Obesity, cellulitis, and lymphoedema severity: A retrospective analysis of risk and resource inequity in UK specialist services

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Key words

BMI, cellulitis, lymphoedema, obesity, self-management

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Abstract

Background: Lymphoedema is a chronic, progressive condition marked by impaired lymphatic drainage and recurrent cellulitis. Obesity is increasingly recognised as both a cause and consequence of lymphatic dysfunction, yet its effects on disease severity, infection risk, and engagement with care remain underexplored. **Aims:** To assess the relationship between body mass index (BMI), cellulitis incidence, and lymphoedema severity, with secondary analysis of pain scores, self-management participation, and regional variation. **Methods:** A retrospective cohort study was undertaken using anonymised data from adult lymphoedema patients across two NHS Trusts in Southeast England. Variables included BMI, International Society of Lymphology (ISL) staging, cellulitis history, pain scores, and self-management. Analyses involved chi-square, Kruskal–Wallis, logistic regression, and multiple imputation for missing data. **Results:** Higher BMI was significantly associated with increased cellulitis incidence ($\chi^2 = 59.84$, $p < 0.0001$) and more advanced ISL stage (χ^2, $p = 2.07 \times 10^{-11}$). Increasing BMI was inversely associated with high self-management participation (severe obesity: OR 0.34; 95% CI [0.23–0.49]; $p < 0.0001$). Pain severity was not associated with cellulitis or ISL stage. **Conclusion:** Obesity worsens lymphoedema outcomes and complicates care. These findings challenge the use of BMI-based criteria to exclude patients from treatment or specialist services and support more inclusive, multidisciplinary models.

Lymphoedema is a chronic, progressive condition characterised by lymphatic insufficiency, resulting in the accumulation of protein-rich interstitial fluid. This leads to tissue fibrosis, swelling, and a heightened risk of cellulitis, a serious bacterial skin infection that often necessitates hospitalisation (Rockson, 2022). Though most commonly affecting the limbs, lymphoedema can involve the trunk, head, or genitals and substantially impairs quality of life (Moffatt et al, 2003).

Secondary lymphoedema is acquired following damage to the lymphatic system, for example from cancer treatment, injury or filariasis (Grada and Phillips, 2017). In the UK, it affects up to 400,000 individuals, with prevalence rising due to ageing and obesity (National Lymphoedema Partnership, 2019). Obesity-induced lymphoedema arises from both mechanical compression of lymphatics and cytokine mediated inflammation, leading to structural lymphatic dysfunction (Harvey et al, 2005). Clinical imaging confirms that individuals with BMI >60 kg/m^2 show lymphatic impairment in the vast majority of cases (Harvey et al, 2005). Cohort studies have identified a strong association between obesity and advanced lymphoedema staging (Burian et al, 2024).

Obesity also markedly increases cellulitis risk. A recent meta-analysis found that individuals with obesity have approximately 2.7-fold higher odds of cellulitis compared with non-obese controls, underscoring the roles of systemic inflammation and impaired local immune systems (Taira et al, 2024). Cellulitis episodes not only exacerbate lymphatic injury, but also impede recovery and mobility, reinforcing a self-perpetuating disease cycle.

In clinical practice, patients with lymphoedema frequently report pain, reduced mobility and psychological distress, particularly when obesity is also present (Harvey et al, 2005). Despite this known burden, UK lymphoedema services often exclude patients with severe obesity due to rigid BMI thresholds, contravening equity principles outlined in national commissioning guidance (National Lymphoedema Partnership, 2019; Taira et al, 2024).

Aim

This study aimed to evaluate the relationship between BMI, cellulitis, and lymphoedema severity (ISL stage) in a UK cohort, with secondary analyses examining pain, self-management participation, and regional variation in outcomes. By exploring these interactions in a real-world setting, the study seeks to inform the development of inclusive, multidisciplinary lymphoedema care models that reflect current patient

needs and practice realities.

Methods

Study design

This retrospective cohort study used anonymised clinical data from adult patients with lymphoedema treated at two specialist NHS services insoutheast England. The study investigated associations between BMI, cellulitis incidence, lymphoedema severity (ISL stage) and secondary outcomes, including pain, self-management, and regional variation.

Data sources and participants

Data were extracted from routinely collected clinical records at East Sussex Healthcare NHS Trust and Sussex Community NHS Foundation Trust.

Included patients were ≥18 years with a confirmed diagnosis of primary or secondary lymphoedema within a specialist lymphoedema service and complete data on BMI, cellulitis history, and ISL stage. Patients with head or neck cancer or less than 12 months of clinical history were excluded.

Demographic (age, sex), clinical (BMI, ISL stage, pain score, cellulitis history), and comorbidity data were recorded. Self-management participation was assessed via documented use of compression, skin care, and exercise. Data were cleaned and recoded; missing values were addressed using multiple imputation.

Variables

BMI was classified using WHO (2000) criteria. ISL staging (Stages I–III) defined lymphoedema severity. Cellulitis history was binary (yes/no). Pain was recorded on a 0-10 scale and grouped as low (0-3), moderate (4-7), or severe (8-10).

Statistical analysis

Analysis was performed using R version 4.4.2. Descriptive statistics summarised cohort characteristics. χ^2 and Kruskal–Wallis tests assessed associations between categorical and continuous variables, respectively. Correlation analysis (Pearson or Spearman) examined relationships between BMI, pain and ISL stage.

Logistic regression was used to model binary outcomes (e.g. cellulitis, self-management), adjusting for age, sex and comorbidities. ANOVA was used for group comparisons across sites. A p-value of <0.05 was considered statistically significant.

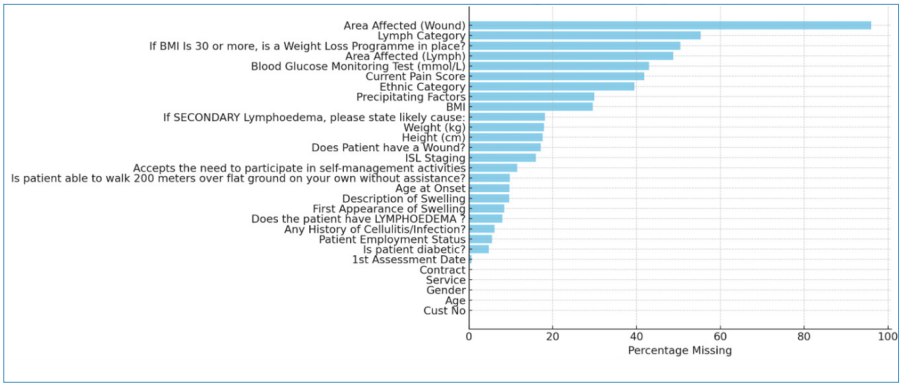

Figure 1. Distribution of missing data in the lymphoedema overview.

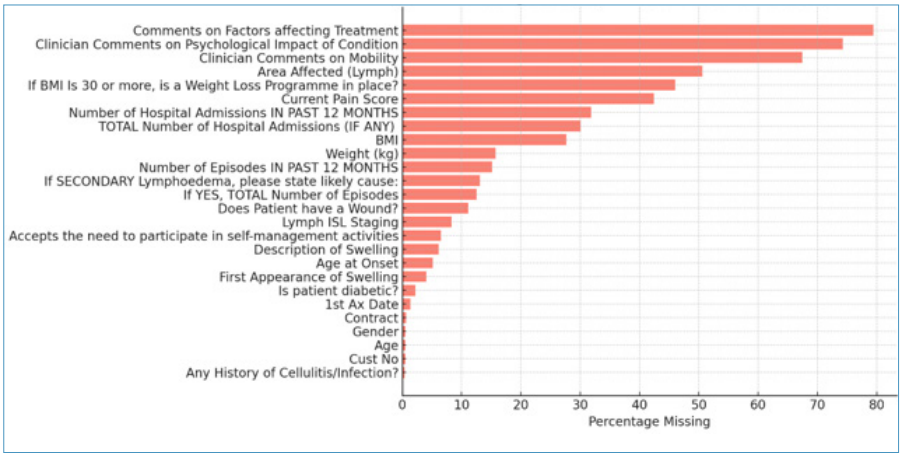

Figure 2. Distribution of missing data (%) in the cellulitis cohort.

Ethics

Ethical approval was granted by the University College London Ethics Committee. All data were anonymised and handled in accordance with the Data Protection Act 2018 and GDPR.

Results

Missing data

Of the 2,062 patients in the full dataset, 430 (21%) were excluded from BMI-related analyses due to missing height and/or weight. Cellulitis status was missing in 6 % of the full cohort, and 3% of the BMI subset.

The Lymphoedema Overview dataset was the most complete, with low missingness for age, gender, contract site, and ISL stage. However, pain score (~40%), BMI (~35%), and self-management data (~40–50%) were frequently incomplete.

The cellulitis cohort dataset had more than 70% of free-text clinical notes missing and around 35–40% of BMI and pain missing. Cellulitis outcomes were well recorded.

The Patient Information Management System (PIMS) dataset was extracted from the service's electronic clinical record; however this contained several empty fields and had 20–30% missing for key variables, including BMI, pain, and cellulitis. Variables with more than 50% missing were excluded. Summary graphs are shown in *Figure 1* (overview dataset) and *Figure 2* (cellulitis cohort).

Relationship between age, BMI, and cellulitis

The incidence of cellulitis increased progressively with BMI. Among patients with normal BMI, 35.5% had a history of cellulitis, rising to 40.6% in the overweight group, 47.6% in the obese group, and peaking at 63.1% in those with severe obesity. A chi-square test for independence confirmed a statistically significant association between BMI category and cellulitis incidence (χ^2 = 59.84, df = 3, p < 0.0001), demonstrating a robust dose–response relationship.

Figure 3 highlights the sharp increase in cellulitis burden among patients with morbid obesity, reinforcing the critical

role of BMI as a modifiable risk factor in lymphoedema-related infection risk.

Relationship between BMI and ISL stage

ISL stage distribution varied significantly across BMI categories. Patients with severe obesity were more likely to present with Stage II or Stage III lymphoedema, whereas those with normal BMI were more likely to be in Stage I.

A χ^2 test confirmed a statistically significant association between BMI category and ISL lymphoedema staging ($p=2.07\times10^{-11}$). This indicates that the distribution of disease severity is not independent of BMI, although it does not imply a directional trend.

A Spearman's rank correlation was also performed to assess monotonic relationships between BMI and ISL stage. A weak, but statistically significant, positive correlation was observed ($\rho=0.201$; $p=1.38\times10^{-13}$), suggesting that higher BMI is associated with more advanced lymphoedema.

The ISL stage distribution by BMI category is presented in *Figure 4*.

Relationship between pain severity and ISL lymphoedema staging

Pain severity was assessed across ISL stages I–III. Most patients in all groups reported low pain (0–3), with 55.9% in Stage I, 60.0% in Stage II, and 55.3% in Stage III. The proportion reporting severe pain (8–10) was slightly higher in Stage III (13.2%) compared to Stage I (9.8%) and Stage II (10.0%).

Despite this trend, a Kruskal-Wallis test showed no statistically significant difference in pain scores across ISL stages ($H=1.98$, $p=0.372$), indicating that ISL staging is not strongly associated with pain severity in this cohort.

Relationship between pain and cellulitis

The proportion of patients with a history of cellulitis was similar across all pain categories: 33.6% in those with low pain, 34.2% in moderate pain, and 35.8% in severe pain. A χ^2 test revealed no statistically significant association between pain severity and cellulitis incidence ($\chi^2=0.23$, $p=0.894$).

These results indicate that pain intensity is not a useful predictor of cellulitis risk in this cohort. This may reflect the multifactorial nature of pain in lymphoedema, which can be influenced by fibrosis, limb heaviness, and psychological factors, rather than by infection alone (Grada and Phillips, 2017).

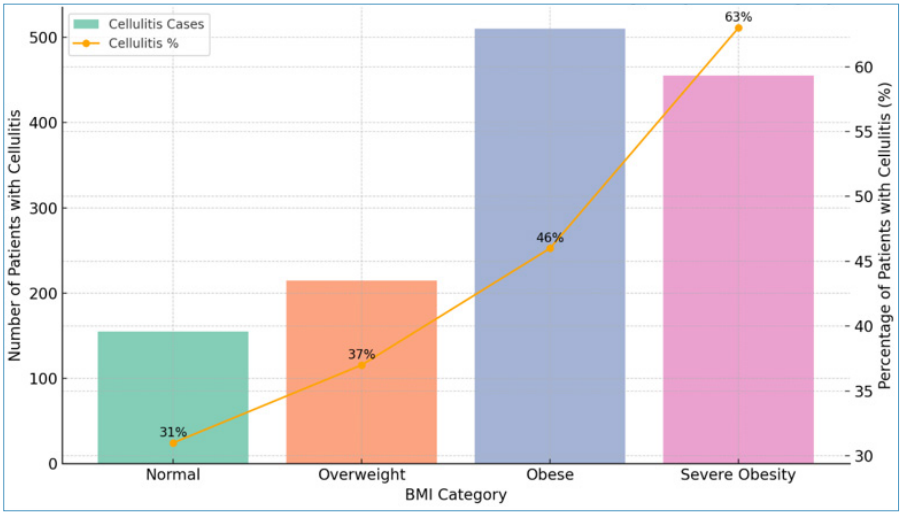

Figure 5. Combined distribution of cellulitis cases and percentages by BMI.

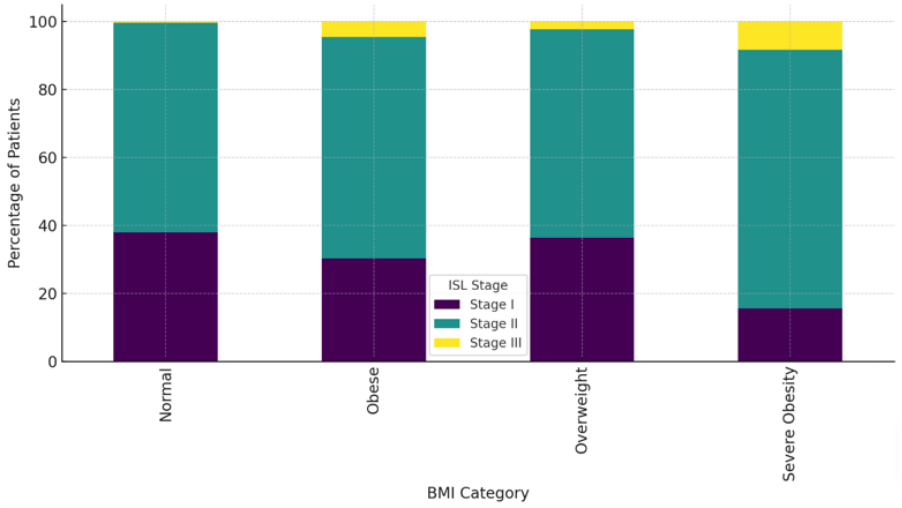

Figure 4. ISL lymphoedema staging distribution by BMI.

Relationship between BMI and self-management participation

There was a clear trend showing reduced self-management engagement as BMI increased. Among patients with normal BMI, 75.1% reported high self-management, compared to 69.0% in the overweight group, 63.8% in the obese group, and only 52.7% in those with severe obesity. This shift towards medium and low engagement is visualised in *Figure 5*.

A χ^2 test confirmed a significant association between BMI category and self-management level ($\chi^2=52.41$; d.f.=9; $p<0.000001$), indicating that the observed distribution was unlikely to have occurred by chance.

To further assess the relationship, a logistic regression model was fitted with high self-management (versus not high) as the binary outcome. Compared to patients with normal BMI, those with obesity had 48% lower odds of reporting high self-management (OR=0.52; 95% CI [0.37–0.74]; p=0.0002), while those with severe obesity had 66% lower odds (OR = 0.34, 95% CI: 0.23–0.49, p<0.0001). Results are summarised in *Table 1*.

These findings suggest that individuals with higher BMI are significantly less likely to engage in high levels of self-care, potentially due to physical limitations, comorbidities, or psychological factors such as stigma and low motivation. This insight is crucial for tailoring interventions and identifying high-need groups for targeted support.

Relationship between duration of oedema and clinical outcomes

Oedema duration was determined using a combination of structured onset data and patient-reported history. Participants were grouped into three categories: less than 1 year, 1–5 years, and more than 5 years. The clinical significance of this temporal stratification was then explored across three key parameters: BMI, pain severity and ISL lymphoedema staging.

BMI increased significantly with longer disease duration (Kruskal-Wallis H=64.93; p<0.0001). Patients in the >5 years group had the highest median BMI (35.1), while those with oedema for <1 year had the lowest (29.1). This trend suggests either that obesity may predispose individuals to more chronic lymphatic dysfunction, or that longer standing lymphoedema may itself be exacerbated by reduced mobility and metabolic changes associated with high BMI. This association is illustrated in *Figure 6*, which clearly shows a rightward shift in BMI distribution as duration increases.

Pain scores did not differ significantly across duration groups (Kruskal-Wallis H=3.14; p=0.208). Median scores were stable across all categories (ranging from 2.0 to 3.0), suggesting that pain intensity is not directly influenced by the chronicity of swelling. This may reflect a degree of adaptation or variability in individual pain experiences and challenges the notion that more longstanding lymphoedema is inherently more painful.

The distribution of pain scores is visualised in *Figure 7*, which shows overlapping interquartile ranges across all three groups.

A statistically significant difference in ISL staging was observed between duration groups (Kruskal-Wallis H= 7.11; p=0.029). Interestingly, all three groups shared the same median stage (Stage I), suggesting that the difference arose from changes in distribution rather than central tendency.

This is consistent with the hypothesis that cumulative lymphatic dysfunction over time may contribute to subtle disease progression, even when median values remain unchanged.

In summary, while pain intensity appears unaffected by duration of oedema, both BMI and ISL staging show associations with chronicity. Notably, the staging results highlight the importance of examining full distribution patterns rather than relying solely on median values, a point reinforced through the inclusion of both violin and boxplot visualisations.

Cellulitis history was also associated with oedema duration (p=0.0011), with the highest proportion of cellulitis seen in the >5 years group. This finding supports the view that prolonged lymphatic dysfunction increases infection risk.

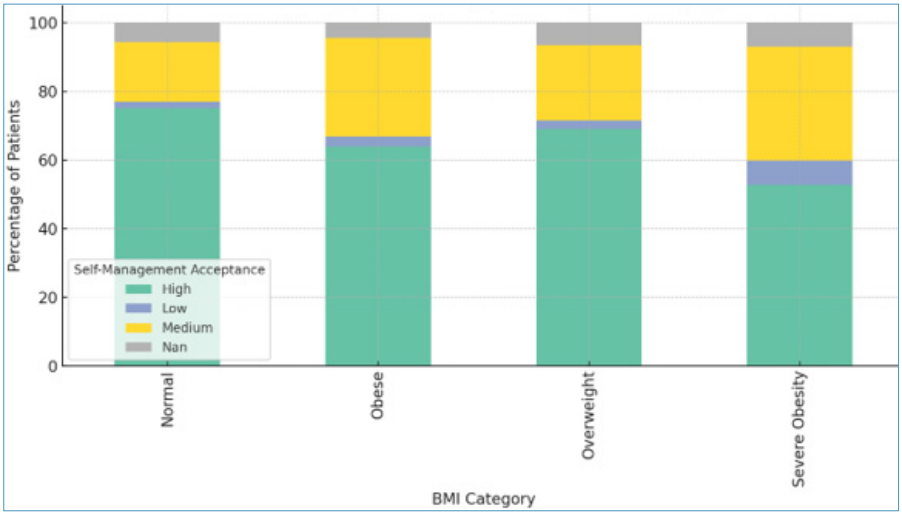

Figure 5. Self-management acceptance stratified by BMI.

Table 1. Odds of high self-management participation by BMI category.

BMI	*OR*	*95% CI*	*p-value*
Normal (reference)	1.00	–	–
Overweight	0.73	0.49–1.09	0.122
Obese	0.52	0.37–0.74	0.0002
Severe obesity	0.34	0.23–0.49	<0.0001

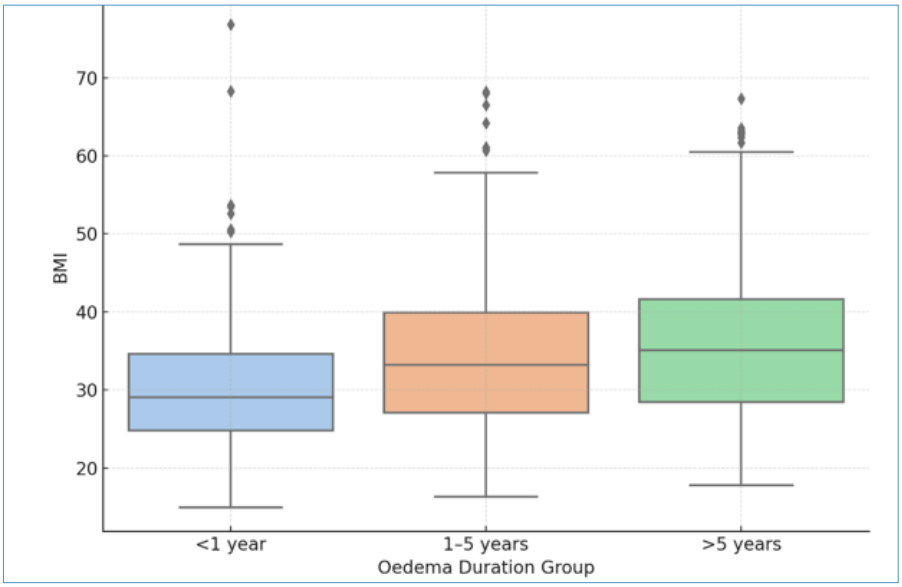

Figure 6. Boxplot of BMI by oedema duration. Median BMI increases across the three groups, with outliers present in each category.

Relationship between age and ISL lymphoedema staging

ISL stage was converted into ordinal numeric values for analysis (*Table 2*).

A Spearman rank correlation was performed to evaluate the association between patient age and ISL lymphoedema staging. A weak but statistically significant positive correlation was observed ($\rho = 0.152$, $p = 2.25 \times 10^{10}$), indicating

a tendency for higher ISL stage with increasing age.

The scatterplot illustrating the relationship between age and ISL stage is presented in Figure 8.

This is consistent with disease progression and impaired lymphatic recovery with age, as lymphatic vessel contractility and repair capacity are known to decline over time (Grada and Phillips, 2017).

Discussion

This study demonstrates a clear association between obesity and both cellulitis risk and lymphoedema severity. Higher BMI was strongly associated with advanced ISL staging and a higher likelihood of previous cellulitis, showing a robust dose–response relationship. These findings are consistent with the LIMPRINT study, which found that obesity was associated with more advanced lymphoedema staging and a greater likelihood of cellulitis in the preceding 12 months (Burian et al, 2024).

Importantly, these results question current service protocols that restrict access to lymphoedema treatment based on BMI. National standards call for equitable and accessible lymphoedema care irrespective of weight or BMI (British Lymphology Society, 2016).

They may benefit from timely intervention focused not just on limb volume, but also on preventing cellulitis and maintaining function. A UK service evaluation found that specialist-supported education and lymphoedema management were associated with reduced cellulitis admissions (Thomas et al, 2024).

Such insights support emerging clinical practice guidelines (e.g. the All-Ireland Lymphoedema Guidelines), which advocate for BMI-inclusive care pathways (Lymphoedema Network Northern Ireland and Health Service Executive, 2022). These combine compression, exercise, and skin care with weight management support. Services must avoid rigid exclusions and instead tailor interventions using bariatric equipment, adapted compression, and multidisciplinary teams including dietitians, physiotherapists, and psychologists.

Pain did not significantly differ by ISL stage or cellulitis status. This finding aligns with literature suggesting pain in lymphoedema is multifactorial, involving not only swelling but fibrosis, neuropathy, and mental health (Harvey et al, 2005). As such, pain management should be personalised, addressing physical and psychological contributors.

Self-management participation declined markedly with increasing BMI. Physical challenges, low mood, and stigma may reduce motivation and capability. Logistic regression confirmed that patients with severe obesity were significantly less likely to engage in high-level self-care. Interventions such as tailored education, peer support, and digital tools could help improve engagement. NHS England's Long-term Plan calls for personalised care and self-management support goals

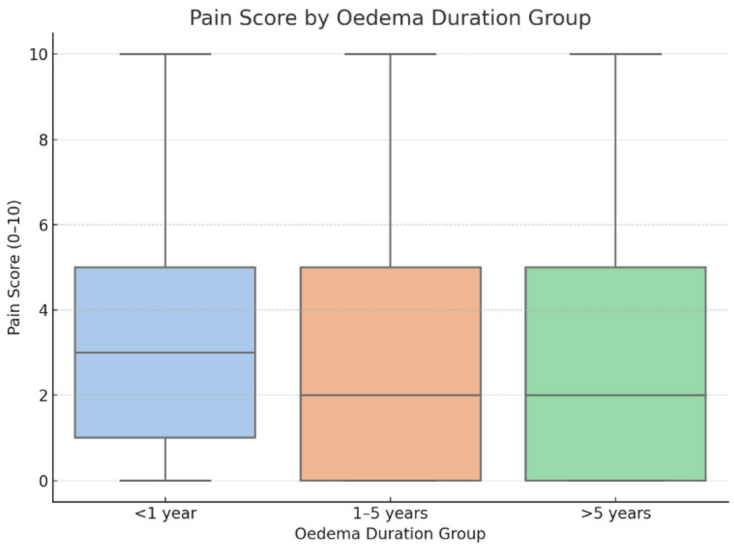

Figure 7. Boxplot of pain scores by oedema duration .

Table 2. ISL stage mapped to ordinal values for statistical comparison.

ISL Stage	Ordinal value
Stage 0	0
Stage I	1
Stage II	2
Stage – Late II	2.5
Stage III	3

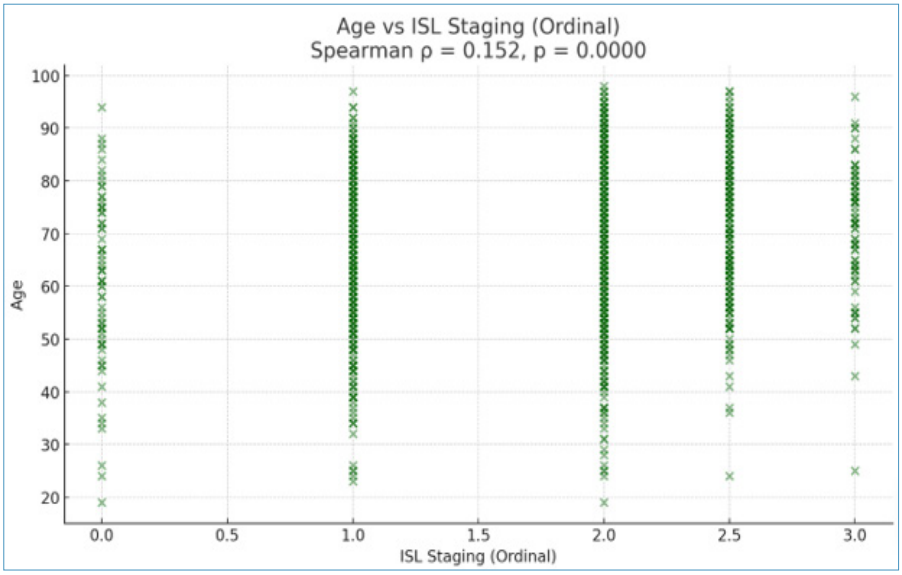

Figure 8. Scatterplot of age (years) versus ISL lymphoedema staging (ordinal).

particularly relevant for this group.

Duration of oedema was associated with higher BMI and cellulitis history, supporting lymphoedema's progressive nature. Patients with >5 years of swelling were more likely to have complications, underscoring the importance of early diagnosis. Existing evidence supports the value of prompt intervention to prevent chronic progression (Burian et al, 2024). Policy initiatives should prioritise early identification in at-risk populations, such as cancer survivors, to interrupt disease escalation.

Limitations

This study is limited by its retrospective design and reliance on clinical documentation. Missing data particularly on BMI, pain, and self-management may have introduced bias. Although multiple imputation was used, some degree of measurement error is likely. The analysis was cross-sectional, precluding causal inference between obesity and disease progression. Additionally, potential confounders such as smoking, diabetes, and deprivation were not captured. These factors may influence both BMI and infection risk. Lastly, generalisability may be limited, as all patients were drawn from specialist services in one UK region.

Clinical and policy implications

Findings support a shift towards integrated lymphoedema–obesity services. Patients with high BMI should not be excluded but instead prioritised for multidisciplinary care that addresses physical, psychological, and behavioural challenges. Early cellulitis prevention: including education and possibly antibiotic prophylaxis may reduce admissions. NICE advises against routinely offering antibiotic prophylaxis to prevent recurrent cellulitis or erysipelas. For adults who have received treatment in hospital or under specialist advice for at least two separate episodes in the preceding 12 months, a specialist may consider a trial of prophylaxis following discussion with the patient (NICE, 2019). Cost savings from reduced hospitalisations are likely to be substantial. Services should also prepare for increased demand as obesity rates rise.

Conclusion

This study provides clear evidence that obesity significantly exacerbates the clinical trajectory of lymphoedema, increasing the risk of cellulitis and complicating patient self-management. Elevated BMI emerged as a key modifiable risk factor, with patients in the highest weight category experiencing more frequent and severe infections. These findings challenge current service exclusions based on BMI and reinforce the clinical need for inclusive, multidisciplinary care models.

Crucially lymphoedema management should address underlying adiposity, not merely its effects. Patients with severe obesity require tailored interventions focused on infection prevention, functional maintenance, and self-care support. From a health system perspective, integrated lymphoedema–obesity services offer the potential to reduce avoidable hospital admissions and enhance quality of life.

Despite the value of these findings, several questions remain. The reversibility of obesity-induced lymphoedema through weight loss and the efficacy of anti-inflammatory or lymphangiogenic therapies warrant further study. Likewise, research into scalable, patient-centred models to improve engagement; particularly among those facing stigma and functional barriers is urgently needed.

As obesity prevalence rises, lymphoedema care must evolve to meet changing population needs. A proactive, equitable approach will be essential to ensure no patient is left behind due to body weight.

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