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REVIEW

New Insights on the Association Between Socioeconomic Status and Weight Loss After Bariatric Surgery: a Systematic Review and Meta-analysis

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Abstract

The effect of socioeconomic status (SES) on weight loss (WL) after bariatric surgery (BS) remains unclear. This systematic review and meta-analysis aimed to investigate the association between SES and WL at least 12 months after BS. This study included 53 observational studies (retrieved from databases in October 2021 and updatedin February 2022) involving adults who underwent any type of BS; SES data and data regarding outcomes of weight loss were also retrieved. Our results revealed that white individuals had a higher percentage of excess WL than blacks (95% confidence interval [CI]: 3.25–10.99, heterogeneity index [I^2] = 44.87% and 95% CI: 8.08–13.59, I^2 = 0%, respectively; both $p < 0.01$) after 12 and 24 months of BS. In conclusion, only race/ethnicity was associated with WL after BS.

Keywords Socioeconomic factors · Weight loss · Bariatric surgery

Introduction

Bariatric surgery (BS), combined with a healthy lifestyle, is considered the most effective procedure for controlling weight-associated comorbidities in severe obesity [1].

Key Points

- There is an urgent need to standardize weight loss variables in bariatric surgery.
- Equity in permanent access to health systems may reflect better surgical outcomes.
- Black individuals showed less weight loss at 12–24 months after bariatric surgery.

Although weight loss (WL) is the most frequently used marker in clinical practice, there is still no consensus on the best criteria to consider while determining prognosis after surgical treatment. Many studies have shown excellent results in the medium- and long-term after surgery for WL [2–6]; however, other studies have indicated that approximately 20–25% of patients struggle with insufficient WL [7] and some patients regain weight 2 years after surgery [8–10].

Postoperative WL and its maintenance are related to several factors, including age [11–13], sex [12], preoperative body mass index (BMI)/body composition [11, 14, 15], number of

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pre- and post-operative appointments with the multidisciplinary team [16–18], time after surgery [12], healthy lifestyle habits [19, 20], and type of surgery [13]. Additionally, socioeconomic factors, such as educational and income levels [21], ethnicity and racial disparities [22–24], and health insurance type [25] also influence the magnitude of WL after BS. However, the level of evidence from these studies remains unclear, especially considering the impact of the markers analyzed separately and the confounding factors in treatment outcomes [26, 27].

Since BS is a treatment option in various countries for people of different socioeconomic statuses (SES), races, and ethnicities, it is important to understand the degree of risk of or vulnerability to the social determinants of this type of treatment. A recent systematic review investigated the racial disparities, not on WL, but in postoperative adverse events, and found increased 30-day morbidity, mortality, and length of stay in black patients [28]. Thus, systematization specifically related to WL would contribute to the screening and follow-up of patients from the preoperative period and to the monitoring of WL and prevention of obesity recurrence. Therefore, this systematic review and meta-analysis aimed to investigate the association between SES and weight loss at least 12 months after BS.

Methods

Protocol and Registration

This systematic review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol [29]. The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (no. CRD42020150681).

Research Question

The research question was elaborated using the Population, Exposure, and Comparison Outcome (PECO) strategy, as recommended by the PRISMA protocol [29, 30], as follows: "Do socioeconomic factors influence weight loss 12 months after bariatric surgery?".

Eligibility Criteria

Inclusion Criteria

This review included observational studies involving adults who underwent any type of BS. Studies relating WL outcomes after surgery to socioeconomic data, such as level of education, occupation, employment status, income, ethnicity/race, health insurance, and any other scale of assessing SES, were included. To reduce publication and retrieval bias, the search was not restricted by language or publication date and status.

Exclusion Criteria

The exclusion criteria were as follows: individuals aged < 18 or > 65 years; procedures for WL other than BS; self-reported WL; socioeconomic data that had not been obtained through direct interview; follow-up period < 12 months; reviews, letters, conference abstract, personal opinions, books, cross-checking information, case reports, and qualitative studies; and studies with required data being unavailable, even after several attempts to contact the authors by email.

Information Sources and Search Strategies

The search strategy was developed in accordance with the criteria established by the Peer Review of Electronic Search Strategies (PRESS) checklist [31]. Subsequently, two researchers with expertise in systematic review evaluated and contributed to its adequacy. The following databases were searched: PubMed, Embase, Lilacs, Scopus, and Web of Science. The gray literature was also partially searched using ProQuest Dissertations and Theses Global and Google Scholar (limited to the first 200 most relevant articles). The search was conducted on October 25, 2021, and updated on February 28, 2022. Additionally, manual searches were performed using selected articles in the reference lists. The details of the search terms used in each database are described in Table S1. To eliminate duplicate references and screening, the Rayyan app was used [32].

Study Selection

Two authors (M.S.M.A. and L.C.L.B.) independently selected the studies to be included in two phases. The first phase comprised screening of the articles by their titles and abstracts. The second phase involved reading the remaining articles in full and selecting eligible ones for review. The included articles were analyzed by the two authors.

Data Collection

Data were extracted by one author (M.S.M.A.), and all information was cross-checked by a second author (L.C.L.B.). We considered WL data obtained 12 months after surgery, and the following information was collected from all selected studies: authors, publication year, country of the study, aim of the study, type of surgery, intervals of follow-up/postoperative period of evaluation, sample size, sex, age, exposure, outcomes, and socioeconomic variables associated with successful surgery. When a study presented insufficient data, all study authors were contacted by email, at least twice.

Methodological Quality in Individual Studies

The quality of the methodology of each included study was assessed using the Newcastle–Ottawa Quality Assessment Scale (NOQAS) [33]. Two authors independently assessed the quality of each study. The NOQAS grades studies in three domains as follows: study group selection, study group comparability, and the assessment of either the outcome or exposure of interest. A maximum of nine points can be awarded, and studies with three or four points in the selection domain, one or two points in the comparability domain, and two or three points in the outcome/exposure domain were considered of good quality. Those with two stars in the selection domain, one or two stars in the comparability domain, and two or three stars in the outcome/exposure domain were considered of fair quality. Poor-quality studies were those with no or one star in the selection domain, no star in the comparability domain, and no or one star in the outcome/exposure domain [33].

Certainty of Evidence

The certainty of the evidence for studies was evaluated by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) guidelines [34], based on an explicit question, including the specifications of all important and critical outcomes. According to the methodological design used, initial certainty was defined and then analyzed according to different domains (risk of bias, inconsistency, indirectness, imprecision, and publication bias). Finally, the evidence was summarized considering its certainty and the strength of the recommendations that the studies indicated.

Data Synthesis

The main outcome was WL after BS, as shown in different ways as the total WL (TWL), percentage of total WL (%TWL), percentage of excess WL (%EWL), percentage of excess BMI loss (%EBMIL), percentage of sample with successful WL or weight gain, and BMI change.

Data were analyzed using the STATA® program version 17 (Stata Corp LLC, College Station, TX, USA; serial number: 301706385466). Data were analyzed using the STATA® program version 17 (Stata Corp LLC, College Station, TX, USA), serial number: 301706385466.

The degree of statistical heterogeneity of the studies was evaluated using the heterogeneity index (I^2), applying the following cutoff points: 0–40% (not very important), 30–60% (moderate), 50–90% (substantial), and 75–100% (considerable). Standardized and unstandardized mean differences and beta coefficients were used for the meta-analysis of evaluated outcomes. To estimate statistical significance, 95% confidence intervals were calculated. The random-effects model was used through the restricted maximum likelihood, Hedges estimator, and DerSimonian–Laird method. Sensitivity analysis was conducted to estimate the effect of heterogeneity on the outcome of the meta-analysis.

Results

Literature Search

A total of 8963 records were obtained from the database search. After eliminating duplicates, 4693 records were screened through their titles and abstracts; 104 articles were selected for full-text reading, of which 64 were excluded from the analysis (Table S2). Thirteen additional records were identified from the manual search of the reference list of the fully read articles. Fifty-three original articles were included for qualitative synthesis as described in the study flowchart (Fig. 1), and 21 were included for quantitative synthesis (meta-analysis). The summary of the characteristics and results of individual studies is presented in Table 1.

Study Characteristics

In this review, 72,087 patients were evaluated at least 12 months after BS. Twenty studies presented results after 36 months [35–37, 39, 41, 43, 44, 46–49, 52, 53]. All included studies had an observational design (cohort) with 37 retrospective [35–37, 39, 41, 43, 44, 46–49, 52–77] and 16 prospective [38, 40, 42, 45, 50, 51, 78–87] cohorts; they were published between 1991 and 2022. The number of participants ranged from 50 [72] to 16,629 [68].

The studies included were conducted in the United States of America (USA) [35–45, 49–61, 63–65, 67, 69, 70, 72–79, 81–84, 86, 87], Brazil [80], Iran [79], Israel [62, 85], Germany [47], Sweden [46] and the UK [48]. One study was conducted on patients form 14 specialized centers in Singapore, Malaysia, Taiwan, Hong Kong, Japan, Korea, India, Australia, Switzerland, and the USA [66]. All studies were available in English.

In terms of surgical techniques, nine different procedures were identified, and in most studies, the sample consisted wholly or partially of patients who underwent Roux-en-Y

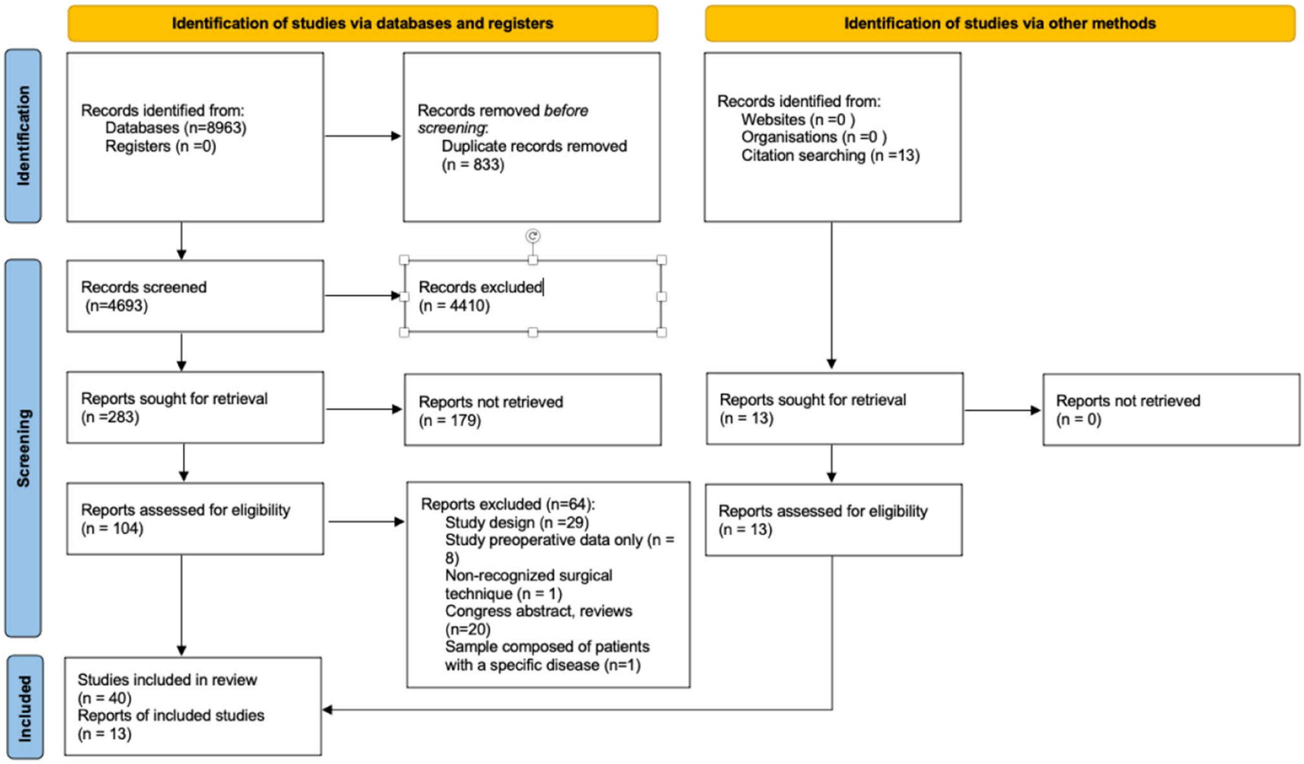

Fig. 1 Flowchart of the search and selection process of studies

gastric bypass [35–50, 52, 53, 55–57, 59, 61–65, 67–78, 80, 82, 84–86]. Sleeve gastric surgery was performed in 20 studies [36, 37, 41, 44, 47, 53, 56, 60, 62, 65, 66, 68, 69, 71, 73, 77, 82, 83, 85]. In 23 studies, more than one surgical technique was performed [36, 37, 41, 44, 47–49, 53, 54, 56, 62–65, 68–71, 73, 77, 81, 82, 85].

The socioeconomic variables studied included the income level [35, 36, 39, 46–48, 65, 70, 78, 80, 82], insurance type [39–42, 44, 52, 54, 58, 61, 67, 73, 78, 83, 84], employment status [39, 45, 46, 52, 59, 60, 68, 79, 83], educational level [36, 39, 41, 46, 59, 67, 68, 79], and race/ethnicity [35–39, 41, 49–53, 55–57, 59, 60, 62–70, 72, 74–77, 81–83, 85–87].

Indexes used to represent SES included the following: the Distressed Communities Index, a composite ranking by zip code that quantifies socioeconomic risk called neighborhood [43]; the Hollingshead four-factor index of social status based on occupation and educational level [57]; neighborhood socioeconomic status, six aggregate census tract measures including educational level, employment status, income, and the value of occupied housing [52]; and the European Deprivation Index quintiles and Geographical Health Accessibility [71]. Nineteen studies evaluated more than one socioeconomic factor [35, 36, 39, 41, 46, 52, 57, 59, 60, 65, 67, 68, 70, 71, 78, 79, 82–84].

Postoperative WL was presented in different ways in the studies: TWL [42, 61, 70, 78, 83], BMI change [39, 56, 68, 72, 78, 85, 86], %BMI change [58, 74], %EBMIL [35, 43, 54, 65], percentage of the sample with success in WL [8, 38, 41, 45, 57, 59, 60, 84], %TWL [39, 44, 46, 47, 50, 53, 55, 61, 64, 66, 70, 71, 75, 77, 85, 86], percentage of participants who regained weight [80], %EWL [8, 36, 37, 39, 40, 44, 48, 49, 51, 58, 62, 63, 66, 67, 73, 74, 76, 81, 82, 86–88], and percentage of the sample with ongoing WL, with weight stable or weight regain [52].

Results of Individual Studies

In this review, 29 (54.7%) studies reported the influence of at least one socioeconomic factor on WL outcomes [35, 37, 39, 41, 46, 47, 49–53, 55, 56, 63, 65–72, 75, 80–83, 86, 87]. Among these, 22 studies (75.8%) showed an association between race/ethnicity and weight loss [37, 39, 41, 49–51, 53, 55, 56, 63, 65, 67, 69, 70, 72, 75, 77, 81, 82, 86, 87], three (10.3%) found association with income level [35, 46, 47], three (10.3%) found an association with educational level [41, 46, 68], and three (10.3%) found an association with employment status [46, 68, 83]. Details on exposure and outcome variables of each study are available in Table 1 and Table S3.

Table 1 Summary of characteristics of the included studies and socioeconomic variables associated with weight loss after bariatric surgery in order of year of publication ($n = 53$)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Martin et al.,1991/ USA/ Prospective cohort	To determine how various demographics affect RYGB weight loss associated with obesity based on the type of health care system	12, 18, 24, 36, and 48 months	100 M = 10; F = 90 Public = 37 ± 8.2; Private = 38.5 ± 8	Insurance type	TWL (kg) %EWL	None
Capella and Capella, 1993/ USA/ Prospective cohort	To compare weight loss among ethnicity following VBG and VBG-RGB	≥ 12 months	682 M = N/A; F = N/A 37	Race/ethnicity	%EWL	Race/ethnicity
Durkin et al., 1999/ USA/ Retrospective cohort	To determine if funding status is a predictor of outcome in patients undergoing VBG based on the type of insurance	12, 24 months	131 M = 20; F = 111 Insured = 41 ± 9 Medicare = 36 ± 8 Medicaid = 43 ± 10	Insurance type	%BMI change %EWL	None
Demaria et al., 2001/ USA/ Prospective cohort	To report the results from one of the eight original US centers performing adjustable gastric banding (AGB) based on the race/ethnicity	12,24,36 months	37 M = 34; F = 34 38.9 ± 8.9 years	Race/ethnicity	%EWL	Race/ethnicity
Buffington et al., 2006/ USA/ Prospective cohort	To determine the effects of RYGB on changes in body weight, excess weight loss and body composition in weight-matched groups of African American and Caucasian women	12 months	74 M = 0; F = 153 African American = 43.0 ± 2.2; Caucasian = 45.0 ± 1.5	Race/ethnicity	%TWL %EWL BMI change (kg/m^2)	Race/ethnicity
Anderson et al., 2007/ USA/ Retrospective cohort	To describe differences in weight loss, dietary intake, and cardiovascular risk factors between white and African American patients after RYGB	12 months	50 M = 13; F = 37 African American = 43 ± 10 White = 43 ± 10	Race/ethnicity	BMI change (kg/m^2) %WL	Race/ethnicity
Carlin et al., 2008/ USA/ Retrospective cohort	To evaluate the potential role of vitamin D nutritional status on the rate of resolution of hypertension in patients undergoing RYGBP	12 months	196 M = 23; F = 173 Caucasian = 132 African American = 56 Other = 8	Race/ethnicity	%EWL	None

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Alexander et al., 2008/ USA/ Retrospective cohort	To analyze outcomes in OGB and BSG patients with the lowest socio-economic status based on the type of insurance	12 months	830 M = 149; F = 681 Medicaid = 42.1; Medicare = 53.2; Comercial: 44.0	Insurance type	% EBMIL	None
Guajardo-Salinas et al., 2008/ USA/ Retrospective cohort	To compare the rate of weight loss, effectiveness of RYGB, and variables influencing success after the operation in two different ethnic populations: the Hispano-American and the Caucasian population	12 months	75 Caucasian = 26 Hipanic = 49; 46.3 (30–61)	Race/ethnicity	%BMI change %EWL	None
Harvin et al., 2008/ USA/ Retrospective cohort	To determine predictors of long-term weight loss after RYGB surgery	24 months	111 M = 17; F = 94 44 (18–68)	Race/ethnicity	%TWL	Race/ethnicity
Melton et al., 2008/ USA/ Prospective cohort	To delineate factors associated with poor weight loss outcomes and post-operative comorbidity resolution after RYGB	12 months	495 M = 91; F = 404 42 (19–66)	Insurance type Race	% of the sample with suboptimal (< 40% %EWL) and successful (≥ 40% %EWL) weight loss	None
Akkary et al., 2009/ USA/ Prospective cohort	To examine several components of the socioeconomic status and its relationship to weight loss 1 year after RYGB	12 months	309 M = 58; F = 251 41.7 ± 0.6	Income level Insurance type	TWL (lbs) BMI change (kg/m^2)	None
Coleman and Karen, 2010/ USA/ Retrospective cohort	To evaluate if demographic factors, psychological and physical health before surgery, behavioral compliance, differed between patients with successful and unsuccessful weight loss after RYGB	≥ 12 months	110 M = 15; F = 95 44.4 ± 10.6	Race/ethnicity Hollingshead four-factor index of social status**	% of the sample with successful WL (stratified by four criteria: BMI < 30 kg/m^2 BMI < 35 kg/m^2 EWL ≥ 70% EWL ≥ 50%)	None

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Kasza et al., 2011/ USA/ Prospective cohort	To review the initial consecutive AGB experience at an urban academic center in terms of complications, reoperative rate, EWL, and comorbidities	6, 12, 18, 24 months	144 M = 14; F = 130 43 years ± 11 years	Race/ethnicity	%EWL BMI	Race/ethnicity
Bayham et al., 2012/ USA/ Retrospective cohort	To compare weight loss, payment methods, and early postoperative complications between black and white females after RYGB and SG	12, 18, and 24 months	874 M = 0; F = 874 RYGB: White females: 40.2 ± 10.9 Black females: 37.9 ± 9.5 SG: White females: 44.1 ± 11.2 Black females: 39.9 ± 10.2	Race/ethnicity	%TWL	Race/ethnicity
Bastos et al., 2013/ Brazil/ Prospective cohort	To identify determinants of weight regain after RYGB	≥ 24 months	64 M = 7; F = 57 41.76 ± 7.93	Income level	% of the sample with weight regain	None
Khorgami et al., 2014/ USA/ Retrospective cohort	To compare weight loss after RYGB and AGB by ethnic group	12, 24 months	3268 M = 788; F = 2480 41.7 ± 12.6	Race/ethnicity	%EWL BMI change (kg/m^2)	Race/ethnicity
Limbach et al., 2014/ USA/ Retrospective cohort	To identify modifiable and non-modifiable factors that predict racial variance in RYGB weight loss outcomes	12 months	415 M = 99; F = 316 47.38 ± 10.54	Educational level Insurance type Race/ethnicity	%EWL	Race/ethnicity
Wali et al., 2014/ UK/ Retrospective cohort	To assess whether deprivation was associated with AGB/RYGB weight loss outcomes at a single city-based academic center offering obesity surgery to all socioeconomic patient groups	12, 24, and 36 months	983 M = 204; F = 779 48.10 ± 11.25	Income level	%EWL	None

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Fox et al., 2015/ USA/ Retrospective cohort	To examine preoperative dietary and psychological predictors of successful weight loss after RYGB	12 months	97 M = 17; F = 80 49 ± 12	Educational level Employment status Race/ethnicity	% of the sample with successful WL ($EWL \geq 50\%$)	None
Gomberawalla et al., 2015/ USA/ Retrospective cohort	To identify preoperative factors that are predictive of successful weight loss after SG	12 months	100 M = 13; F = 87 Success = 44.90 ± 10.49; suboptimal = 45.12 ± 10.31	Employment status Race/ethnicity	% of the sample with successful WL ($EWL \geq 42.2$) *Suboptimal weight loss: $EWL \leq -1$ SD from mean EWL	None
Gullick et al., 2015/ USA/ Retrospective cohort	To identify the association of race and socioeconomic characteristics with clinical outcomes following RYGB	12, 24, 60 months	663 M = 148; F = 515 42.1 ± 9.5	Education level Employment status Income level Insurance type Race/ethnicity	%EWL %TWL BMI change (kg/m^2)	Race/ethnicity
Hayes et al., 2015/ USA/ Prospective cohort	To compare pre- and post-surgical data and outcomes among RYGB patients based on the type of insurance	36 months	2553 M = 498; F = 2055 Medicaid = 39.9 ± 9.9/ Medicare = 52.9 ± 11.5/ private = 45.0 ± 10.1	Insurance type	%EWL	None
Jensen-Otsu et al., 2015/ USA/ Retrospective cohort	To compare outcomes after laparoscopic RYGB for patients covered by Medicaid, other (non-Medicaid) government insurance, and commercial insurance	12 months	459 M = 60; F = 399 Medicaid = 35.9 ± 8.1; other government insurance = 43.5 ± 11.7; commercial = 42.0 ± 10.7	Insurance type	TWL (kg) %TWL	None
Baldridge et al., 2015/ USA/ Retrospective cohort	To assess surgical and demographic predictors of long-term weight loss after RYGB	≥ 12 months	162 M = 25; F = 137 46.7 ± 10.8	Race/ethnicity	%TWL	Race/ethnicity
Elli et al., 2016/ USA/ Retrospective cohort	To examine %EWL across and between racial groups in patients undergoing RYGB and SG	12, 24, 36 months	749 M = 109; F = 640 41,9 ± 10.4	Race/ethnicity	%EWL	Race/ethnicity

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Ng et al., 2015/ USA/ Retrospective cohort	To investigate demographic differences in weight loss and comorbidities outcomes after AGB and RYGB	12, 24, 36 months	1684 M = 321; F = 1363 45.0 ± 11.1	Race/ethnicity	%EWL BMI (kg/m^2)	Race/ethnicity
Keith et al., 2017/ USA/ Retrospective cohort	To investigate the predictive factors of weight regain after RYGB	12, 24, 36, 48, 60, 72, 84, 96, and 120 months	586 M = 125; F = 461 43 (36–51)	Employment status Insurance type Neighborhood socioeconomic status*** Race/ethnicity	% of the sample divided by groups: Ongoing WL; Weight stable; Weight regain	Neighborhood socioeconomic status
Sillén and Andersson, 2017/ USA/ Prospective cohort	To identify preoperative patient related factors predicting unsuccessful weight loss following RYGB	12, 24, 36 months	281 M = 83; F = 198 40.8 (16–67)	Employment status	% of the sample with successful (EWL ≥ 60%) and unsuccessful (EWL ≤ 59%) WL	None
Jambhekar et al., 2018/ USA/ Prospective cohort	To determine if demographic factors may predict postoperative weight loss following SG surgery	12, 18, 24 months	713 M = 91; F = 622 M = 42.7 ± 11; F = 41.6 ± 11.2	Employment status Insurance type Race/ethnicity	TWL (kg)	Employment status
Carden et al., 2018/ USA/ Retrospective cohort	To examine the impact of socioeconomic status on long term weight loss after RYGB in the veteran population	≥ 120 months	83 M = 66; F = 17 51.1 ± 8.7	Income level Race/ethnicity	%EBMIL	Income level
Clark-Sienkiewicz and Miller-Matero, 2019/ USA/ Retrospective cohort	To test if racial disparities in weight loss outcomes between African American and Caucasian patients who underwent RYGB and SG, were due to pre-surgical BMI differences	12 months	136 M = 28; F = 102 46.69 ± 11.94	Race/ethnicity	BMI change (kg/m^2)	Race/ethnicity
Jalilvand et al., 2019/ USA/ Retrospective cohort	To determine if baseline comorbidities, socioeconomic status, and post-surgical follow-up influence weight loss in RYGB and SG surgeries	12, 24, 36 months	571 M = 119; F = 452 44.8 ± 10.9	Race/ethnicity Insurance type Education level	% of the sample with poor and successful WL	Race/ethnicity Education level

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
King et al., 2019/ USA/ Retrospective cohort	To assess the role of ethnicity on weight loss and attrition after either RYGB or AGB surgery, in an ethnically diverse urban cohort largely comprised of Medicaid-insured patients	12 months	570 M = 76; F = 494 47.3 ± 7.9	Race/ethnicity	%TWL	None
KOH et al., 2019/ multicentric study (countries from all continents, except Africa)/ Retrospective cohort	To examine differences in weight loss outcomes following SG between Asian ethnicities	> 12 months	2150 M = 707 ± 32.9; F = 1443 ± 67.1 37.1 ± 11.2	Race/ethnicity	%TWL %EWL	Race/ethnicity
Lovrics et al., 2019/ Canada/ Retrospective cohort	To examine metabolic outcomes post RYGB and SG surgeries in Indigenous and non-Indigenous populations in Ontario	12 months	16,629 M = 5043; F = 11,586 Indigenous = 45.5 ± 10.5 Non-Indigenous = 45.2 ± 10.3	Educational level Employment status Ethnicity	BMI change (kg/m^2)	Educational level Employment status
Mehaffey et al., 2019/ USA/ Retrospective cohort	To determine if Distressed Communities Index (DCI) was associated with 10-year outcomes after RYGB surgery or long-term survival	120 months	681 F = 484; M = 197 41	The Distressed Communities Index (DCI)	% EBMIL	None
Petrick et al., 2019/ USA/ Retrospective cohort	To review both the safety and efficacy of RYGB and SG surgeries in Medicare patients compared with other payers	12, 18, 24, 30, 36 months	3300 M = 770; F = 2530 Medicare = 50.1 ± 9.3; Medicaid = 40.2 ± 10.0; commercial = 44.3 ± 10.3	Insurance type	%TWL %EWL	None

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Valencia et al., 2019/ USA/ Retrospective cohort	To investigate ethnic differences in the improvement of weight loss and glucose metabolic profiles between non-Hispanic white, Hispanic, black, and Asian patients with T2DM who underwent RYGB or laparoscopic SG	12 months	687 M = 199; F = 488 < 50 years old = 49.4%; > 50 years old = 50.6%	Race/ethnicity	BMI (kg/m^2) Weight (lbs)	Race/ethnicity
Turner et al., 2019/ USA/ Prospective cohort	To investigate the weight loss and remission of obesity related comorbidities based on race/ethnicity after RYGB surgery	12 to 60 months	1695 White, *n* = 1425 Black, *n* = 195 Other, *n* = 59 White: 45.4 (44.8–46); Black: 42.1 (40.7–43.4); Others: 45.9 (43.3–48.6)	Race/ethnicity	%TWL	Race/ethnicity
Wood et al., 2019/ USA/ Retrospective cohort	To better understand the association of race with the safety and effectiveness of RYGB, SG, and AGB surgeries	12 months	7105 M = 2000; F = 5105 Black = 44 ± 10.4 White = 43 ± 12.6	Income level Race/ethnicity	TWL (kg) %TWL	Race/ethnicity
Masrur et al., 2020/ USA/ Retrospective cohort	To examine factors associated with percent total weight loss (%TWL) after RYGB and SG among an ethnically diverse sample of patients	12, 18, 24, 36, 48 months	1012 M = 145; F = 867 41.6 ± 10.4	Race/ethnicity	%TWL	Race/ethnicity
Kitamura et al., 2020/ USA/ Retrospective cohort	To examine the predictive factors of weight loss up to 10 years following RYGB and SG	12 to 120 months	340 M = 262; F = 78 53.2 (28–69)	Income level Race/ethnicity	%EBMIL	Race/ethnicity
Hecht, et al. 2020/ USA/ Prospective cohort	To examine the influence of race and socioeconomic factors on whether patients undergo bariatric surgery and post-surgical weight loss outcomes	12 months	314 M = 54; F = 260 46.51 ± 10.44	Income level Race/ethnicity	%EWL	Race/ethnicity

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Gorecki et al., 2020/ USA/ Prospective cohort	To describe the long-term effects and the dynamic of weight loss after laparoscopic RYGB by analyzing patients undergoing this procedure up to 10 years after initial surgery at a single metabolic and bariatric surgery center	12, 18, 24, 36, 48, 60, 72, 84, 96, 108, and 120 months	576 M = 68; F = 508 38.2 ± 10.9	Race/ethnicity	% of the sample with successful WL (> 25% TWL)	None
Chen et al., 2020/ USA/ Retrospective cohort	To evaluate the impact of income, education, and race on weight loss outcomes up to 3 years after SG and RYGB surgeries	12, 24, and 36 months	564 M = 118; F = 446 Low income, 43 (35–52) Middle/high income, 45 (37–53)	Educational level Income level Race/ethnicity	%EWL	None
Ansar et al., 2020/ Iran/ Prospective cohort	To determine the independent effects of demographic, socio-economic, and clinical factors on the 1-year postoperative weight loss values following OAGB-MGB	12, 18, 24 months	1701 M = 384; F = 1317 39.0 ± 10.2	Educational level Employment Status	% of the sample with successful WL (EWL ≥ 50%)	None
Stenberg et al., 2021/ Sweden/ Retrospective cohort	To identify socioeconomic factors associated with suboptimal postoperative weight loss 5 years after RYGB surgery	60 months	13,275 M = 2974; F = 10,301 42.3 ± 11.1	Educational level Employment status Income level Financial aid Heritage	%TWL	Education level Employment status Income level Financial aid Heritage
Wagner et al., 2021/ Germany/ Retrospective cohort	To investigate whether socioeconomic status is linked with an inferior outcome after RYGB, SG, and other procedures (AGB, SADI, and conversion of sleeve gastrectomy to gastric bypass)	12, 24, 36, 48, and 60 months	559 M = 171; F = 388 44.2 ± 11.5	Income level	BMI (kg/m^2) Weight (kg) %TWL %EWL	Income level

Table 1 (continued)

Author/year/ Country/ Study design	Aim of study/type of surgery	Intervals of follow-up/ postoperative period of evaluation*	Sample size/ Sex/ Age (years old)	Exposure variables	Outcome variables	Socioeconomic variables associated with weight loss after surgery
Sakran et al., 2021/ Israel/ Prospective cohort	To evaluate the outcomes at 1 year post-RYGB and SG surgeries based on ethnicity	12 months	121 M = 770; F = 77 Israeli-Jews = 43.9 ± 12.3; Israeli-Arabs = 41.4 ± 11.0	Race/ethnicity	BMI change (kg/m^2) %TWL	None
Pouchucq et al., 2022/ France/ Retrospective cohort	To assess whether geographical health accessibility and socio-economic deprivation infuence outcomes after RYGB or SG surgeries	12 months to over 12 years	1599 M = 359; F = 1240 EDI 1 to 3: 43.7 ± 0.4 EDI 4 and 5: 42.5 ± 0.4	Geographical health accessibility Socieconomic status (European Deprivation Index quintiles — EDI)	%TWL	Geographical health accessibility
Kaplan et al., 2022/ Israel/ Retrospective cohort	To evaluate the relative influence of age and other factors on RYGB and SG outcomes	12 months	3166 M = 511; F = 2655 44.8 ± 10.3	Race/ethnicity	%EWL	None
Akhtar et al., 2022/ USA/ Retrospective cohort	To evaluate whether insurance status affects the outcomes post RYGB or SG surgeries	12 months	408 M = 68; F = 340 Private and self-pay = 44.8 ± 11.3 Medicaid = 39.3 ± 9.2 Medicare disability = 51.9 ± 8.8 Medicare retired = 68.6 ± 3.8	Insurance type	%EWL	None

EWL nadir: the maximum weight loss achieved from at least three available measurements between 6 and 36 months after surgery

%EWL percentage of excess weight loss, *%TWL* percentage of total weight loss, *AGB* adjustable gastric banding, *BMI* body mass index, *BSG* banded sleeve gastrectomy, *F* female, *M* male, *OAGB-MGB* one anastomosis gastric bypass-minigastric bypass, *OGB* open gastric bypass, *RYGB* Roux-en-Y gastric bypass, *SADI* single anastomosis duo-denoileal bypass, *SG* sleeve gastric, *USA* United States of America, *VBG-RGB* vertical banded gastroplasty-gastric bypass, *VBG* vertical banded gastroplasty, *EBWL* excess body weight loss, *EBMIL* excess body mass index loss, *WL* weight loss, *AWL* absolute weight loss, *SD* standard deviation, *UK* United Kingdom, *TWL* total weight loss, *EDI* European Deprivation Index

*Follow-up times greater than 12 months were considered

**Hollingshead four-factor index of social status based on occupation and educational level

***Six aggregate census tract measures including educational level, empolyment status, income, and value of occupied housing

Methodological Quality in Studies

The average NOQAS score for all studies was 6.8 ± 1.1 (Table S4). Out of the 53 studies, 34 (64.1%) were of good quality [8, 35–42, 44, 46, 47, 49, 50, 52, 53, 55, 57, 59–66, 68–70, 73, 78, 82–84], while 10 were of fair quality [43, 45, 67, 72, 74–77, 81, 87]. Nine studies were classified as having poor quality [48, 51, 54, 56, 58, 71, 80, 85, 86]. The "comparability" parameter (adjustment for confounding factors in the analyses) presented a critical performance among studies with the lowest scores.

Results of Syntheses

Regarding race/ethnicity, Figs. 2 and 3 show that, on average, white individuals had greater WL (%EWL) compared to blacks in the first and second years of follow-up, respectively. In linear regression analysis, the results were not statistically significant due to the high heterogeneity of the studies. When performing a sensitivity analysis, $I^2 = 0$ was considered statistically significant. All meta-analyses are presented in Figures S1–S7.

Certainty of Evidence

In the evaluation by the GRADE process (Table S6), all studies were rated with very low certainty of evidence and classified with serious risk of bias, inconsistency, indirectness, and imprecision. Therefore, in all studies, publication bias strongly suggested spurious effects, while no effect was observed.

Discussion

The meta-analyses performed in this study highlighted that race/ethnicity was the factor that most influenced the different markers of therapeutic success. However, there is no standard method for evaluating WL, which makes comparative analyses challenging. We compiled the main studies that investigated the association of socioeconomic factors with long-term WL after BS.

Socioeconomic variables, to some extent, affect health and lead to the development of chronic diseases, such as obesity [89]. The mechanisms involved in these associations are complex and need further clarification [2]. Studies that assess the association between SES and obesity show contradictory results, probably due to the different ways of classifying socioeconomic levels and factors related to the level of development of the countries where the studies were conducted.

Newton et al. [90], in a systematic review to summarize the evidence on the association of life course SES with obesity, found that women with low SES had a higher prevalence of obesity in developed countries. Furthermore, Purslow et al.[91], in a study on middle-aged men and women, showed that individuals with low SES had the highest risk of weight gain. This can be explained by numerous factors, from less healthy dietary patterns to psychological stress and discrimination [92]. Restricted environmental opportunity and cultural issues have been speculated as possible explanations [93]. In contrast, Dinsa et al. [94], in a systematic review, investigated the association between SES and obesity in low- and middle-income countries among men and women. In low-income countries, better SES correlated

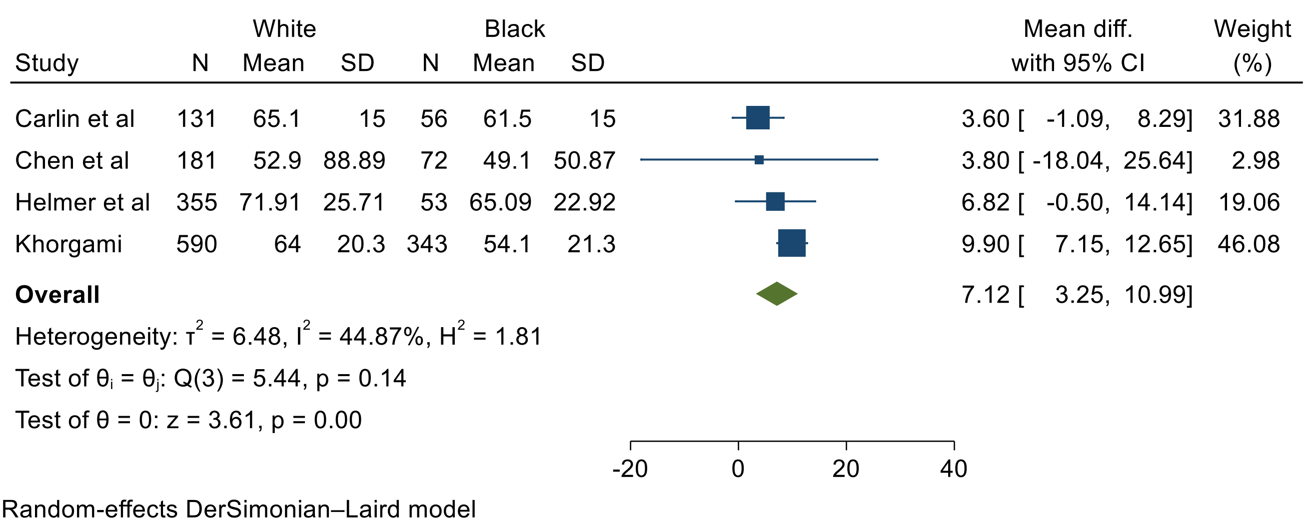

Fig. 2 Meta-analysis of the mean difference and 95% confidence interval in terms of race/ethnicity, with the percentage of weight loss (%EWL) in patients 12 months after bariatric surgery

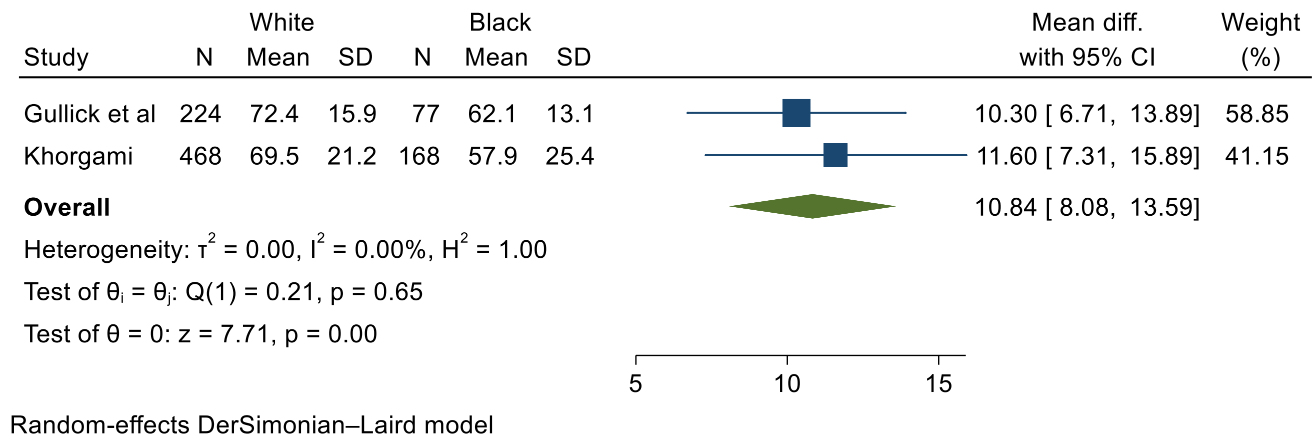

Fig. 3 Meta-analysis of the mean difference and 95% confidence interval in terms of race/ethnicity, with the percentage of weight loss (%EWL) in patients 24 months after bariatric surgery

with a higher prevalence of obesity in both sexes. In middle-income countries, better SES correlated with a lower prevalence of obesity in women.

Regarding severe obesity, the likelihood of undergoing BS is lower in males and individuals with low income, low education levels, and no health insurance [88, 95, 96]. However, even among those who could not undergo BS, the impact of SES on the outcomes was complex, and one key issue was the country's health system model. All existing health systems worldwide have numerous shortcomings regardless of the funding approach model [97] or the country's level of development [98].

An effective healthcare system provides hypothetically equitable access to high-quality healthcare, including treatment and curative, health promotion, prevention, and rehabilitation services to all [99]. Although access to BS is equal in some countries, such as Sweden [27], therapeutic results may vary depending on the follow-up model of the healthcare system. Therefore, the degree of WL after surgery may have been influenced by the characteristics of the healthcare system of the countries where studies were conducted.

Studies associating socioeconomic factors with less postoperative WL showed discrepant results. Individuals with lower educational levels tended to lose less excess weight after BS [41, 100]. Contrastingly, Stenberg et al. [46] found that a higher educational level was also associated with less WL [46], which can be partially explained by the long working hours and poor work-life balance observed among people with higher education [101]. Regarding employment status, a possible explanation for the association between unemployment and less long-term WL after surgery is that health insurance, which allows for necessary postoperative follow-up, is unavailable to unemployed individuals [42, 62, 76]. In contrast, employed patients demonstrate greater treatment adherence, even when universal health coverage is available [102].

Regarding income levels, all studies included in this review were conducted in developed countries, which requires a more careful analysis of the results and demonstrates the need for further studies, especially in less developed countries. Therefore, people with lower incomes may experience lower postoperative WL [46, 47]. Some authors describe poor access to healthy food [103] and physical activities as possible causes of the negative effects of low income on WL, especially in women [104]. However, even among individuals with low income, it is assumed that when they are well-assisted, they can establish priorities to maintain a healthy diet and an active lifestyle.

Regarding racial disparities in BS, the meta-analysis showed that black people experienced less WL after 12 and 24 months of surgery compared to white individuals. This association was also observed by Zhao et al. [105] in a systematic review that investigated racial disparities in postoperative WL and comorbidity resolution. They found that racial minorities lost less weight than non-Hispanic white individuals; however, the factors associated with this discrepancy remain unclear. In another study, Admiraal et al. [106] conducted a meta-analysis to determine the difference in %EWL 12 to 24 months after BS in people of African and Caucasian descent. They found better WL results in patients of Caucasian descent than in patients of African descent, regardless of the type of BS. The etiology of the difference in WL between patients of African and Caucasian descent is unclear, although metabolic, behavioral, and socioeconomic factors are considered probable causes. White individuals with greater improvement in energy expenditure in response to diet and exercise WL interventions [107–109] are more physically active and consume a diet lower in calories than black individuals [86, 110], suggesting that economic issues related to ethnic minorities and biological and environmental factors may synergistically explain these results.

The broad investigation of the main available databases and most of the studies used in this review can be considered strengths of this review. In addition, the use of tools such as meta-analysis showed results that can be useful in the management of patients undergoing BS in the long term.

Despite the considerable amount of studies, this review has some limitations. In general, the nomenclatures of race and ethnicity are not generally standardized across studies, the classifications used for income level and educational level were different in many studies, and there are different ways of presenting the weight loss outcomes, which made it difficult to compile the results. Concerning the quantitative synthesis, it was not possible to conduct more advanced analytical techniques to investigate the source of heterogeneity, such as subgroup, sensitivity, and meta-regression analyses due to the small number of studies included in the meta-analysis. Additionally, there is an inherent limitation that all the studies have an observational design which limits the assessment of causality.

This review indicates the importance of the government guaranteeing people access to BS and follow-up. Access to postoperative consultations, safety, transport, and equal opportunities can also affect adequate health status and its long-term maintenance [111]. The standardization of presenting variables related to both postoperative WL and SES is urgently required for further analysis to be conducted.

Conclusion

Race/ethnicity is associated with WL outcomes after BS, which may be related to equality in permanent access to healthcare systems. To obtain better results, further studies are needed to address socioeconomic issues related to surgical outcomes.

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Author Contribution Mariana Silva Melendez-Araújo, Eliane Said Dutra, and Kênia Mara Baiocchi de Carvalho wrote the study protocol and designed the study. Mariana Silva Melendez-Araújo and Larissa Cristina Lins Berber performed literature searches, study selection, data collection, data analysis, and manuscript preparation. Ana Cláudia Godoy contributed to data analysis. Karyne Miranda Quirino de Sousa contributed to figures, and table conception. Fernando Lamarca contributed to abstract, discussion and all manuscript preparation. All authors reviewed the manuscript and approved the version to be submitted.

Declarations

Ethical Statement This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent Statement For this type of study, formal consent is not required and does not apply.

Conflict of Interest The authors declare no competing interests.

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