Research Article

Sociodemographic, Clinical, Dietary, and Inflammatory Determinants of Super-Morbid Obesity in Bariatric Surgery Candidates

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ABSTRACT

Background: Severe obesity, clinically defined as a Body Mass Index (BMI) ≥ 40 kg/m² or ≥ 35 kg/m² in the presence of weight-related comorbidities, is a major contributor for non-communicable diseases, including type II diabetes and cardiovascular pathology. This condition is characterised by chronic, low-grade systemic inflammation triggered by visceral adiposity and ectopic lipid deposition. While haematological indices such as the neutrophil-to-lymphocyte ratio (NLR) have emerged as robust surrogate markers of systemic inflammation, their clinical utility in bariatric risk stratification remains underutilised in the Malaysian context. This study investigated sociodemographic, clinical, and dietary determinants of BMI and assessed the role of neutrophil-to-lymphocyte ratio (NLR) as an inflammatory marker in bariatric surgery candidate. Methods: A retrospective cross-sectional study was conducted on 219 patient records (year 2022–2024) at Institut Kanser Negara. Data regarding sociodemographic characteristics, comorbidities, dietary intake, body composition (via bioelectrical impedance analysis), and haematological profiles were reviewed. Statistical significance was evaluated using Chi-square tests and Pearson or Spearman correlation coefficients. Results: The study was predominantly female (65.3%) and Malay (85.8%). Significant associations were found between BMI category and gender (p=0.019), hypertension (p=0.048), and childhood obesity (p=0.027). Positive correlations were observed between BMI and energy intake (r=0.211, p=0.002), protein intake (r=0.199, p=0.003), and fat free mass (r=0.336, p<0.001). Notably, the NLR showed a strong positive correlation with BMI (r=0.232, p<0.001), highlighting a progressive inflammatory burden associated with increased adiposity. Fat body percentage (OR = 1.642), fat-free mass (OR = 1.233), and STOP-BANG score (OR = 1.592) were independently associated with super-morbid obesity (all p ≤ 0.007). Conclusion: These findings emphasise the necessity of integrating systemic inflammatory profiling and body composition analysis into preoperative protocols. Body composition and sleep apnoea risk independently differentiate obesity severity beyond BMI classification.

Keywords: [bariatric surgery, body composition, morbid obesity, neutrophil-to-lymphocyte ratio, systemic inflammation]

1. Introduction

The National Institutes of Health defines morbid obesity as having a body mass index (BMI) of 40 kg/m² or above, or between 35-40 kg/m², with severe weight-related comorbidities (Rifin et al., 2024). Furthermore, obesity-related illnesses are predominantly mediated by inflammation caused by visceral fat and fat accumulation in non-adipose tissue (Rifin et al., 2024). This growing trend is linked to an

increased risk of non-communicable diseases such as diabetes, hypertension, and heart disease (Khaw et al., 2024). According to the National Health and Morbidity Survey (NHMS) 2023, 54.4% of Malaysian adults are overweight or obese, up 10 % from 2011 (Khaw et al., 2024; Rifin et al., 2024). This increase is especially noteworthy at Institut Kanser Negara (IKN), where obesity is a known risk factor for at least 13 different forms of cancer, including endometrial, colorectal, and postmenopausal breast cancer. Bariatric surgery is no longer seen solely as a weight-loss technique, but rather as "metabolic surgery" that can considerably lower cancer risk and treat NCDs such as type 2 diabetes and hypertension (Arterburn et al., 2020). While the benefits of bariatric surgery are well-documented, patients often present at clinics with super morbid obesity (BMI >50 kg/m²) (Arterburn et al., 2020).

Dietary behaviours, particularly excessive calorie and protein intake in relation to metabolic demands, are associated with increases in BMI (Deledda et al., 2021; Ho et al., 2023). However, in super-morbidly obese people, obesity malnutrition is common, with high caloric consumption combined with nutritional deficits. Bioelectrical Impedance Analysis (BIA) is a common technology used at clinics like IKN to distinguish between fat mass and fat-free mass, which is critical for determining dietary requirements (Ho et al., 2023). Obstructive sleep apnoea (OSA) is one of the most common and deadly comorbidities among bariatric patients (Al Oweidat et al., 2023). The prevalence of OSA in the severely obese population can surpass 80% (Al Oweidat et al., 2023; Ho et al., 2023). The mechanical stress of extra neck fat and truncal obesity causes airway collapse during sleep, resulting in intermittent hypoxia that worsens systemic inflammation and cardiovascular strain (Al Oweidat et al., 2023).

Obesity is distinguished by chronic, low-grade systemic inflammation, often known as "meta-inflammation" (Ho et al., 2023; Soták et al., 2025, Huertas-Campos et al., 2025). While NLR is frequently utilised as a prognostic marker in oncology (Alazawi et al., 2016), its role in determining obesity severity and predicting bariatric results in Malaysia has received less attention. However, research into the clinical value of NLR in Malaysia's population is limited. This study looks at the factors that influence BMI in patients' first visits to a bariatric clinic, with an emphasis on the confluence of clinical, nutritional, and inflammatory markers. There is a critical need to understand the preoperative profile of these patients to optimise surgical outcomes. Specifically, the role of systemic inflammation, measured through the NLR, remains under-explored in the Malaysian bariatric context despite its known prognostic value in surgical and oncological settings. These findings highlight the potential role of incorporating inflammatory markers into preoperative assessment protocols. This study aimed to examine the associations between sociodemographic characteristics, clinical background, dietary factors, and body mass index (BMI) among bariatric surgery candidates, and to evaluate the role of the neutrophil-to-lymphocyte ratio (NLR) as an inflammatory marker in bariatric surgery candidates.

2. Materials and Methods

2.1 Study Design and Participants

This was a retrospective cross-sectional study utilising Electronic Medical Records (EMR) from the IKN bariatric clinic. The study included patients aged 18-60 years with body mass index (BMI) ≥35kgm² who attended their first consultation at the bariatric clinic. Patients receiving mental health medication, those with incomplete medical records and not seen by dietitians were excluded from this study. A total of 219 patients were selected through convenience sampling.

2.2 Data Collection

Data from year 2022 to 2024 were extracted from the hospital's Electronic Medical Record (EMR) system using structured data collection forms. The information gathered included sociodemographic details (age,

gender, and marital status) and clinical background (comorbidities and history of obesity). From dietitian's nutrition care plan record, the anthropometry (weight, height, and BMI), body composition (fat mass, fat-free mass, and muscle mass), nutritional intake (24-hour dietary recall via face-to-face interview by dietitian during bariatric clinic), and biochemical parameters (neutrophil count, lymphocyte count, NLR, and total cholesterol). The nutrition assessment was conducted by dietitian who in charge of bariatric clinic.

Anthropometry measurement, including weight and height, were measured during the first clinic visit using calibrated digital scales and stadiometer. For the purpose of this study, participants were further categorised based on BMI into two groups: the Morbid Obese Group (MOG), defines as individuals with BMI ≤49.9 kg/m², and the Super Morbid Obese Group (SMOG), defined as individuals with BMI ≥50 kg/m². Body composition parameters (fat mass, fat free mass, and muscle mass) were assessed using bioelectrical impedance analysis (BIA) with a TANITA body composition analyser during the same visit. Biochemical parameter collection was on the same day of bariatric clinic.

2.3 Statistical Analysis

The analysis was performed using IBM SPSS Statistics for Windows (Version 23.0. Armonk, NY: IBM Corp.). Chi-square tests for categorical data, Pearson correlation for normal distributed numerical data and Spearman correlation for non-normally distributed numerical data as well as logistic regression model were used to assess these relationships, with the level of significance set at $p < 0.05$.

2.4 Ethical Considerations

The study was reviewed and granted approval by the Medical Research Ethics Committee with identity number NMRR ID-24-00914-JUB.

3. Results

A total of 219 patient records were reviewed with 67.6% falling under the Morbid Obese Group (MOG) category and 32.4% under the Super Morbid Obese Group (SMOG). Majority of participants are Malay (88.6%), followed by 6.8% Indian (n=15), 3.7% Chinese (n=8) and 0.9% other ethnicity (n=2). Approximately 54.8% (n=120) of the patients had mechanical issues (knee pain and slipped disc), followed by 46.1% hypertension (n=101), 38.8% dyslipidaemia (n=85), 37% other diseases (fatty liver, PCOS, hyperthyroidism, gastritis, asthma or gout), 32.9% Type 2 Diabetes Mellitus (n=72) and 30.6% sleep apnoea (n=67).

Table 1. Sociodemographic characteristics and nutrition assessment of participants (N=219)

Variable	Category	N	%	Mean ± SD
Age (years)				38.3 ± 7.5
Gender	Male	68	31.1	
	Female	151	68.9	
Ethnicity	Malay	194	88.6	
	Chinese	8	3.7	
	Indian	15	6.8	

	Others	2	0.9
Marital Status	Single	153	69.9
	Married	57	26
	Others	9	4.1
Employment	Employed	187	85.4
	Non-employed	28	12.8
	Retired	4	1.8
Social Support	Dependant	37	16.9
	Independent	182	83.1
Comorbidities	Hypertension	101	46.1
	Dyslipidemia	85	38.8
	Type 2 Diabetes Mellitus	72	32.9
	Sleep apnoea	67	30.6
	Mechanical issue	120	54.8
	Other diseases	81	37
Medication			
Hypertension	Yes	76	34.7
	No	143	65.3
Diabetes Mellitus	Yes	64	29.2
	No	155	70.8
Hyperlipidaemia	Yes	163	74.4
	No	56	25.6
Body Composition	Height (m)		1.63 ± 8.71
	Weight (kg)		123.2 ± 29.6
	BMI (kg/m²)		46.5 ± 8.6
	BMI < 49.9kg/m²	148	67.6
	BMI > 50kg/m²	71	32.4
	Fat Body Percentage (%)		53.1 ± 7.9
	Fat Free Mass (kg)		56.9 ± 14.3
	Muscle Mass (kg)		51.6 ± 14.8
Biochemical Profile	Neutrophil (10^9/L)		5.5 ± 1.8
	Lymphocyte (10^9/L)		2.9 ± 0.9
	Neutrophil-Lymphocyte Ratio		2.0 ± 0.8
	Cholesterol (mmol/L)		5.2 ± 1.0
Dietary Intake	Total Daily Energy Intake (kcal/kg/day)		1873 ± 509

Total Daily Protein Intake (g/day)	62.1 ± 16.7

Mechanical issues: knee pain and slipped disc; Other diseases: fatty liver, PCOS, hyperthyroidism, gastritis, asthma or gout

Associations between BMI and sociodemographic and clinical background are shown in Table 2. There were statistically significant associations between BMI category and gender ($p = 0.019$), hypertension ($p = 0.048$), sleep apnoea ($p = 0.020$), and obesity since childhood ($p = 0.027$). No significant associations were observed between BMI category and other sociodemographic variables such as age, ethnicity, marital status, employment, household income and social support.

Table 2. Association of sociodemographic and clinical background with BMI category (n=219)

Variables	MOG, n (%)	SMOG, n (%)	x^2	P-value
Gender			6.159	0.019**
Male	38(25.7)	30(42.3)		
Female	110(74.3)	41(57.7)		
Hypertension	62(41.9)	39(54.9)	3.282	0.048*
Sleep Apnoea	35(23.6)	32(45.1)	10.369	0.020*
Obese since childhood	80(54.1)	50(70.4)	5.329	0.027*

Abbreviation: BMI: Body Mass Index; MOG: Morbid Obese Group; SMOG: Super Morbid Obese Group; *p<0.05; **p<0.01; Chi-square Test

Associations between BMI and anthropometry, nutritional intake, body composition and biochemical data is shown in Table 3. BMI demonstrated significant positive correlations with weight at age 17 ($p < 0.001$), STOP-BANG score ($p < 0.001$), energy intake ($p = 0.002$), protein intake ($p = 0.003$), fat mass ($p < 0.001$), fat-free mass ($p < 0.001$), and muscle mass ($p < 0.001$). Similarly, biochemical parameters such as neutrophil count ($p < 0.001$) and NLR ($p < 0.001$) were positively correlated with BMI. However, cholesterol was negatively correlated with BMI ($p < 0.001$). These correlations are detailed in Table 3. The most significant finding was the strong positive correlation between BMI and NLR (r=0.232, p<0.001).

Table 3. Association of anthropometry, nutritional intake, body composition and biochemical data with BMI (n=219)

Variables	r-value	P-value
Weight at age 17 [b]	0.31	<0.001***
STOP-BANG score[a]	0.38	<0.001***
Energy Intake (kcal) [a]	0.211	0.002**
Protein intake(g) [b]	0.199	0.003**
Fat Body Percentage (%)[a]	0.517	<0.001***
Fat Free Mass (kg)[a]	0.336	<0.001***
Muscle Mass (kg)[a]	0.304	<0.001***
Neutrophil (10^9/L)[b]	0.266	<0.001***

Neutrophil-Lymphocyte Ratio[b]	0.232	<0.001***
Cholesterol (mmol/L)[a]	-0.243	<0.001***

Abbreviation: BMI: Body Mass Index; STOP-BANG questionnaire: screening obstructive sleep apnoea (OSA)
**p<0.01; ***p<0.001;
[a]Pearson correlation; [b]Spearman correlation

In multivariable binary logistic regression analysis (Table 4), fat body percentage, fat-free mass, and STOP-Bang score were independently associated with super-morbid obesity. Each 1% increase in fat body percentage was associated with a 64.2% higher odds of super-morbid obesity (OR = 1.642, p < 0.001). Similarly, each 1 kg increase in fat-free mass increased the odds by 23.3% (OR = 1.233, p < 0.001). Additionally, higher STOP-Bang score was significantly associated with super-morbid obesity, with each 1-point increase conferring a 59.2% higher odds (OR = 1.592, p = 0.007).

Table 4. Association of body composition and STOP-BANG scores with BMI (n=219)

Variables	B	Exp (B)	P-value
Fat Body Percentage (%)	0.496	1.642	<0.001***
Fat Free Mass (kg)	0.209	1.233	<0.001***
STOP-BANG score	0.465	1.592	0.007**

**p<0.01; ***p<0.001;
Logistic regression test

4. Discussion

The analysis revealed a statistically significant association between gender and BMI category, with a higher proportion of females observed in both the Morbid Obese Group (MOG) and Super Morbid Obese Group (SMOG) compared to males. This may suggest that men in Malaysia delay seeking bariatric intervention until their condition becomes severe (Ho et al., 2023; Nor Hanipah et al., 2025). This finding is consistent with studies indicating that women tended to have higher rates of severe obesity and were more likely to seek bariatric care (McCarthy et al., 2025). In particular, hypertension was more common in the SMOG group and showed a statistically significant correlation with BMI category.

This aligns with previous research indicating a dose-response relationship between increasing BMI and the risk and severity of hypertension (McCarthy et al., 2025). A positive correlation was found between BMI and total energy intake (r=0.211, p=0.002). This aligns with the "energy balance" theory of obesity but also highlights the need for intensive dietitian-led intervention pre-surgery to manage caloric density (Ho et al., 2023). Additionally, sleep apnoea and hypertension were significantly more prevalent in the SMOG, suggesting gradual worsening upper airway collapsibility as BMI increased (Arterburn et al., 2020; McCarthy et al., 2025).

A significant association was found between a history of obesity since childhood and BMI category, with a higher proportion of individuals in the SMOG group reporting childhood obesity compared to the MOG group. This finding reinforced the long-term impact of early-onset obesity on the trajectory of weight gain and the development of severe adult obesity (Farella et al., 2025). The STOP-BANG score and weight at age 17 were a positive correlation with BMI, indicating the strong association between obesity, sleep apnoea risk and the long-term effects of early weight status (Farella et al., 2025; Zhong et al., 2025). A significant positive correlation was observed between protein intake, energy intake, body fat percentage, fat free mass and muscle mass with BMI (Gazarova et al., 2023).

These findings suggested that higher nutritional intake may have contributed to higher BMI (Deledda et al., 2021), but also preserved lean mass, aligning with previous research that highlights the importance of adequate protein intake in obesity management, especially in preoperative contexts (Gazarova et al., 2023; Luo et al., 2023). Interestingly, biochemical markers such as neutrophil count, neutrophil-lymphocyte ratio (NLR), and total cholesterol were significantly correlated with BMI. Neutrophils were the first immune cells to respond to inflammation, and they could gradually worsen an inflammatory state by attracting macrophages and interacting with antigen-presenting cells (Rosales 2020). The positive correlation between NLR may suggest the crucial parameter needed to assess especially for patients waiting for surgery and not only serve as a biomarker of systemic inflammation. As BMI increases, the systemic inflammatory burden rises linearly.

This shows that super-morbidly obese patients are in a state of high physiological stress even before surgery. Monitoring NLR could help clinicians identify "high-risk" patients who require more aggressive preoperative optimisation or prehabilitation. In addition, this may also aid in prehabilitation strategies and surgical readiness. It found that higher preoperative NLR has been associated with increased risk of complications, longer hospital stay (Kriplani et al., 2022), higher reoperation rates, and poorer early weight loss outcomes (Kriplani et al., 2022). Achieving a preoperative NLR of less than 2.36 has been associated with more successful weight loss outcomes following bariatric surgery (Chi et al., 2022).

On the other hand, the negative significant correlation between cholesterol and BMI observed in this study was an unexpected finding, as higher BMI is generally associated with adverse lipid profiles, including elevated total cholesterol and LDL-cholesterol, and reduced HDL-cholesterol. While a positive correlation between BMI and cholesterol is typical in the general population, the negative correlation observed in this study likely reflects the impact of pharmacological intervention. Specifically, patients with higher BMIs were more frequently prescribed lipid-lowering medications as part of standard clinical care. This treatment effect successfully lowered cholesterol levels in the higher-BMI group (Vekic et al., 2023).

The present study demonstrated that body composition parameters and sleep apnoea risk were independently associated with super-morbid obesity among bariatric surgery candidates. Fat body percentage emerged as the strongest predictor, underscoring the role of adiposity beyond BMI alone (Ho et al., 2023). This finding reinforces the importance of body composition assessment in patients with severe obesity, as excess adiposity may better reflect metabolic burden than BMI alone. Interestingly, fat-free mass was also positively associated with super-morbid obesity. This may reflect adaptive increases in lean mass to support greater body weight, a phenomenon commonly observed in individuals with extreme obesity (Ho et al., 2023). Furthermore, STOP-Bang score independently predicted super-morbid obesity, suggesting a close interplay between obesity severity and obstructive sleep apnoea risk. This finding aligns with previous evidence linking adiposity and upper airway dysfunction, and highlights the need for routine sleep apnoea screening in this high-risk population (Al Oweidat et al., 2023).

4.1 Strength & Limitations

This research investigates the multifaceted clinical, nutritional, and biochemical determinants of obesity severity in a unique cohort of bariatric candidates at a national referral centre. By exploring the complex interplay between sociodemographic profiles, early-life obesity, and macronutrient intake, the study addresses critical gaps in the preoperative management of super-morbidly obese individuals within the Malaysian clinical context. Focus of this investigation is the evaluation of the NLR as a low-cost, accessible marker of systemic inflammation, which offers significant potential for enhancing clinical risk stratification. The findings underscore the necessity of a comprehensive multidisciplinary approach that integrates inflammatory profiling with targeted nutritional prehabilitation to optimise metabolic health and improve surgical readiness in high-risk populations.

Due to time constraints, data collection was limited to electronic medical records and did not include face-to-face patient interviews. This may be subject to limitations such as missing information or variations in data recording. Furthermore, self-reported measures recorded in the medical records were used to obtain information on obstacles to weight loss. With this, self-reporting is prone to recall bias, where participants may unintentionally overestimate or underestimate their challenges, or omit relevant information.

4.1 Recommendation

Preoperative optimisation necessitates a high-intensity, multidisciplinary approach led by dietitians, focusing on the simultaneous management of caloric excess and the modulation of systemic inflammation through evidence-based anti-inflammatory dietary patterns. Moreover, future longitudinal research is essential to elucidate the postoperative dynamics of the Neutrophil-to-Lymphocyte Ratio (NLR) and its potential as a robust biomarker for tracking weight loss velocity and the long-term resolution of obesity-related comorbidities.

5. Conclusion

In conclusion, body composition measurements and sleep apnea risk independently distinguished super-morbid from morbid obesity among bariatric surgery candidates. Higher fat body percentage revealed as the most powerful predictor, emphasizing the importance of excess adiposity beyond BMI classification alone. The independent association of the STOP-BANG score underscores the direct relationship between obesity severity and obstructive sleep apnea risk. Overall, our data support the incorporation of body composition analysis and sleep apnea assessment into preoperative risk classification for individuals with extreme obesity. Ultimately, addressing these metabolic and dietary drivers at national referral centers like Institut Kanser Negara is essential for optimizing surgical readiness and improving long-term clinical outcomes for high-risk bariatric patients.

Author contributions

Conceptualization, H.C.Y; methodology, H.C.Y.; data collection: N.W.S.Z.N; formal analysis, N.W.S.Z.N & H.C.Y.; investigation, N.W.S.Z.N & H.C.Y.; writing—original draft, N.W.S.Z.N.; writing—review and editing, H.C.Y & Z.A.M.D.; supervision, H.C.Y & Z.A.M.D. All authors have read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

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