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# Measuring Associations Between Community-Level Social Determinants of Health and Bariatric Surgery Weight Loss Outcomes

Nicholas SKOUFIS[a], Rui ZHANG[b] and You CHEN[a,1]
[a]*Vanderbilt University, Nashville, TN, USA*
[b]*University of Minnesota, Minneapolis, Minnesota, USA*

**Abstract.** Bariatric surgery is a crucial intervention in managing obesity and related conditions. However, weight loss outcomes can vary significantly, and social determinants of health (SDoH) at the community level may play a role. Our objective is to identify community-level SDoH factors associated with reduced weight loss after bariatric surgery. We conducted an analysis of electronic health records and the social vulnerability index (SVI) of 3,800 patients who underwent bariatric surgery at Vanderbilt University Medical Center. We measured the associations between SVI social factors and the percent change in body mass index three months after surgery using linear regression. The SVI factors with a false discovery rate-adjusted p-value < 0.05 were deemed significant. Statistical results show that patients who reside in communities with racial minority groups or lower insurance rates had reduced weight loss three months after surgery.

**Keywords.** bariatric surgery, body mass index, SDoH, electronic health record

## 1. Introduction

Obesity is a significant and growing health concern nationwide, affecting over 40% of adults in the United States [1]. Bariatric surgery is a widely used intervention to help patients lose weight, and in 2018 alone, approximately 252,000 bariatric surgeries were performed in the US [2]. While patients can lose a significant amount of weight in the first year after surgery, weight regain is common, with some studies suggesting that up to 50% of patients experience weight regain over a five-year period [3]. This suggests that factors beyond the surgery itself may contribute to the variability of weight loss outcomes. Previous studies have found that age, sex, diabetes, hypertension, and the type of surgery can significantly influence bariatric surgery weight loss outcomes [4]. More recent studies have explored the influence of social determinants of health (SDoH) factors, including neighborhood conditions and insurance status, on complications and weight loss outcomes following bariatric surgery [5-7]. These studies suggest that SDoH factors may play a role in determining weight loss outcomes. In this paper, we aim to investigate the associations between SDoH factors and weight loss outcomes following bariatric surgery, specifically focusing on community-level

[1]Corresponding Author: You Chen, email: you.chen@vumc.org.

factors such as race/ethnicity, income, and insurance status. We analyze data from a large bariatric surgery cohort of 3,800 patients at a large academic medical center and utilize a social vulnerability index (SVI) to measure the effects of community-level SDoH factors on weight loss outcomes three months after surgery. By identifying the community-level factors that impact weight loss outcomes, our study can inform interventions and policies aimed at improving weight loss outcomes for patients undergoing bariatric surgery.

## 2. Methods

This study was conducted at Vanderbilt University Medical Center (VUMC). We collected electronic health records of 3800 patients who received bariatric surgeries at VUMC between Jan, 2018 and Jan, 2022. A summary of patients' diagnosis and demographics is provided in Table 1.

**Table 1.** Summary statistics of patients' diagnosis and demographics.

| Item | Value |
|---|---|
| Age (min, median, max) | (15.1, 46.1,77.7) |
| Sex (Female, Male) | (2986, 814) |
| **Diabetes: N (%)** | |
| No diabetes | 2953 (77.7%) |
| Insulin dependent | 289 (7.6%) |
| Non-insulin dependent | 532 (14.0%) |
| No data | 26 (0.7%) |
| **Operation: N (%)** | |
| Roux-en-Y gastric bypass | 2392 (62.9%) |
| Sleeve gastrectomy | 828 (21.8%) |
| Adjustable gastric banding | 216 (5.7%) |
| Other | 364 (9.7%) |

For each patient, we calculated their percent change in body mass index 3 months after receiving bariatric surgery (pcBMI). The distribution of pcBMI is shown in Figure 1.

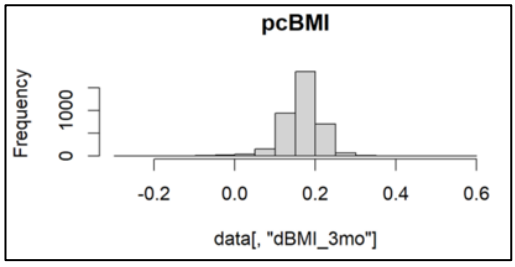


**Figure 1.** Distribution of the percent change in body mass index three months after surgery.

### *2.1. Social Vulnerability Index*

SVI, one of the most commonly used definitions for SDoH, covers 15 social factors categorized into four themes: socioeconomic status, household composition and disability, minority status and language, and housing type and transportation [8]. SVI measures the potential negative effects on communities caused by external stresses on human health. Six values were used to describe a social factor, including absolute value

(with the margin of error (MOE)), percentile (with the MOE), percentile ranking, and flag (whether the percentile is in the 90th percentile). We focus on percentile ranking values in this study because they represent relative vulnerability of an individual tract. The percentile ranking values range from 0 to 1, higher values indicating greater vulnerability. We used patients' five and nine digital zip codes in EHRs to link census tracts and blocks which are connected to community health records to derived SVI scores of each investigated patient. It is noted that the SVI scores are at the community level rather than individual patient level. The distribution of patients across regions is shown in Figure 2.

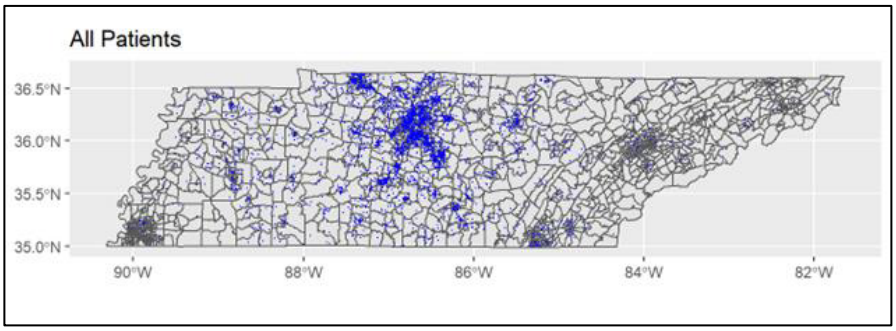


**Figure 2** Origins of patients. Each blue point is a patient. The location information is based on a patient's home address characterized by nine digital zip codes.

### *2.2. Associations between SVI and pcBMI*

We sort patients by pcBMI and divide patients into upper and lower quantiles. We code patients in the upper quartile as high (1) and patients in the lower quartile as low (0). For each SVI variable from the census data, we perform a linear regression between patients' pcBMI code and the value of the SVI variable. A variable was regarded as significant if it has a false discovery rate (FDR)-adjusted p-value $< 0.05$.
For SVI variables which are confirmed to be significantly associated with pcBMI, we conduct a further analysis to verify how they are associated with pcBMI under each specific comorbidity. We select all patients with a given comorbidity (i.e., diabetes, surgery type). For each significant SVI variable, we group patients into upper and lower quartiles by the median value of the SVI variable. We perform a t-test to verify if the difference in the value of pcBMI between patients in the upper and lower groups is significant through FDR-adjusted p-value $< 0.05$.

## 3. Results

We found that patients living in areas where the rates of racial minority or patients without insurance are higher had significant associations with the pcBMI coding 0 (reduced weight loss). From there, we looked for an impact of intersections between comorbidities and SVI factors on pcBMI. We found patients with specific comorbidities and the two SVI social factors were associated with poor weight loss outcomes. For instance, among patients with type 1 diabetes, patients from

communities with lower rates of insurance experienced less weight loss than patients from communities with higher rates of insurance. Similarly, among female patients, patients from communities with higher percentages of minorities experienced less weight loss. Another example is among patients who received RYGB procedure, and those patients living in areas where the rate of racial minority population was higher, was associated with lower pcBMI. Table 2 shows results of patients with a specific comorbidity (i.e., ≤54 years, no diabetes, RYGB, Female) divided by upper and lower groups based on median values of the two SVI factors: minority group and uninsured group, had significant different pcBMI (<.001). Figure 3 plots maps to illustrate individual patients colored by pcBMI, with their census tracts colored by the rate of insurance (left) and rate of racial minority patients (right).

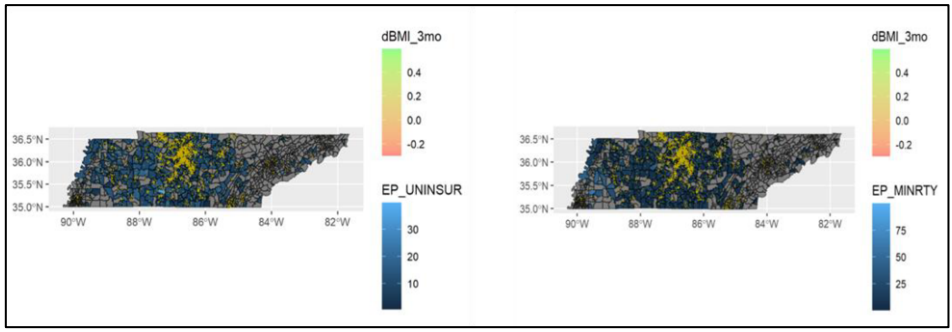


**Figure 3.** Map illustrating individual patients colored by pcBMI, with their census tracts colored by the rate of insurance (left) and rate of racial minority patients (right).

**Table 2.** Patients with a specific comorbidity (i.e., ≤54 years, no diabetes, RYGB, Female) divided by upper and lower groups based on median values of the two SVI factors: minority group and uninsured group, had significant different pcBMI (<.001).

| Comorbidity | Value | Minority group | Uninsured group |
|---|---|---|---|
| Age | >54 years | | |
| | ≤54 years | <.001 | |
| Diabetes | No diabetes | <.001 | |
| | Type 1 | | <.001 |
| | Type 2 | | |
| Operation | RYGB | <.001 | |
| | SG | | <.001 |
| Sex | Female | <.001 | |
| | Male | | <.001 |

## 4. Discussion

Using EHR and publicly available social vulnerability data, we assessed relationships of SVI variables with pcBMI. Our findings suggest that patients who live in communities belonging to racial minority groups or groups with lower rates of insurance had reduced weight loss three months after surgery. These results help elucidate the role of community factors in facilitating weight loss and may help guide healthcare providers to give special attention to patients from more vulnerable communities. Limitations of this investigation include the possibility of unaddressed

confounding medical factors. Additionally, the patients were predominantly from middle Tennessee, US. Therefore, caution should be exercised when generalizing these findings to other populations. We recommend further investigations into using causal inference and machine learning methods for counterfactuals to establish a causal relationship between demographic factors and weight loss outcomes. In addition, SVI data used in this study was based on 2018 surveys, while our study period was from 2018 to 2021. Therefore, an updated result is suggested when a newer version of SVI data becomes available. Finally, although SVI was investigated in this study to characterize social status, more social factors, such as environmental exposome, food accessibility, and education attainment, should be included in future studies. In conclusion, our investigation provides important insights into the associations between social vulnerability and bariatric surgery weight loss outcomes. By identifying these community-level factors, healthcare providers can better understand the social context in which patients live and tailor interventions to improve weight loss outcomes. Further studies are needed to confirm our findings and to explore additional social determinants of health that may impact bariatric surgery weight loss outcomes.

## 5. Conclusions

The results of bariatric surgery are influenced by not only the care provided during the operation but also the post-operative care. SDoH are crucial factors that significantly impact post-surgery care. This study leverages EHRs and community-level SDoH - SVI to assess the correlations between SVI factors and the change in BMI three months post-surgery. Our findings indicate that community-level SDoH factors are associated with patients' weight loss outcomes. Further research is essential to identify strategies to minimize SDoH disparities, thereby reducing the inequality in weight loss outcomes.

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