

Prevalence and Correlates of Dumping Syndrome After Bariatric Surgery in Saudi Adults: The Role of Social Determinants and Nutrition Knowledge

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Purpose: Dumping syndrome (DS) is a postsurgical complication of bariatric procedures. It is classified into early and late dumping based on occurrence within different postprandial timeframes. This study measures the prevalence of DS among adult patients and its association with social determinants and nutrition knowledge.

Patients and Methods: This cross-sectional study used a convenience sampling method via distributing an online validated questionnaires to patients who underwent sleeve gastrectomy or gastric bypass surgery in ≥ 3 months.

Results: Out of 352 participants, 237 (67.3%) had a modified Sigstad weighted DS score of ≥ 3.26 , indicating the presence of DS; 182 (76.8%) had early DS (symptoms within 1 hour postprandially) and 55 (23.2%) had late DS (symptoms 1–3 hours postprandially). Only gender and monthly income showed statistically significant differences between early and late DS patients. No statistically significant associations were found between the DS subtypes and sociodemographic characteristics, although participants' age approached significance ($p = 0.052$). Type 1 diabetes was significantly associated with DS and affected patients were 6.7 times more likely to experience symptoms. The mean nutrition knowledge score among all the participants was 60.88 (SD = 14.76) suggesting moderate nutrition knowledge.

Conclusion: There is a high prevalence of DS (67.3%) among post-bariatric surgery patients in Saudi Arabia, and early DS is more common than late DS. The findings suggest a strong correlation between type 1 diabetes and DS. Nutrition knowledge was moderate but insufficient in key areas that affect postoperative outcomes. The study is novel in reporting a high prevalence of DS among post-bariatric patients in Saudi Arabia and uniquely explores the association of DS with social determinants, nutrition knowledge, and type 1 diabetes—areas less examined in previous research. It emphasizes the imperative need for comprehensive patient education and continuous dietary counseling to improve long-term management and outcomes for bariatric surgery patients.

Keywords: dumping syndrome, sleeve gastrectomy, gastric bypass surgery, bariatric surgery, social determinants, diet

Introduction

Obesity is defined as an abnormal or excessive accumulation of body fat that poses significant health risks. Body mass index (BMI), a commonly used measure that relates weight to height, classifies individuals with a BMI of ≥ 30 kg/m² as obese.¹ The World Health Organization (WHO) recognizes obesity as one of the most pressing global health challenges, with its prevalence steadily increasing despite wide-ranging public health efforts.² According to the 2023 World Obesity Atlas, 38% of the global population is now classified as overweight or obese.³ This global trend is reflected in Saudi Arabia, where high obesity rates have led to a corresponding increase in bariatric procedures. Obesity prevalence rates in Saudi Arabia vary depending on the age group and data collection methods. The 2019 National Health Information Survey reports an obesity rate of 20.2% among adults aged 18 years and over, with overweight at 38.2% and higher rates

among women (21.4%) than men (19.2%).⁴ The 2024 General Authority for Statistics data reports a higher obesity rate of 23.1% and overweight at 45.1% but includes individuals aged 15 years and above,⁵ which may inflate the prevalence due to the inclusion of younger participants.

As obesity rates continue to rise, bariatric surgery—specifically sleeve (SG) or Roux-en-Y gastric bypass (RYGB), collectively referred to by the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) as ‘Metabolic and Bariatric Surgery (MBS) has become a widely accepted and effective intervention for achieving sustained weight loss, particularly among patients with morbid obesity who do not respond adequately to lifestyle modifications.⁶ The SG and RYGB are the most commonly performed procedures.⁷ These surgeries reduce stomach capacity and alter the gastrointestinal anatomy to limit nutrient absorption. They also exert physiological effects by influencing appetite, satiety, food preferences, and energy expenditure.^{8,9}

Bariatric surgery is considered one of the most effective long-term treatments for obesity,¹⁰ but carries the risk of several postoperative complications. One of the most frequent complications is dumping syndrome (DS), which affects a considerable proportion of patients after gastric or bariatric procedures.¹¹ Globally, the prevalence of DS is 20% to 40%,¹² while recent studies in Saudi Arabia report a prevalence of 31.4%.¹³ DS arises from alterations in gastric structure or nerve supply to the stomach leading to abnormal and accelerated gastric emptying; as a result, undigested food moves too quickly into the small intestine, in addition to the rapid and sharp increase in blood insulin levels, and eventually puts the body at risk of a hypoglycemic coma.^{14,15} It is not a single disease entity but rather a syndrome encompassing a range of symptoms that are classified into early and late DS.

Early DS occurs within the first hour postprandially and is driven by the high osmolality of ingested food, which causes a rapid shift of fluid from the intravascular compartment into the intestinal lumen. This fluid shift leads to decreased blood volume and activation of the sympathetic nervous system. Clinically, it presents with gastrointestinal symptoms, such as abdominal pain, bloating, nausea, borborygmi, and diarrhea, and vasomotor symptoms like palpitations, tachycardia, hypotension, flushing, sweating, and fatigue.^{14,15}

Late DS Late dumping syndrome, now more accurately termed post-bariatric hypoglycemia or postprandial hyperinsulinemic hypoglycemia; it occurs 1–3 hours postprandially and is primarily due to an exaggerated insulin response following rapid carbohydrate absorption resulting in hypoglycemia. A recent study indicates that postprandial insulin levels can serve as a predictor for late DS.¹⁶ Symptoms of hypoglycemia include neuroglycopenic manifestations such as confusion, fatigue, hunger, and syncope as well as adrenergic signs such as palpitations, irritability, tremors, and diaphoresis.^{14,15}

A typical clinical diagnosis of DS is supported by diagnostic tools such as the modified Sigstad scoring system, where a score of ≥ 3.26 is indicative of the syndrome. The modified Sigstad dumping score is a diagnostic tool that assigns weighted points to specific symptoms of dumping syndrome, such as nausea, vomiting, palpitations, and the desire to lie down, with a threshold value (eg, >3.26) indicating the presence of the syndrome.¹⁷ This scoring system is used to quantify symptom severity and improve the identification of dumping syndrome in post-bariatric surgery patients.¹⁷

Further diagnostic clarification can be obtained using glucose challenge tests, gastric emptying studies or an upper gastrointestinal series.^{17,18} The provocative test for DS involves ingesting 50 g or 75 g of glucose after fasting overnight, with blood glucose, hematocrit, pulse rate, and blood pressure monitored every 30 minutes for 180 minutes. A positive result indicates late hypoglycemia (120–180 minutes) or a hematocrit increase of over 3% within 30 minutes. A pulse rate increase of more than 10 pulse per minutes is a strong predictor of DS. Hypoglycemia is typically defined as a blood glucose level below 60 mg/dL, though some sources cite 50 mg/dL, indicating variability in the literature.^{14,17,18} Management is primarily dietary and includes modifications such as smaller, more frequent meals, separating fluid intake from meals by at least 30 minutes, and avoiding simple carbohydrates.^{18,19}

Despite the high rates of obesity and bariatric surgery in Saudi Arabia^{20,21} there is limited national data on dumping syndrome and almost no research examining patients’ postoperative nutrition knowledge. This gap is critical because inadequate nutrition literacy after bariatric surgery is directly linked to behaviors—such as consumption of simple sugars, drinking with meals, and inappropriate meal timing—that increase the risk and severity of DS. Given the large number of patients undergoing sleeve gastrectomy and gastric bypass in the country, poor nutrition knowledge could amplify preventable postoperative complications and undermine long-term outcomes. Therefore, studying nutrition knowledge in this population represents a novel and essential step toward understanding DS risk and improving postoperative care.

This study aims to assess the prevalence of DS among Saudi adults who have undergone SG or gastric bypass surgery, and identify the factors, such as sociodemographic characteristics, type of surgery, comorbidities, follow-up adherence, and postoperative nutrition knowledge, that are associated with both, the development and type (early vs late) of DS.

Materials and Methods

Study Design

This cross-sectional study was conducted using a self-administered questionnaire distributed online via social media platforms between February 2024 and December 2024. We included individuals aged ≥ 18 years, who live in Saudi Arabia and had undergone bariatric surgery—specifically SG or RYGB, collectively referred to by the IFSO as ‘Metabolic and Bariatric Surgery (MBS)’. We chose the convenience sampling technique to include patients who had undergone the operation in a variety of hospitals nationwide.

Questionnaires

Modified Sigstad Dumping Syndrome Questionnaire

The modified Sigstad DS questionnaire¹⁷ is adapted from the original Sigstad score system.¹⁹ The modified version consists of 10 items with a diagnostic threshold of ≥ 3.26 points. The modified scores were statistically correlated and criterion validity was established, individuals who exceeded the ≥ 3.26 -point threshold were considered to have DS. Participants were further divided into those with early and late DS based on the onset of symptoms experienced within 1 hour postprandially for early DS and 1–3 hours postprandially for late DS.¹⁷

Nutrition Knowledge Post-Bariatric Surgery Questionnaire

A nutritional knowledge post-bariatric surgery questionnaire was used to assess participants’ nutrition knowledge following bariatric surgery; it had 11 questions with multiple answers.

The questionnaire included both single-response and multi-response items. For multi-response questions, each correct option was assigned an equal number of points (2–4 points per correct response, depending on the question), and the same number of points was deducted for incorrect selections, with a minimum score of zero per question. The multi-response items were scored as follows: Question 1 (4 points per correct answer; 12 points total), Questions 3 and 4 (2 points per correct answer; 12 points total each), Question 5 (2 points per correct answer; 6 points total, with the vitamin B12 option awarded zero points), Question 7 (4 points per correct answer; 12 points total), Question 8 (3 points per correct answer; 15 points total), and Question 11 (3 points per correct answer; 9 points total).

Single-response questions awarded the full score for selecting the correct option without negative marking: Question 2 (4 points) and Questions 6, 9, and 10 (6 points each). After summing the raw scores, the total was standardized to a 0–100 scale, with higher scores indicating greater knowledge.²²

We designed the online questionnaires to have a question that first assessed the type of surgery performed. If the participant had undergone a surgery other than SG or gastric bypass, the questionnaire would cease and exclude the participant. Another question assessed the timing of the surgery. If the participant had the surgery < 3 months ago, the questionnaire would cease and exclude the participant.

Subject Recruitment Procedures

A convenience sampling method was used, recruiting participants through social media platforms to reach a diverse national sample of patients from various healthcare sectors. We chose convenience sampling rather than simple sampling for many reasons, including difficulty accessing patients who underwent surgery at King Khalid University Hospital, difficulty obtaining permissions to access patients’ names and contact information, and because we wanted to include bariatric surgery patients from a variety of private and government hospitals nationwide. The method of data collection was through a validated online English and Arabic questionnaires administered via social media. It was disseminated among individuals who had undergone SG or gastric bypass surgery in Saudi Arabia at least 3 months ago to capture early manifestations of DS and allow for timely interventions.^{23,24}

The main outcome is DS, which was assessed using a validated score. The self-administered questionnaire had 44 questions distributed in five different sections. The weighted Sigstad score for DS was computed using the modified Sigstad questionnaire²¹ and a threshold of Sigstad score ≥ 3.26 points was used to define patients with positive DS.^{21,25,26}

A nutrition knowledge post-bariatric surgery questionnaire was used to assess the participants' nutrition knowledge post-bariatric surgery on a point scale of 0–100.²⁷ The modified version of the Sigstad scoring system and bariatric surgery nutrition knowledge questionnaire were originally in English and were translated into Arabic following the WHO guidelines for tool translation, which include forward translation by bilingual experts, review by an expert panel, back-translation into English, pretesting, cognitive interviewing, and finalization of the Arabic version.²⁸ Prior to the main study, the questionnaires were piloted on 15 participants to assess clarity and comprehensibility; these pilot participants were not included in the final study sample.

The Sigstad DS questionnaire was tested for reliability using Cronbach's alpha test for internal consistency and the findings showed adequate internal consistency for this questionnaire, (Cronbach's $\alpha = 0.722$). These findings indicate that people were able to read and understand the measured questionnaire equally reliably.

All data collected was confidential. Written informed consent was obtained in Arabic and the study's purpose was explained before conducting the study. Participants were informed that answering the questions was voluntary and they had the right to stop answering at any point. The participants had the right to withdraw at any time without obligation to the research team. The information collected was anonymous, and participants were allocated identification numbers. No incentives or rewards were given to the participants with no obligation to participate. The Institutional Review Board at the College of Medicine/ King Saud University gave ethics approval for this study (approval number: E-24-8508, date of approval: 21 January 2024).

Sample Size

A previous study in Saudi Arabia reported a 31.4% prevalence of DS¹³ and we used this percentage to calculate the sample size. We needed a minimum of 331 responses to achieve a 95% confidence level so that the true value is within $\pm 5\%$ of the measured/surveyed value.

$$\text{sample size} : \frac{(Z_{\alpha/2}) \times p(1-p)}{d^2} = \frac{1.96^2 \times 0.314(1-0.314)}{0.05^2} = 331$$

Statistical Analysis

Descriptive analysis with mean and standard deviation (SD) were applied to continuous variables and frequencies and percentages for the categorical data. The independent samples *t*-test was used to assess the statistical significance of mean differences between the numerical variables across the two groups (early DS vs late DS). Multivariable binary logistic regression analysis Multivariable binary logistic regression analysis was performed to identify predictors of having DS among bariatric surgery patients. The model included the following independent variables based on clinical relevance and prior literature: age, gender, education level, monthly household income, type of bariatric surgery (SG or RYGB), presence of comorbidities (including type 1 diabetes and type 2 diabetes), and compliance with postoperative follow-up sessions. Adjusted odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were reported for each variable. SPSS statistics software (v.30 IBM Corp., Armonk, NY, USA.) was used for all descriptive and inferential analysis. The level of significance was 0.05 with *p*-values < 0.05 reported as statistically significant.

Results

Prevalence of Dumping Syndrome

A total of 373 participants completed the questionnaire, thereby achieving the required sample size for the study. However, 21 participants were excluded because they had undergone procedures other than SG and RYGB. Out of 352 participants who completed the questionnaire, 237 (67.3%) had a modified Sigstad weighted DS score of ≥ 3.26 , which indicated the presence of DS; 182 (76.8%) had early DS and 55 (23.2%) had late DS. Therefore, only these 237 patients are included in further analysis. The remaining 115 participants with modified Sigstad weighted DS scores of < 3.26 have been excluded.

Sociodemographic Characteristics

Table 1 shows the sociodemographic characteristics of the study participants. The study population had 75.1% women. The participants' ages were between 18 and 60 years with a mean age of 31.57 years (SD= 9.37 years). The monthly household income (HHI) for 55.3% of respondents was ≤5000 SAR/month, and only 39.7% of participants had private health insurance. Almost half (41.4%) of the participants reside in the Central region of Saudi Arabia. There were a significantly higher proportion of women in the early DS group (79.1%) compared to women with late DS (61.8%), and there was a statistically significant difference between the groups ($p = 0.009$).

Table 1 Sociodemographic and Baseline Characteristics of the Post-Bariatric Surgery Cohort (N=237)

	Total Sample (n = 237)	Early DS (n = 182)	Late DS (n = 55)	Comparison Between Subgroups
Sex				$p = 0.009^C$
Female	178 (75.1%)	144 (79.1%)	34 (61.8%)	
Male	59 (24.9%)	38 (20.9%)	21 (38.2%)	
Age Group (years)				$p = 0.377^F$
18-20 years	21 (8.9%)	19 (10.4%)	2 (3.6%)	
21-30 years	103 (43.5%)	78 (42.9%)	25 (45.5%)	
31-40 years	78 (32.9%)	57 (31.3%)	21 (38.2%)	
41-50 years	23 (9.7%)	17 (9.3%)	6 (10.9%)	
≥51 years	12 (5.1%)	11 (6.0%)	1 (1.8%)	
Marital Status				$p = 0.777^C$
Never married	116 (48.9%)	90 (49.5%)	26 (47.3%)	
Ever married	121 (51.1%)	92 (50.5%)	29 (52.7%)	
Education Level				$p = 0.327^C$
High school or lower education	56 (23.6%)	47 (25.8%)	9 (16.4%)	
Diploma degree	36 (15.2%)	26 (14.3%)	10 (18.2%)	
University degree or postgraduate	145 (61.2%)	109 (59.9%)	36 (65.5%)	
Households' Monthly Income Saudi Riyals (SAR)				$p = 0.068^F$
<5000 SAR/month	131 (55.3%)	108 (59.3%)	23 (41.8%)	
5000-10000 SAR/month	56 (23.6%)	37 (20.3%)	19 (34.5%)	
11,000-15000 SAR/month	18 (7.6%)	12 (6.6%)	6 (10.9%)	
>15000 SAR/month	32 (13.5%)	25 (13.7%)	7 (12.7%)	
Private Health Insurance				$p = 0.188^C$
No	143 (60.3%)	114 (62.6%)	29 (52.7%)	
Yes	94 (39.7%)	68 (37.4%)	26 (47.3%)	
Access to Healthcare				$p = 0.656^C$
No	30 (12.7%)	24 (13.2%)	6 (10.9%)	
Yes	207 (87.3%)	158 (86.8%)	49 (89.1%)	
Resident in				$p = 0.390^C$
Eastern Provinces	50 (21.1%)	37 (20.3%)	13 (23.6%)	
Western Provinces	43 (18.1%)	33 (18.1%)	10 (18.2%)	
Northern Provinces	24 (10.1%)	22 (12.1%)	2 (3.6%)	
Southern Provinces	22 (9.3%)	18 (9.9%)	4 (7.3%)	
Central Region	98 (41.4%)	72 (39.6%)	26 (47.3%)	

Note: Reported values are frequency (%) or Mean $\pm$ SD (standard deviation); ^Cchi-square test; ^FFisher's Exact test.

Abbreviations: DS, Dumping Syndrome; SAR, Saudi Riyal.

A comparison of monthly HHI between the groups showed a trend toward significance ($p = 0.068$), with patients in the late DS group having slightly higher incomes than those in the early DS group. No statistically significant associations were found between the DS subtypes and sociodemographic characteristics, although participants' age approached significance ($p = 0.052$). Most participants (94.9%) underwent SG, and 79.5% were compliant with follow-up sessions.

Medical and Surgical History

Table 2 shows the descriptive analysis for the participants' experience of bariatric surgery and type of DS. The majority of respondents (93.2%) underwent SG and 6.8% underwent RYGB. There were more patients with early DS than late DS among those who underwent SG (94.5% vs 89.2%) but there was no statistically significant difference ($p=0.216$) between the groups. The majority of patients (80.2%) were compliant and attended the postoperative follow-up sessions with only 19.8% non-compliant participants. The main reason for non-compliance in attending postoperative sessions was unwillingness (36.2%).

Table 2 Clinical History, Surgical Procedure Details, and Compliance with Postoperative Follow-Up (N=237)

	Total Sample (n = 237)	Early DS (n = 182)	Late DS (n = 55)	Comparison Between Subgroups
Type of Bariatric Surgery				$p = 0.216^F$
Sleeve gastrectomy	221 (93.2%)	172 (94.5%)	49 (89.1%)	
Gastric bypass surgery	16 (6.8%)	10 (5.5%)	6 (10.9%)	
Body Weight (Kg) Before the Operation	118.48 ± 21.33	118.06 ± 21.55	119.87 ± 20.74	$p = 0.582^T$
Indication to Undergo the Bariatric Operation				$p = 0.472^C$
Personal decision	172 (72.6%)	130 (71.4%)	42 (76.4%)	
Recommended by physician	65 (27.4%)	52 (28.6%)	13 (23.6%)	
Hospital Where Operation Performed				$p = 0.215^C$
Private hospital	165 (69.6%)	123 (67.6%)	42 (76.4%)	
Public government hospital	72 (30.4%)	59 (32.4%)	13 (23.6%)	
Attended Postoperative Follow-up Sessions				$p = 0.114^C$
No	47 (19.8%)	32 (17.6%)	15 (27.3%)	
Yes	190 (80.2%)	150 (82.4%)	40 (72.7%)	
Reasons for Non-compliance	(n = 47)	(n = 32)	(n = 15)	
Financial	15 (31.9%)	11 (34.4%)	4 (26.7%)	$p = 0.742^F$
Transportation	15 (31.9%)	10 (31.3%)	5 (33.3%)	$p = 1.00^F$
Time constraint	15 (31.9%)	9 (28.1%)	6 (40.0%)	$p = 0.508^F$
Unwillingness	17 (36.2%)	12 (37.5%)	5 (33.3%)	$p = 1.00^F$
Comorbidities				$p = 0.204^C$
No	160 (67.5%)	119 (65.4%)	41 (74.5%)	
Yes	77 (32.5%)	63 (34.6%)	14 (25.5%)	
Types of Comorbidities	(n = 77)	(n = 63)	(n = 14)	
Asthma	5 (6.5%)	4 (6.3%)	1 (7.1%)	$p = 1.00^F$
Hypothyroidism	8 (10.4%)	8 (12.7%)	0 (0%)	$p = 0.338^F$
Dyslipidemia	1 (1.3%)	1 (1.6%)	0 (0%)	$p = 1.00^F$
Diabetes Type 2	8 (10.4%)	7 (11.1%)	1 (7.1%)	$p = 1.00^F$
Diabetes Type 1	15 (19.5%)	14 (22.2%)	1 (7.1%)	$p = 0.280^F$
Insulin resistance	3 (3.9%)	2 (3.2%)	1 (7.1%)	$p = 0.457^F$
Hypertension	37 (48.1%)	29 (46.0%)	8 (57.1%)	$p = 0.452^C$
Ovarian cyst	7 (9.1%)	6 (9.5%)	1 (7.1%)	$p = 1.00^F$
Other comorbidity	10 (13.0%)	8 (12.7%)	2 (14.3%)	$p = 1.00^F$

Note: Reported values are frequency (%) or Mean $\pm$ SD (standard deviation); ^Cchi-square test; ^FFisher's Exact test; ^Tindependent samples t-test^T.

Abbreviation: Kg, kilogram.

Some of the participants (32.5%) had comorbidities; those most mentioned were hypertension (48.1%), diabetes type 1 (19.5%), and diabetes type 2 (10.4%). The participants with type 1 diabetes were 6.7 times more likely to have DS compared to the patients who did not have type 1 diabetes ($p = 0.026$).

Post-Bariatric Surgery Nutrition Knowledge

[Supplementary tables S1](#) and [S2](#) display the detailed results of descriptive analysis of participants' knowledge on nutritional aspects. For the question, "For how long, after the bariatric surgery, you should take dietary supplements (K6)", 13.9% of participants picked the right option (for a life-time). Most respondents (68.4%) chose "depends on blood test results", which is the incorrect answer. Slightly above half (52.7%) of the respondents chose the recommended number of dietitian sessions following bariatric surgery, which was "at least 6 sessions during the first year, and then at least 1–3 sessions per year (K10)." Mean nutrition knowledge score was 60.88 (SD = 14.76), suggesting moderate nutritional knowledge among the participants. There was no statistically significant difference in the nutrition knowledge of participants with early and late DS.

Discussion

This study examined the prevalence of DS in Saudi Arabia and its association with sociodemographic characteristics, comorbidities, and nutrition knowledge among patients who underwent bariatric surgery in Saudi Arabia. Our study demonstrates that DS is a prevalent complication following bariatric surgery, 67.3% among the study population had DS based on the modified Sigstad weighted score. The majority (76.8%) reported symptoms consistent with early DS, occurring within the first hour postprandially, while the rest (23.2%) experienced late DS, which manifests 1–3 hours postprandially. These findings highlight the clinical relevance of DS in post-bariatric surgery patients and highlight the predominance of early DS. Compared to a previous study conducted at King Fahad General Hospital in Jeddah, which reported a DS prevalence of 31.4% using the same diagnostic tool,¹³ our findings indicate a notably higher rate. This discrepancy may be attributed to differences in the study population characteristics, types of bariatric procedures performed or the follow-up duration. The prevalence of early vs late DS symptoms is known to vary based on the type and extent of surgery.²⁵

The diagnosis of DS remains challenging due to the lack of a single, highly reliable test. Symptom-based questionnaires, while widely used, have limited diagnostic accuracy and are not sensitive to treatment effects. The modified Oral Glucose Tolerance Test (OGTT) is the current reference standard, with established criteria for early and late dumping, but its clinical utility is hampered by poor tolerability and questionable reproducibility. Mixed-meal tests and continuous glucose monitoring offer additional insights, particularly for monitoring and management, but are not validated as primary diagnostic tools. Imaging and gastric emptying studies are generally unhelpful. Overall, a combination of clinical suspicion, symptom assessment, and selective use of provocation tests is recommended, while further research is needed to develop more accurate and patient-friendly diagnostic methods.^{29–31}

A statistically significant association was found between DS type and gender ($p = 0.009$), with early DS more prevalent among women (79.1%) compared to late DS (61.8%). This result is also consistent with previous studies by Alsulami et al and Banerjee et al, who reported a higher prevalence of DS among women.^{13,26}

Although not statistically significant ($p = 0.068$), HHI showed a trend toward higher income brackets among participants with late DS compared to those with early DS. This contrasts with the findings of Alsulami et al,¹³ who reported a stronger association between DS and higher income levels. This discrepancy may be attributed to several factors. One possible explanation is that Alsulami et al's study had a notably small proportion of high-income participants (only 3.3% reported incomes >15,000 SAR), suggesting the possibility of a statistical artifact or selection bias in that subgroup.

Other sociodemographic variables, such as age, marital status, education level, nationality, access to healthcare, and private insurance coverage did not show statistically significant differences between participants with early and late DS. These results support the conclusion that aside from gender and a potential trend related to income, most sociodemographic characteristics were similarly distributed between the two DS types.

Our study provides an insight into the surgical history of the participants, revealing that 93.2% had undergone SG, while only 6.8% had RYGB. Although the association between the type of surgery and the type of DS was not

statistically significant, Tack et al reported a higher incidence of DS primarily among patients who underwent gastric bypass and approximately 40% of them experienced related symptoms.¹⁵ The higher prevalence of SG may be because it has gained significant popularity over the past few years due to its efficacy and substantial weight-loss properties.²⁷ Studies have shown SG is superior to other procedures for weight reduction.^{28,32} It is also relevant to note that SG is the most common bariatric procedure in Saudi Arabia, accounting for a significant majority of bariatric surgeries performed. This preference is often due to its minimally invasive nature, favorable safety profile, and effective weight loss outcomes, along with cultural and healthcare system factors that favor SG. Consequently, understanding the occurrence of DS post-SG is particularly pertinent in the Saudi context, as the high volume of these procedures makes the recognition and management of potential complications like dumping syndrome especially important.³³

Our study shows high compliance by postoperative patients, as 80.2% of them attended follow-up sessions. Among the non-compliant participants (19.8%), the main reason reported was unwillingness (36.2%). These findings highlight the importance of follow-up care and patient motivation in managing postoperative symptoms such as DS; however, this association was not significant. There are no previously reported data correlating follow-up sessions for patients.

We identified a significant correlation between type 1 diabetes and the likelihood of developing DS among bariatric surgery patients. Specifically, patients diagnosed with type 1 diabetes were approximately 6.7 times more likely to experience DS compared to those without diabetes. Patients with type 1 diabetes undergoing bariatric surgery are at increased risk of hypoglycemia due to their dependence on insulin therapy. The combination of surgery-induced changes in glucose absorption and ongoing use of glucose-lowering medications can further elevate the risk of both hypoglycemic episodes and DS, especially when dietary intake is inconsistent or rapidly absorbed carbohydrates are consumed. Importantly, the occurrence of DS in these patients is not solely attributable to the surgical procedure; rather, it results from a complex interplay between altered gastrointestinal physiology and the pharmacologic management of diabetes.^{33,34} This finding highlights the need for heightened awareness and tailored management strategies for patients with type 1 diabetes, who undergo bariatric surgery, as they may be at increased risk of postoperative complications, such as DS.

We found that patients who underwent bariatric surgeries had a moderate level of nutrition knowledge with notable gaps in key areas known to affect postoperative outcomes. No significant differences were observed between patients experiencing early vs late DS. These findings are consistent with previous local studies that reported poor levels of nutrition knowledge before and after bariatric surgery among the Saudi population.³⁵

Our findings indicate that 19.8% of participants believed it was advisable to eat and drink simultaneously, while 19% did not select the option recommending liquids be separated from solid food. This misconception is particularly concerning, as our findings align with a local hospital study that identified consuming liquids with meals along with failing to adhere to recommended meal frequency and portion sizes after bariatric surgery; this was a significant factor that contributed to the occurrence of DS and negatively impacted patient outcomes.¹³

Moreover, the findings of this study reveal a variable level of nutrition knowledge regarding protein- and carbohydrate-rich foods among participants, which have highlighted widespread gaps in basic dietary knowledge. Over half the participants (62.5%) were only able to identify three or fewer protein-rich foods out of six, indicating limited awareness of protein sources. Only 2.5% of participants correctly identified all protein-rich foods, and importantly, none of the individuals with late DS demonstrated complete knowledge. Participants' knowledge about carbohydrate-rich foods was more polarized: 33.8% of participants correctly identified all six carbohydrate sources, while 28.3% of them identified three or fewer carbohydrate sources out of six. This result is in agreement with findings from a similar study that demonstrated that only a minority were able to identify all protein-rich foods (4%) and all carbohydrate-rich foods (29%).²² This pattern may be explained by greater emphasis on carbohydrate management in dietary recommendations for DS patients, as carbohydrates can exacerbate DS symptoms due to rapid gastric emptying and glucose absorption.^{14,15}

Overall, our findings highlight the necessity of enrolling bariatric surgery patients in nutrition knowledge interventions, considering the clear link between understanding nutrition and sustained weight-loss outcomes for this group.^{36,37} The implementation of nutrition education has been shown to facilitate positive changes in dietary behavior, as improved knowledge empowers patients to make healthier food choices.³⁸ It is further demonstrated that engaging these patients in programs and interventions designed to improve nutrition knowledge and literacy leads to more effective postoperative weight loss.³⁹ Therefore, it is essential to design a standard nutritional knowledge program, particularly in countries such as Saudi Arabia, where

standardized nutritional guidelines for post-bariatric surgery care have yet to be established. Such programs would fill a critical gap in patient care, which in turn may help patients achieve and maintain sustainable weight loss after surgery.

Future studies should explore the long-term effects of educational interventions and adherence to dietary and behavioral recommendations by patients with DS. The interpretations of this study are subject to certain limitations inherent to its design. The cross-sectional design captures a snapshot in time; thus, its findings are correlational, and cannot establish causal relationships between variables. Additionally, this study used a convenience sampling technique, which may introduce selection bias and limit the generalizability of the findings. One limitation of this study is that most participants in our study were from the central region of Riyadh. Our recruitment strategy aimed to achieve broad regional representation by disseminating invitations through multiple channels, including social media platforms across all regions of Riyadh. However, due to higher population density and greater accessibility in the central region, response rates were higher from this area. While these measures were necessary to ensure the participants reflected a good cross section relevant to the research objectives, they may have restricted the pool of eligible participants. As a result, the findings may not be fully generalizable to the broader population, and there is a potential for selection bias. This limitation should be considered when interpreting the results, and future research may benefit from broader inclusion criteria and probability-based sampling methods to enhance representativeness. Another limitation of this study is the use of the Sigstad scoring system, which, while currently the most relevant and widely used tool available for assessing DS after bariatric surgery, has not been shown to reliably detect late dumping or post-bariatric hypoglycemia and may underestimate the prevalence or severity of these conditions. The lack of objective glucose measurements, standardized provocative tests, and detailed information about meal composition prior to symptom onset further limits the reliability of symptom reporting and diagnosis. Another limitation of this study is the reliance on retrospective, symptom-based questionnaires, which are inherently subject to recall bias and may lead to inaccurate or biased reporting of symptoms compared to real-time or prospective assessments. In future cohort studies, we plan to incorporate more specific instruments for hypoglycemia assessment, such as the Edinburgh hypoglycemia scale, to improve diagnostic accuracy and symptom characterization.

Despite these limitations, this study represents a significant contribution to the field, as it is one of the few studies in Saudi Arabia to quantify the prevalence of DS and the first to assess nutrition knowledge among post-bariatric surgery patients. A key strength of this manuscript is the rigorous evaluation of the questionnaire's reliability prior to its use. Assessing and confirming the reliability of a research instrument ensures that the data collected are consistent and dependable, thereby enhancing the credibility and scientific value of the study's findings. Reliability testing—such as internal consistency and test-retest analysis—demonstrates that the questionnaire produces stable results over time and across different populations, which is essential for high-quality research and meaningful interpretation of outcomes.

Hence, the data collected from this study represents a crucial step in assessing the nutrition knowledge of post-bariatric surgery patients with DS in Saudi Arabia and sheds light on gaps in their nutritional literacy.

Conclusion

The prevalence of DS in Saudi Arabia was 67.3% (early DS 76.8% of participants and late DS 23.2% of participants). There was a statistically significant association between DS and gender, where women constituted the predominant patient group. A significant correlation was identified between type 1 diabetes and an elevated risk of developing DS. Bariatric surgery patients exhibited moderate yet insufficient nutrition knowledge in critical areas highlighting knowledge gaps that affect postoperative outcomes, with no significant differences noted between early and late DS groups.

This study provides novel insights by reporting a high prevalence of DS among post-bariatric surgery patients in Saudi Arabia and uniquely examining the influence of social determinants, nutrition knowledge, and type 1 diabetes on DS risk—factors that have been underexplored in previous research. The findings highlight the need for comprehensive, culturally tailored patient education and ongoing dietary counseling to improve postoperative outcomes. Future research should focus on standardizing diagnostic criteria, conducting multicenter and longitudinal studies to validate predictors, and developing targeted interventions that address both clinical and social determinants of health. Additionally, exploring individualized management strategies and the impact of comorbidities such as diabetes will be essential for optimizing care and reducing the burden of DS after bariatric surgery.

Statement on AI use

We acknowledge the use of the generative AI tool ChatGPT to support language review and proofreading in the preparation of some sections of this manuscript.

Abbreviations

BMI, body mass index; DS, dumping syndrome; HHI, household income; OR, odds ratio; RYGB, Roux-en-Y gastric bypass; SAR, Saudi riyal; SD, standard deviation; SG, sleeve gastrectomy; WHO, World Health Organization.

Data Sharing Statement

All data generated or analyzed during this study are included in this published article or are available from the corresponding author L.R.B. upon reasonable request.

Ethics and consent

Our study was conducted in accordance with the Declaration of Helsinki. Participants gave written informed consent, could withdraw at any point in the study, received no incentives for participation, and were assigned a number instead of a name for anonymity. The Institutional Review Board at the College of Medicine/ King Saud University gave ethics approval for this study (approval number: E-24-8508, date of approval: 21 January 2024).

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Author contributions

Conceptualization, L.R.B.; methodology, L.R.B., H.K.A., R.A.A., J.I.A., F.M.A. and S.H.A.; software, H.K.A., R.A.A., J.I.A., F.M.A. and S.H.A.; validation, L.R.B.; formal analysis, L.R.B., H.K.A., R.A.A., J.I.A., F.M.A. and S.H.A.; investigation, L.R.B., H.K.A., R.A.A., J.I.A., F.M.A. and S.H.A.; resources, L.R.B.; data curation, H.K.A., R.A.A., J.I.A., F.M.A. and S.H.A.; writing—original draft preparation, L.R.B., H.K.A., R.A.A., J.I.A., F.M.A. and S.H.A.; writing—review and editing, L.R.B., H.K.A., R.A.A., J.I.A., F.M.A. and S.H.A.; visualization, L.R.B.; supervision, L.R.B.; project administration, L.R.B. All authors have given final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare they have no conflicts of interest.

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