
Mean systolic blood pressure (SD)	131	(22.1)	132	(20.9)	NS
Mean diastolic blood pressure (SD)	72.5	(12.0)	69.5	(12.0)	<0.0001
Total cholesterol (mg/dL)					
Mean total cholesterol (SD)	156	(75.2)	161	(57.1)	NS
Triglycerides (mg/dL)					
Mean triglycerides (SD)	253	(497)	183	(227)	<0.0001
High density lipoprotein (mg/dL)					
Mean high density lipoprotein (SD)	31.5	(10.9)	37.2	(12.1)	<0.0001
Low density lipoprotein (mg/dL)					
Mean low density lipoprotein (SD)	81.3	(35.8)	88.3	(38.7)	<0.0001

NS – not statistically significant at $\alpha=0.05$.

Table 2. Characteristics of obese and non-obese hospitalized patients with type 2 diabetes.

Characteristic	Type 2 diabetes and BMI <30 kg/m ²		Type 2 diabetes and BMI ≥30 kg/m ²		p-value	
	Male (N=495)	Female (N=369)	Male (N=595)	Female (N=585)	Male (BMI <30 kg/m ² vs. BMI ≥30 kg/m ²)	Female (BMI <30 kg/m ² vs. BMI ≥30 kg/m ²)
Age (years)						
Mean age (SD)	66.4 (13.8)	68.2 (14.2)	58.6 (13.2)	61.0 (13.5)	<0.0001	<0.0001
18–29 n (%)	3 (0.6%)	3 (0.8%)	7 (1.2%)	5 (0.9%)	NS	NS
30–39 n (%)	15 (3.0%)	10 (2.7%)	41 (6.9%)	33 (5.6%)	0.003	0.03
40–49 n (%)	52 (10.5%)	27 (7.3%)	108 (18.2%)	88 (15.0%)	0.0003	0.0002
50–59 n (%)	82 (16.6%)	60 (16.3%)	145 (24.4%)	129 (22.1%)	0.002	0.03
60–69 n (%)	113 (22.8%)	72 (19.5%)	174 (29.2%)	161 (27.5%)	0.02	0.005
70–79 n (%)	136 (27.5%)	101 (27.4%)	81 (13.6%)	123 (21.0%)	<0.0001	0.03
80–89 n (%)	94 (19.0%)	96 (26.0%)	39 (6.6%)	46 (7.9%)	<0.0001	<0.0001
Length of hospitalization (days)						
Mean length of hospitalization (SD)	4.8 (4.4)	4.9 (4.4)	5.0 (5.3)	4.7 (4.3)	NS	NS
Glucose (mg/dL)						
Mean glucose (SD)	177 (136)	168 (111)	193 (109)	178 (93.1)	0.03	NS
Blood pressure (mmHg)						
Mean systolic blood pressure (SD)	129 (23.8)	132 (21.6)	133 (20.5)	133 (20.4)	0.002	NS
Mean diastolic blood pressure (SD)	70.6 (12.1)	68.2 (11.9)	74.1 (11.6)	70.3 (12.0)	<0.0001	0.008
Total cholesterol (mg/dL)						
Mean total cholesterol (SD)	149 (66.7)	158 (54.6)	162 (81.1)	163 (58.6)	0.002	NS
Triglycerides (mg/dL)						
Mean triglycerides (SD)	217 (535)	164 (217)	283 (461)	195 (232)	0.03	0.03
High density lipoprotein (mg/dL)						
Mean high density lipoprotein (SD)	33.1 (12.2)	39.0 (12.4)	30.1 (9.5)	36.1 (11.8)	<0.0001	0.0003
Low density lipoprotein (mg/dL)						
Mean low density lipoprotein (SD)	78.5 (37.9)	85.8 (37.6)	83.6 (33.7)	89.9 (39.4)	0.02	NS

NS – not statistically significant at $\alpha=0.05$.

that may have exceeded the normal range. For diabetics, the American Diabetes Association recommends a blood glucose target range of 90–130 mg/dL before meals, and less than 180 mg/dL after meals [14]. In our study, hospitalized male and female type 2 diabetes patients had a mean plasma glucose level of 185 mg/dL and 174 mg/dL, respectively. These levels were even higher in the subgroup of obese patients. Admittedly, however, we were unable to ascertain precisely when the plasma blood glucose measurement occurred in relation to meal intake. Self monitoring is an important tool in maintaining glycemic control and is a vital component in diabetes education. The frequency of self monitoring requires individualized goals and willingness to participate [15]. It is not clear to what extent

this cohort of type 2 diabetics adhered to self management given the presence of other potentially serious comorbidities which may have been the primary reason for hospitalization.

Recently, glycemic variability has gained recognition as a risk factor for complications from diabetes. Specifically, high levels of glycemic variability may induce oxidative stress, diabetes complications, and cardiovascular outcomes [16]. There has been a growing amount of research in establishing reference values for glycemic variability as a measure of glycemic control [16].

The American Diabetes Association recommends that diabetics maintain a blood pressure less than 130/80 mmHg as a

measure of achieving glycemic control [14]. Patients observed in our study had slightly higher systolic blood pressure readings, although diastolic blood pressure values were in the normal range. This was true for obese patients and patients with BMI <30 kg/m². Triglyceride and HDL levels were especially suboptimal among hospitalized type 2 diabetes patients with and without obesity. A previous study reported that individuals with a BMI of at least 28 kg/m² experienced a 30% increase in blood triacylglycerol (TAG) concentration, while those with BMI less than 28 kg/m² had no change in TAG concentration. TAG concentration is typically elevated following meal intake in patients with coronary artery disease [17]. Thus, certain characteristics, such as BMI, may make individuals particularly sensitive to lipid changes when there is an increase in dietary carbohydrates. In a study of 200 healthy men with no evidence of insulin resistance, those subjects with a BMI above 25 kg/m² had significantly more small, dense LDL particles than leaner subjects. And men with a BMI greater than 27 kg/m² had the highest concentration of circulating small, dense LDL particles [18]. The effect of exercise and diet in a four-week intervention program proved effective in significantly reducing small, dense LDL particles in male patients who were obese and with type 2 diabetes [19]. Interestingly, our study indicated that women had higher LDL levels compared to men, possibly due to differences in treatment. Epidemiological data have shown that obesity dramatically increases the risk of coronary heart disease in people with diabetes [20]. In addition, studies have found that obesity is predictive of future coronary and cerebrovascular disease events in those who eventually develop diabetes [20,21].

The hospitalized type 2 diabetes patient population identified in this study likely had a number of other comorbidities that reflected potentially advanced cardiovascular disease and that could potentially attenuate the beneficial effect of weight loss. In fact, the five other most commonly diagnosed conditions at admission included hypertension, hyperlipidemia, hypercholesterolemia, acute kidney failure, and congestive heart failure. Daousi et al. [13] cite the evidence for weight loss in overweight patients with type 2 diabetes. In particular, an early study demonstrated that a very-low-calorie diet in obese, type 2 diabetic subjects resulted in a significant decrease in fasting plasma glucose and total glycosylated hemoglobin [22]. Other intervention studies have shown that type 2 diabetics who lose weight and maintain weight loss have some improvement in glycemic control and obesity comorbidities. Specifically, shorter duration of type 2 diabetes and greater percent excess weight loss were associated with an increased likelihood of remission or improvement in type 2 diabetes status through laparoscopic adjustable gastric banding after two

years [23]. Furthermore, there is epidemiological evidence that even a modest weight loss in diabetic patients results in a reduction in mortality [24,25].

Potential study limitations include the use of an electronic health records database that was not originally designed to examine the prevalence of obesity in hospitalized type 2 diabetes patients. Since the database covers the southwestern region of the United States, the obesity prevalence estimates may not necessarily be representative of other parts of the country. This is also true given the relatively strict inclusion/exclusion criteria that reduced the number of eligible patients. Because we selected patients with complete laboratory data, the population may be biased toward those with more severe cardiometabolic disease and who require more complete laboratory testing. Although most type 2 diabetes patients are treated in an outpatient setting, our objective was to examine the prevalence of obesity among hospitalized diabetics. This afforded the ability to compare the findings in our study with published data and observe the potential impact of having patients with many health problems on certain laboratory measures. It is not clear how many obese patients had their first hospitalization for diabetes management. If this was not the first hospitalization, then this would add to the laboratory evidence suggesting a lack of adequate diabetes management. The relatively short patient identification period may have prevented us from conducting additional analyses, such as examining the effect of type 2 diabetes duration or the actual number of comorbidities on obesity prevalence. Also, this particular database lacked HbA1c data, and thus we examined mean glucose levels as a measure of glycemic control. As a result, the results may not provide much inference on long-term glycemic control.

Nevertheless, the fact that similar epidemiological findings were observed in other studies suggests that this particular database may be helpful for studying the prevalence of different medical conditions, which in turn can assist in the generation of new hypotheses.

Conclusions

This study demonstrates a high prevalence of obesity in hospitalized patients with type 2 diabetes. Obese patients with type 2 diabetes were younger, appeared to have inadequate glycemic control, high blood pressure, and suboptimal lipid levels. Weight loss reduction may provide substantial benefit to treating obesity among diabetics, even in a population with potentially advanced cardiovascular disease.

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