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Estimating the hospitalisation burden of obesity in Europe: evidence from the European health interview survey (EHIS) wave 3

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Abstract

Background Obesity represents a significant public health and economic challenge across Europe, driving an increased chronic disease burden and increased hospital utilisation. Despite this impact, cross-national evidence quantifying obesity's hospitalisation burden remains sparse, and there is only a limited understanding of the potential cost savings achievable through obesity prevalence reduction.

Methods We analysed European Health Interview Survey (EHIS) Wave 3 (2019) data, encompassing adults aged 18 years and older across eight countries (Belgium, the Netherlands, Germany, Luxembourg, Spain, Italy, Portugal and Denmark). Our primary outcome was the number of hospital nights in the preceding 12 months. We employed negative binomial regression models with zero-inflated specifications to estimate the associations between hospitalisation and body mass index (BMI), alongside sociodemographic, health and lifestyle factors. Simulations were used to project the impacts of a 1% obesity prevalence reduction on hospital expenditures.

Results Compared to normal weight, obesity and underweight were strongly associated with increased hospital nights (IRR = 1.19 and 1.92, respectively), while pre-obesity showed no such association. Hospitalisation increased markedly with age, whereas higher education and income provided protective effects in this regard, reducing stays by 7% and 8%, respectively. Hypertension, diabetes and depressive symptoms substantially elevated hospital utilisation, while physical activity reduced it by 28%. Regional variation emerged, with Southern and Northern Europe reporting lower rates than Western Europe. A 1% obesity prevalence reduction would yield €4.27 billion in annual savings, representing 1.71% of combined hospital budgets.

Conclusions Obesity and underweight significantly increase hospitalisation across Europe, placing substantial strain on health systems. Preventive strategies that promote healthy weight, physical activity and mental health could markedly reduce hospital demand and generate major economic savings. Even modest reductions in obesity prevalence offer strong health and fiscal benefits, underscoring the importance of sustained investment in prevention-focused public health policies intended to increase equity and healthcare sustainability across European countries.

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Keywords Hospitalisation, Obesity, European Health Interview Survey (EHIS), Healthcare utilisation, Cross-country analysis

Background

Obesity has become a persistent public health challenge, and it has far-reaching effects on morbidity, mortality and healthcare financing [1, 2]. In high-income countries, the prevalence of obesity has reached striking levels; by the early 2000s, about two-thirds of American adults already had overweight or obesity, and similar trends have been observed across Europe [3]. The economic burden is substantial, with obesity accounting for 5.5–7% of health expenditures in the US [4] and 0.7%–2.8% of health expenditures in other countries [5]. In Europe, medical costs for individuals with obesity are estimated to be roughly 30% higher than those for normal-weight individuals [6], and in the UK, direct healthcare costs attributable to overweight and obesity were estimated at approximately £5.1 billion in 2006–07 [7].

Looking ahead, projections indicate a steep increase in burden of obesity and overweight. By 2050, if current trends continue, an estimated 3.80 billion adults aged 25 years and older will have overweight or obesity, of whom approximately 1.95 billion will have obesity, meaning nearly two in three adults will be affected. The global age-standardised prevalence of overweight and obesity is expected to increase by about 30.7% over the next three decades [8]. Beyond the associated financial costs, obesity is closely linked to chronic conditions such as cardiovascular disease, diabetes and certain cancers, which frequently require inpatient care [9]. These comorbidities increase the likelihood of hospital admission and contribute to longer stays. For example, in Portugal, inpatient care represents 28% of total health expenditure, and the average hospital stay was 9.4 days in 2020 [10]. As European health systems face rising demand and constrained resources, quantifying how obesity contributes to hospitalisation is essential for planning and resource allocation [11].

Evidence from research in European countries consistently confirms the substantial hospitalisation burden associated with obesity. For example, in Italy, individuals with severe or complicated obesity experience markedly higher hospitalisation rates than the general population, with standardised hospitalisation ratios exceeding three for both all-cause admissions and obesity-related conditions. These elevated rates translate into substantial inpatient costs, which are largely driven by cardiometabolic, respiratory, musculoskeletal and mental health comorbidities [12]. Similar evidence emerges from Portugal, where nationwide population-based data show that obesity is associated with a higher likelihood of hospitalisation and increased inpatient expenditures. Obesity-related hospitalisations account for a significant share of total inpatient costs, with this association being partially mediated by multimorbidity [13]. Comparable patterns have also been documented in other Western European countries. In Belgium, health-related economic modelling indicates that excess body weight substantially increases healthcare utilisation and long-term costs, while reductions in body mass index (BMI) are associated with sizeable savings in healthcare expenditures [14]. In Spain, population-based evidence shows that severe obesity ($BMI \geq 35$ kg/m²) is associated with a significantly higher probability of hospitalisation and greater healthcare resource utilisation. Individuals with severe obesity are approximately 40% more likely to be hospitalised than normal-weight adults [15]. Likewise, in Germany, analyses based on health insurance claims data demonstrate that obesity is associated with substantially higher healthcare utilisation and costs across an individual's lifecycle. The annual direct healthcare costs attributable to obesity exceed €29 billion and increase sharply for obesity severity, reflecting the elevated use of inpatient and other healthcare services among individuals with obesity [16].

Governments and health organisations have responded by promoting prevention strategies, from behavioural counselling and community programmes to digital lifestyle interventions (DLIs) that use smartphones, apps and online coaching to encourage healthy behaviours [17, 18]. While DLIs offer scalability and reach, their capacity to reduce hospital use has been insufficiently evaluated. Evidence linking prevention to inpatient care is limited, with much of it being derived from the US and focusing on admissions, rather than hospital nights [19, 20], and only a few studies examine outcomes across BMI categories [21]. European evidence remains fragmented and largely country specific, leaving uncertainty about system-wide impacts on hospital resource usage [22].

To address this gap, we use harmonised data derived from the European Health Interview Survey (EHIS) 2018–2020 (Wave 3) to estimate the hospitalisation burden of obesity across eight European countries. We analyse self-reported hospital nights in relation to BMI categories, controlling for sociodemographic characteristics, chronic conditions and lifestyle behaviours. In addition, we simulate counterfactual scenarios to estimate potential reductions in hospital nights and associated costs given a lower obesity prevalence. By quantifying the link between obesity and inpatient care at a multi-country level, this study provides policy-relevant evidence on potential savings from prevention and underscores the value of comprehensive strategies, including DLIs and community programmes, that can improve health outcomes while easing the pressure on health systems.

Methods

Study design and data source

The study uses cross-sectional data derived from the EHIS Wave 3 (2018–2020), which were collected across eight European countries: Belgium, the Netherlands, Germany, Luxembourg, Spain, Italy, Portugal and Denmark. All data for key variables, including BMI, chronic disease status and hospital utilisation, are derived from self-reported information collected through standardised questionnaires. The EHIS is a harmonised, cross-national survey coordinated by Eurostat [23] and designed to collect comparable health-related data across EU member states. It targets the non-institutionalised population aged 15 years and older, utilising computer-assisted personal interviews (CAPIs) to gather information on a wide range of themes, including health status, chronic conditions, lifestyle behaviours, socioeconomic circumstances and healthcare utilisation.

Table 1 Description of study variables

Variable	EHIS code	Description
Number of hospitalisation nights	HO12	Total number of nights spent in hospital in the past 12 months; count variable used as the main outcome
Body mass index	BMI[2]	Body mass index is grouped as underweight, normal, overweight, or obesity based on height and weight.
Sociodemographic		
• Age group	AGE[1]	Age is classified into five groups: 18–24, 25–34, 35–44, 45–64, and 65+.
• Gender	SEX	Biological sex is coded as 1 for male and 0 for female.
• Education level	HATLEVEL	Highest level of education completed, following ISCED codes from 0 (pre-primary) to 8 (doctorate).
• Income quintile	HHINCOME	Net monthly equivalised income of the household categorised into five quintiles: 1 = lowest, 5 = highest.
• Region	COUNTRY	EU macro-region classification of countries: Western, Southern, or Northern Europe.
Underlying health condition		
• Hypertension	CD1E	Indicates whether the respondent was ever diagnosed with hypertension: (1 = yes, 0 = no).
• Diabetes	CD1J	Indicates whether the respondent was ever diagnosed with diabetes: (1 = yes, 0 = no).
• Depressive symptoms	CD1O	Self-reported experience of depressive symptoms: (1 = yes, 0 = no).
Lifestyle		
• Physical activity	PE3	Time spent walking per day (0 = No time, 1 = 10–29 min per day, 2 = 30–59 min per day, 3 = 1 h to less than 2 h per day, 4 = 2 h to less than 3 h per day, and 5 = 3 h or more per day
• Smoking habit	SK1	Smoking status: 1 = current smoker, 0 = non-smoker.

[1]Computed based on the variables YEARBIRTH and PASSBIRTH

[2]Computed based on the variables BM1 and BM2

Study variables

The study includes a set of explanatory variables that capture the key dimensions of individual characteristics and health determinants. These variables are grouped into three categories: sociodemographic factors (age, gender, education, income and region), underlying health conditions (high blood pressure, diabetes and depressive symptoms), and lifestyle behaviours (smoking and physical activity). The main outcome variable is the number of nights spent in hospital over the past 12 months, which is measured as a count variable. A detailed description of all variables and their corresponding EHIS code names is provided in Table 1.

The selection of lifestyle behaviour variables was guided by theoretical relevance, prior empirical evidence and considerations of cross-country comparability. For example, physical activity and smoking were included because of their well-established associations with obesity-related morbidity and healthcare utilisation, including hospitalisation risk [24–26]. In addition, these behaviours are measured in a relatively harmonised manner across participating countries in EHIS Wave 3, enhancing comparability in a cross-national context. Depressive symptoms were included as an underlying health condition due to robust evidence documenting a bidirectional relationship between obesity and mental health, as well as their independent contribution to increased healthcare utilisation and hospitalisation [27].

Statistical analysis

Descriptive analyses were conducted to summarise the characteristics of the study population across countries. Frequencies and proportions were calculated for all categorical variables, while means, standard deviations and minimum and maximum values were reported for continuous variables. These descriptive statistics were computed using IBM Statistical Package for the Social Sciences (SPSS) Statistics (Version 31).

The bivariate associations between hospitalisation (number of nights spent in hospital in the past 12 months) and each explanatory variable were examined using Chi-squared (χ^2) tests for categorical variables and t-tests for continuous variables. Given the high proportion of zero values for the dependent variable (approximately 89.7% of respondents reporting no hospitalisation), a negative binomial regression (nbreg) model was estimated, with a zero-inflated negative binomial (zinb) model being used as a robustness check [28]. Model comparisons between nbreg and zinb models were conducted using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) (Appendix 1 in Supplementary Material). Multicollinearity was assessed using the variance inflation factor (VIF).

All regression analyses and simulations were conducted using Stata Version 19, applying individual survey weights to account for the complex sampling design and ensure population representativeness. Statistical significance was evaluated at the 0.05, 0.01 and 0.001 levels. Variance estimation was performed using the Taylor series linearisation method. To maximise statistical power and ensure generalisable insights across countries, a pooled model was adopted. This approach enabled efficient estimation while accounting for regional differences and avoided the reduced precision and limited comparability associated with separate country-specific models.

Impact of obesity on healthcare expenditure

We estimated the potential impact of obesity on healthcare expenditures by simulating the cost savings associated with a hypothetical reduction in obesity prevalence, using results from the nbreg. The simulation compared the total number of hospital nights before and after a 1% reduction in obesity prevalence based on country-level data on population size, average length of hospital stay and per-night hospitalisation costs. Hospital utilisation was adjusted using obesity-related and region-specific incidence rate ratios. The difference in total hospital nights attributable to the reduction in obesity prevalence was then multiplied by the country-specific cost per hospital night to obtain an estimate of potential healthcare savings.

Results

Descriptive results

A total of 134,623 individuals from eight European countries were included in the study (Table 2). Across all countries, the 45–64 age group accounted for the largest proportion of respondents, followed by those aged 65 and older. The gender distribution was relatively balanced in most countries, although women slightly outnumbered men, especially in Portugal and Denmark (56.7% and 56.8%). Educational attainment varied widely: Germany and Luxembourg had the highest shares of respondents with a tertiary education (50.7% and 47.7%), while Portugal reported the lowest share in this regard (16.4%). Household income was evenly distributed across the quintiles by design, although Germany had the highest proportion of respondents in the upper quintile (29.9%).

Regarding health status, the prevalence of obesity ranged from 11.6% in Italy to 19.6% in Portugal. Hypertension and diabetes were also most prevalent in Portugal (35.3% and 13.8%, respectively), and depressive symptoms were highest in that country as well (15.1%). Overall, 46.1% of the sample had a normal BMI, 34.7% were classified as having pre-obesity and 16.3% were classified as having obesity (Table 2). Table 3 summarises the descriptive statistics for all variables included in the pooled model. On average, individuals reported 0.88 hospital nights over the past 12 months, with a standard deviation of 5.97, reflecting a highly skewed distribution. The mean BMI was 25.68, and the average age group code was 3.77, corresponding to middle-aged adults. Physical activity was reported by 38% of respondents, while 21% were current smokers. The prevalences of depressive symptoms, diabetes and high blood pressure were 37%, 8% and 8%, respectively.

Model diagnostics

The multicollinearity test using the VIF shows that all variables have values well below the commonly accepted threshold of 5 [29], with a mean VIF of 1.13 (Appendix 2 in Supplementary Material). The highest VIF observed was 1.28 for education level, and the lowest was 1.03 for mental health and smoking status, indicating very low correlation among the predictors. These results suggest that multicollinearity is not a concern in the negative binomial regression [29].

Model fit and selection

To determine the magnitude of the associations, we fitted negative binomial multivariate regression models. The choice of the nbreg is supported by the distribution of the dependent variable (number of nights spent in hospital over the past 12 months). Descriptive statistics indicated clear signs of overdispersion, with a mean of 0.88 and a variance of 35.68 (Table 3). This discrepancy violates the core assumption of the Poisson model, which requires the mean and variance to be approximately equal [30]. In addition, the distribution was highly skewed, with a skewness value of 31.12, and exhibited extreme kurtosis, at 1,513.47. These values suggest the presence of unobserved heterogeneity and excess variability. Under such conditions, the Poisson model will underestimate standard errors and yield biased inference [31, 32]. The negative binomial model, by contrast, incorporates a dispersion parameter that accounts for overdispersion, making it a more appropriate and reliable choice for modelling count data of this nature [33].

Multivariate findings

Table 4 presents the results of the negative binomial regression, which estimated the predictors of the number of nights spent in hospital over the past 12 months. Model diagnostics indicated a good overall fit. The survey-weighted model was compared to the

Table 2 Sample composition by country, reported as absolute frequencies and percentages

Characteristics		BE (n = 9,644)	NL (n = 8,194)	DE (n = 23,001)	LU (n = 4,504)	ES (n = 22,072)	IT (n = 45,962)	PT (n = 14,617)	DK (n = 6,629)
BMI, kg/m^2									
• Underweight		297 (3.1%)	213 (2.6%)	415 (1.9%)	121 (2.9%)	399 (2.0%)	1,778 (3.9%)	230 (1.6%)	127 (2.0%)
• Normal weight		4,506 (47.5%)	3,937 (48.4%)	9,816 (44.4%)	1,952 (47.4%)	8,722 (43.1%)	23,475 (52.0%)	5,671 (40.3%)	2,926 (47.0%)
• Pre-obesity		3,194 (33.7%)	2,824 (34.7%)	8,027 (36.3%)	1,325 (32.2%)	7,878 (38.9%)	14,920 (33.0%)	5,485 (39.0%)	2,120 (34.1%)
• Obesity		1,494 (15.7%)	1,154 (14.2%)	3,875 (17.5%)	719 (17.5%)	3,238 (16.0%)	4,991 (11.1%)	2,677 (19.0%)	1,046 (16.8%)
Age									
• 18–24		743 (8.0%)	673 (8.6%)	1,174 (5.2%)	359 (8.2%)	1,084 (5.0%)	3,502 (7.9%)	761 (5.3%)	462 (7.2%)
• 25–34		1,340 (14.4%)	1,149 (14.7%)	2,047 (9.0%)	655 (15.0%)	1,823 (8.5%)	4,731 (10.6%)	1,100 (7.7%)	645 (10.0%)
• 35–44		1,579 (16.9%)	1,146 (14.7%)	2,649 (11.7%)	870 (19.9%)	3,642 (16.9%)	6,271 (14.1%)	2,008 (14.0%)	778 (12.1%)
• 45–64		3,386 (36.3%)	2,786 (35.6%)	8,981 (39.5%)	1,728 (39.5%)	7,830 (36.3%)	16,266 (36.6%)	5,125 (35.7%)	2,397 (37.3%)
• 65+		2,282 (24.5%)	2,067 (26.4%)	7,857 (34.6%)	765 (17.5%)	7,194 (33.3%)	13,722 (30.8%)	5,347 (37.3%)	2,143 (33.4%)
Gender									
• Men		4,636 (48.1%)	4,007 (48.9%)	10,890 (47.3%)	2,076 (46.1%)	10,390 (47.1%)	21,868 (47.6%)	6,322 (43.3%)	2,861 (43.2%)
• Women		5,008 (51.9%)	4,187 (51.1%)	12,111 (52.7%)	2,428 (53.9%)	11,682 (52.9%)	24,094 (52.4%)	8,295 (56.7%)	3,768 (56.8%)
Education									
• No formal/Primary		972 (10.4%)	698 (8.7%)	308 (1.3%)	255 (5.9%)	6,322 (28.6%)	7,741 (16.8%)	7,255 (49.6%)	355 (5.8%)
• Secondary		4,867 (52.0%)	4,823 (59.8%)	10,993 (47.9%)	2,009 (46.4%)	9,625 (43.6%)	31,215 (67.9%)	4,972 (34.0%)	3,051 (49.5%)
• Higher		3,523 (37.6%)	2,538 (31.5%)	11,637 (50.7%)	2,064 (47.7%)	6,125 (27.8%)	6,995 (15.2%)	2,390 (16.4%)	2,758 (44.7%)
Net monthly income (quintiles)									
• 1 (lower income)		1,275 (15.6%)	1,267 (15.6%)	2,743 (12.2%)	685 (20.1%)	4,121 (18.8%)	8,355 (18.2%)	2,808 (19.2%)	1,073 (21.0%)
• 2		1,319 (15.3%)	1,169 (14.4%)	3,647 (16.2%)	804 (23.6%)	4,566 (20.8%)	9,084 (19.8%)	3,575 (24.5%)	952 (18.6%)
• 3		1,668 (19.4%)	1,646 (20.3%)	4,218 (18.7%)	681 (20.0%)	4,394 (20.0%)	9,026 (19.6%)	2,993 (20.5%)	914 (17.8%)
• 4		2,081 (24.2%)	1,953 (24.0%)	5,204 (23.1%)	756 (22.2%)	4,255 (19.4%)	9,896 (21.5%)	2,616 (17.9%)	1,204 (23.5%)
• 5 (higher income)		2,267 (26.3%)	2,091 (25.7%)	6,732 (29.9%)	481 (14.1%)	4,602 (21.0%)	9,601 (20.9%)	2,625 (18.0%)	978 (19.1%)
Country of birth									
• Native born		7,297 (75.8%)	7,291 (89.5%)	20,896 (91.1%)	2,257 (50.2%)	20,029 (90.7%)	42,282 (92.0%)	13,544 (92.7%)	6,084 (91.8%)
• EU born		1,048 (10.9%)	182 (2.2%)	949 (4.1%)	1,732 (38.6%)	480 (2.2%)	1,114 (2.4%)	222 (1.5%)	208 (3.1%)
• Non-EU born		1,286 (13.4%)	674 (8.3%)	1,082 (4.7%)	503 (11.2%)	1,563 (7.1%)	2,564 (5.6%)	837 (5.7%)	335 (5.1%)
Underlying health condition									
• Hypertension	Yes	1,756 (18.2%)	1,394 (17.1%)	6,797 (29.7%)	723 (16.5%)	5,506 (25.0%)	9,896 (22.0%)	5,027 (34.7%)	1,479 (23.0%)
	No	7,881 (81.8%)	6,773 (82.9%)	16,121 (70.3%)	3,658 (83.5%)	16,542 (75.0%)	35,102 (78.0%)	9,467 (65.3%)	4,951 (77.0%)
• Diabetes	Yes	612 (6.3%)	494 (6.0%)	2,062 (9.0%)	218 (5.0%)	2,090 (9.5%)	3,177 (7.1%)	1,968 (13.6%)	405 (6.3%)
	No	9,029 (93.7%)	7,699 (94.0%)	20,904 (91.0%)	4,135 (95.0%)	19,979 (90.5%)	41,821 (92.9%)	12,545 (86.4%)	6,015 (93.7%)

Table 2 (continued)

Characteristics		BE (n = 9,644)	NL (n = 8,194)	DE (n = 23,001)	LU (n = 4,504)	ES (n = 22,072)	IT (n = 45,962)	PT (n = 14,617)	DK (n = 6,629)
• Depressive symptoms	Yes	744 (7.7%)	615 (7.5%)	2,077 (9.1%)	439 (10.1%)	1,563 (7.1%)	2,655 (5.9%)	2,142 (14.8%)	596 (9.3%)
	No	8,897 (92.3%)	7,575 (92.5%)	20,871 (90.9%)	3,922 (89.9%)	20,505 (92.9%)	42,343 (94.1%)	12,330 (85.2%)	5,826 (90.7%)

Values are reported as absolute frequencies (n) and percentages (%). Percentages are calculated based on valid (non-missing) responses. Totals may not sum to the overall sample size, due to item-specific missing values. Income quintiles are based on country-specific distributions of net monthly equalised household income, ranging from the 1st quintile (lowest 20%) to the 5th quintile (highest 20%). BMI categories are defined as follows: underweight (< 18.5), normal weight (18.5–24.9), overweight (25.0–29.9) and obesity (≥ 30.0). The countries included in the analysis and their ISO codes are as follows: Belgium (BE), the Netherlands (NL), Spain (ES), Italy (IT), Denmark (DK), Germany (DE), Portugal (PT) and Luxembourg (LU)

Table 3 Descriptive statistics for variables

Variable	Observation	Mean	SD	Variance	Skewness	Kurtosis	Minimum	Maximum
Hospital nights	129,726.00	0.88	5.97	35.68	31.12	1513.47	0.00	365.00
Body mass index	126,387.00	25.68	4.60	0.59	1.46	15.13	6.38	140.85
Age	129,726.00	3.77	1.19	1.41	-0.13	1.73	1.00	5.00
Gender	129,726.00	0.47	0.50	0.25	0.13	1.02	0.00	1.00
Education	128,848.00	3.42	2.12	4.48	0.52	2.13	0.00	8.00
Income level	125,955.00	3.14	1.40	1.97	-0.85	2.85	1.00	5.00
Region	129,726.00	1.71	0.55	0.30	0.51	1.26	1.00	3.00
Hypertension	129,080.00	0.25	0.43	0.19	1.45	3.10	0.00	1.00
Diabetes	129,158.00	0.08	0.28	0.08	0.52	1.27	0.00	1.00
Depressive symptoms	128,668.00	0.08	0.48	0.23	2.98	9.90	0.00	1.00
Physical activity	129,726.00	0.38	0.48	0.23	1.15	2.32	0.00	1.00
Smoking	126,502.00	0.21	0.40	0.16	-0.02	2.44	0.00	1.00

null model using an F-test, the results of which were highly significant (F(17, 116,812) = 114.75, $p < 0.001$), indicating that the predictors jointly improved model fit. Although conventional measures, such as R^2 or pseudo-R^2, are not directly applicable to survey-weighted models, the significant F-test provides strong evidence that the model explains meaningful variation in the outcome. In applied health and social science research, such tests are generally considered sufficient to demonstrate the joint relevance of predictors when using complex survey designs [34, 35] given the complexity of behavioural and health-related outcomes. Evidence of overdispersion was confirmed by the dispersion parameter ($\alpha = 22.87$, 95% CI: 21.94–23.84), which was significantly different from zero. This indicates that the variance exceeded the mean, violating the assumptions of a Poisson model. A positive and statistically significant α supports the notion that the negative binomial model is a more appropriate specification with which to address extra-Poisson variability.

Several factors emerged as significant predictors of hospital nights. The primary variable of interest, BMI, showed clear effects in this regard: compared with individuals of normal weight, those classified as obese had 19% higher hospitalisation rates (IRR = 1.19, 95% CI: 1.04–1.36), while individuals with underweight had almost double the rate (IRR = 1.92, 95% CI: 1.52–2.43). The pre-obesity group did not differ significantly from the reference category. The high association between hospitalisation nights and underweight individuals likely reflects underlying malnutrition status, which is known to be associated with several acute and chronic medical comorbidities that require hospitalisation. Moreover, an assessment of the EHIS data reveals that underweight individuals have a higher prevalence of psychological comorbidities and mental health conditions, particularly depression and severe depressive symptoms. These conditions are associated with increased healthcare use through pathways such as reduced physiological reserve, poorer disease management and a higher risk of acute complications. As a result, underweight likely acts as a proxy for underlying illness and vulnerability, which drive higher hospitalisation rates, rather than being a direct causal factor itself. This inference is confirmed by the strong association recorded between hospitalisation in the model and these health conditions in the nbreg model.

Socioeconomic factors also played an important role. Age exerted the strongest influence, with a steep gradient across categories. Relative to those aged 18–24, hospital nights were 31% higher among respondents aged 25–34 (IRR = 1.31, 95% CI: 0.99–1.72), 28% higher among those 35–44 (IRR = 1.28, 95% CI: 0.98–1.68), 78% higher in the 45–64 group (IRR = 1.78, 95% CI: 1.42–2.24) and more than three times higher in the 65 + group (IRR = 3.15, 95% CI: 2.50–3.97). Each one-unit increase in education level reduced hospitalisation by 7% (IRR = 0.93, 95% CI: 0.90–0.96), while

Table 4 Predictors of the number of nights in hospital, estimated with a negative binomial regression

Explanatory variables	Coefficient (standard error)	Incidence rate ratio (IRR)	95% CI (IRR)
BMI			
• Underweight	0.653*** (0.119)	1.92	[1.52, 2.43]
• Normal	*Reference*		
• Pre-obesity	-0.019 (0.062)	0.98	[0.88, 1.11]
• Obesity	0.172** (0.069)	1.19	[1.04, 1.36]
Sociodemographic			
a) Age group			
• 18–24	*Reference*		
• 25–34	0.266* (0.142)	1.31	[0.99, 1.72]
• 35–44	0.250* (0.138)	1.28	[0.98, 1.68]
• 45–64	0.580*** (0.116)	1.78	[1.42, 2.24]
• 65+	1.148*** (0.117)	3.15	[2.50, 3.97]
b) Gender (Male)	-0.001 (0.051)	0.99	[0.90, 1.10]
c) Education level	-0.072*** (0.017)	0.93	[0.90, 0.96]
d) Net monthly income (quintiles)	-0.088*** (0.021)	0.92	[0.88, 0.95]
e) Region			
• Western Europe	*Reference*		
• Southern Europe	-1.192*** (0.056)	0.30	[0.27, 0.34]
• Northern Europe	-0.084*** (0.126)	0.34	[0.26, 0.43]
Underlying health condition			
• Hypertension	0.487*** (0.048)	1.63	[1.48, 1.78]
• Diabetes	0.570*** (0.056)	1.77	[1.58, 1.97]
• Depressive symptoms	0.631*** (0.055)	1.88	[1.68, 2.09]
Lifestyle			
• Physical activity	-0.334*** (0.034)	0.93	[0.89, 0.97]
• Smoke	0.031 (0.039)	1.06	[0.94, 1.19]
Constant	-0.205***(0.146)	0.81	[0.61, 1.08]
Model fit statistics			
Number of observations(n)	116,829		
Alpha	22.872*** (0.290)	22.87	[21.94, 23.84]
F (17, 116812)	114.75***		

Western Europe includes Belgium (BE), the Netherlands (NL), Germany (DE) and Luxembourg (LU). Southern Europe includes Spain (ES), Italy (IT) and Portugal (PT). Northern Europe includes Denmark (DK). Dependent variable = hospital nights over past 12 months

Statistical significance is denoted by *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$

each higher income quintile corresponded to an 8% reduction (IRR = 0.92, 95% CI: 0.88–0.95). Gender did not significantly influence hospitalisation. Marked regional differences were also observed: Compared with Western Europe, respondents in Southern Europe reported 70% fewer hospital nights (IRR = 0.30, 95% CI: 0.27–0.34), and those in Northern Europe reported 66% fewer nights (IRR = 0.34, 95% CI: 0.26–0.43).

Chronic health conditions were strongly associated with hospital use. Respondents with hypertension (IRR = 1.63, 95% CI: 1.48–1.78), diabetes (IRR = 1.77, 95% CI: 1.58–1.97) or depressive symptoms (IRR = 1.88, 95% CI: 1.68–2.09) spent significantly more nights in hospital as compared with those without these conditions. In terms of lifestyle behaviours, engaging in regular physical activity was linked to a 7% reduction in hospitalisation (IRR = 0.93, 95% CI: 0.89–0.97), whereas smoking status was not significantly associated with hospitalisation. Finally, robustness checks using a zinb model (Appendix 3 in Supplementary Material) produced consistent results, reinforcing confidence in the observed associations between hospitalisation outcomes and both BMI and sociodemographic characteristics, chronic health conditions and lifestyle behaviours.

Simulated cost-saving scenarios

Building on the regression estimates (IRR = 1.19), we simulated the potential impact of a 1% reduction in national obesity prevalence on hospital utilisation and related expenditures. The model suggests that such a reduction would translate into a 19% decrease in hospital nights among individuals with obesity, ultimately lowering the number of inpatient stays and the associated healthcare costs. The simulation incorporated each country's population size, obesity prevalence, average length of hospital stay and cost per hospital night, drawing on the most recent harmonised data obtained from Eurostat [23], the Organisation for Economic Co-operation and Development (OECD) [36] and the World Health Organisation (WHO) [37].

The results of this analysis are presented in Table 5. The projected absolute savings in hospital expenditure ranged from €15.93 million in Luxembourg to €1.70 billion in Germany. In relative terms, savings represented between 1.22% of total hospital expenditure in Denmark and 2.49% of such in Italy. After aggregation across all eight countries examined, the total estimated savings amounted to approximately €4.27 billion, corresponding to 1.71% of their combined annual hospital budgets. These findings underscore the substantial economic benefits that could be achieved with even modest reductions in obesity prevalence. They highlight the compounding effect of reduced hospital demand when scaled across large populations and costly healthcare systems, providing a strong economic rationale for preventive interventions aimed at obesity reduction.

Discussion

This study identifies BMI as a significant predictor of hospitalisation. Both obesity and underweight were associated with substantially higher hospital use as compared with normal weight, while pre-obesity showed no link to an increase in hospital nights. These findings suggest that the health and cost burden is concentrated at the extremes of the weight spectrum. While previous research has consistently linked obesity to greater

Table 5 Simulation of 1% reduction in obesity prevalence on healthcare expenditure across countries

Country	Population (N)	Obesity Rate (P_o)	ALOS (Avg. Length of Stay)	Cost per Night (€)	IRR (Obesity)	New Obesity Rate ($P_o - 0.01$)	Total Nights Baseline (TN_o)	Total Nights with % reduction (TN_1)	Δ Nights (TN_1-TN_o)	Cost Savings (Million €)	% Cost saving
Belgium	11,617,623	0.22	8.00	1,418.95	1.19	0.21	9,297,983,333	9,297,806,745	-176,588	250.57	1.52
Denmark	5,873,420	0.14	6.40	1,412.22	1.19	0.13	3,760,010,117	3,759,938,696	-71,421	100.86	1.22
Germany	83,237,124	0.24	7.40	1,452.99	1.19	0.23	61,623,793,358	61,622,623,044	-1,170,314	1,700.46	1.41
Spain	47,486,843	0.19	11.10	728.17	1.19	0.18	52,729,624,482	52,728,622,985	-1,001,498	729.26	2.11
Italy	59,030,133	0.22	13.10	785.67	1.19	0.21	77,361,210,246	77,359,740,986	-1,469,260	1,154.35	2.49
Luxembourg	645,397	0.20	8.50	1,528.36	1.19	0.19	548,797,998	548,787,575	-10,423	15.93	1.61
Netherlands	17,590,672	0.17	6.50	956.25	1.19	0.16	11,437,608,237	11,437,390,992	-217,245	207.74	1.24
Portugal	10,421,117	0.27	12.80	437.28	1.19	0.26	13,345,898,026	13,345,644,585	-253,442	110.82	2.43
Total savings across countries										4269.99	1.71

Estimation based on 2022 OECD, WHO and EUROSTAT data on health care expenditures, population and obesity prevalence rate

inpatient care needs [13, 38], our results extend this evidence by highlighting the equally strong impact of underweight, which is known to be strongly associated with malnutrition (an ignored condition in public health and clinical settings) and has also received considerably less policy attention than overweight. Importantly, the findings also indicate that obesity-related hospitalisation is not driven by excess body weight alone; rather, it is shaped by sociodemographic and behavioural factors that may mitigate or exacerbate health risks.

Among sociodemographic factors, age was the strongest determinant of hospitalisation, with older adults (≥ 65 years) showing the highest likelihood of hospital stays. This finding is consistent with Naser [39], who reported that hospitalisation rates and lengths of stay increase substantially among older populations due to their higher prevalence of chronic diseases. In the context of obesity, population ageing may further amplify hospitalisation demand, as excess body weight interacts with age-related declines in health and functional performance. These patterns align with demographic projections suggesting that population ageing will remain a key driver of healthcare demand across Europe.

Notably, education appeared to act as a protective factor, with individuals who had higher levels of education experiencing fewer hospital nights. This likely reflects the role of education in promoting healthier behaviours and more effective self-management, which may be particularly relevant for individuals with obesity in terms of managing obesity-related comorbidities and reducing avoidable hospital admissions. This interpretation is consistent with evidence showing that a substantial share of the education–health gradient is explained by differences in health behaviours [40]. Income showed a similar protective effect, providing evidence that greater socioeconomic resources facilitate earlier disease management and the more effective use of outpatient care. Gender showed no significant association with hospitalisation, suggesting that men and women experience comparable inpatient utilisation after BMI, socioeconomic status and health conditions are accounted for. This stands in contrast with Naser [39], who reported higher hospitalisation rates among women compared with men in England and Wales. This discrepancy may reflect differences in data aggregation and model adjustment, as our individual-level analysis controls for key obesity-related and health-related factors that likely attenuate crude gender differences.

Regional differences were also evident. Residents of Southern and Northern Europe reported substantially fewer hospital nights as compared with individuals in Western Europe, highlighting the role of regional context in shaping hospital utilisation. These disparities may reflect differences in healthcare system organisation, admission thresholds and the balance between inpatient and outpatient care. In Southern Europe, a strong reliance on family-based informal caregiving may absorb some care needs within households, potentially reducing reliance on formal hospital services. In Northern Europe, well-developed and accessible primary care systems may help prevent potentially avoidable hospital admissions. Cross-country evidence on informal caregiving further contextualises these patterns. These findings are consistent with the results of Verbakel [41], who documented substantial cross-country variation in both the prevalence and intensity of informal caregiving across Europe. Nordic countries were characterised by a high prevalence but relatively low intensity of caregiving, reflecting the presence of extensive formal care systems. In contrast, Southern European countries exhibited lower caregiving prevalence but higher caregiving intensity, indicating a greater concentration of care responsibilities within households. Although these patterns pertain to caregiving rather than hospitalisation per se, they support the interpretation that both intensive family-based care and well-developed primary care systems may reduce reliance on inpatient services, albeit through different mechanisms.

Underlying health conditions played a strong role in hospitalisation. Individuals with high blood pressure and diabetes reported significantly more hospital nights, highlighting the impact of chronic disease burden on inpatient care among individuals with obesity. Notably, depressive symptoms emerged as an especially important factor that has a stronger influence on hospitalisation than the other conditions examined. This finding underscores the often-underestimated role of mental health in driving hospital demand and suggests that the improved integration of mental health services into routine care may be particularly important for people with obesity, who face elevated risks of both physical and mental health comorbidities. This is consistent with previous evidence showing that depressive symptoms are associated with higher hospitalisation risk, longer length of stay and a greater likelihood of re-admission [27, 42]. While hypertension, diabetes and depressive symptoms were included as key underlying health conditions due to their strong links with obesity and hospitalisation, obesity was also associated with a broader range of comorbidities that may contribute to inpatient care use, including cardiovascular disease, musculoskeletal disorders, respiratory conditions and certain cancers. The inclusion of a limited set of conditions in this study reflects data availability and the need to avoid overadjustment in the regression models. Nevertheless, these conditions capture the major clinical and mental health pathways through which obesity increases hospitalisation risk, suggesting that the estimated burden is likely conservative.

Lifestyle behaviours also contributed to differences in hospitalisation. Regular physical activity was associated with fewer hospital nights, suggesting that active lifestyles may mitigate obesity-related complications that lead to inpatient care. This finding reinforces the potential of preventive strategies targeting physical activity to reduce hospitalisation risk among individuals with obesity. This is consistent with Mizrahi et al. [43], who found that exercise interventions shortened hospital stays, and with Wright et al. [44], who reported lower all-cause hospitalisation among participants in exercise programmes. By contrast, smoking showed no significant association with hospitalisation after adjustment, which may reflect the delayed onset of smoking-related diseases and the fact that many smoking-attributable conditions (e.g., chronic obstructive pulmonary disease and cardiovascular disease) are often managed in outpatient settings until advanced stages [45].

The simulation analysis suggests that even a 1% reduction in obesity prevalence could generate substantial savings on hospital expenditures, amounting to €4.27 billion annually across eight European countries. These results are consistent with previous studies highlighting the high economic burden of obesity. For example, Cawley and Meyerhoefer [20] estimate that obesity accounts for 16–20% of US healthcare spending, while the OECD [46] reports that obesity-related diseases cost member countries approximately 3.3% of their total health budgets. Our estimates fall within this range and extend the evidence by showing the potential impact of small prevalence reductions on inpatient care specifically. The variation across countries reflects differences in population size, obesity prevalence and hospital costs, but the direction of the effect was consistent across all contexts. These findings highlight the dual health and economic rationale for obesity prevention, reinforcing the value of interventions such as lifestyle modification programmes, community-based initiatives, pharmacological weight-loss treatments and digital health solutions.

Limitations

Several limitations should be acknowledged. First, this study relies on self-reported data for BMI, chronic conditions and hospitalisations, which may be subject to recall bias or measurement error. In particular, self-reported height and weight may lead to the underestimation of BMI, while hospital use may be imperfectly recalled. Similarly, physical activity and smoking were assessed through self-reports and may be affected by under- or overestimation bias. Nevertheless, the EHIS employs standardised questionnaires and harmonised data collection procedures across countries, which enhances internal consistency and supports valid cross-national comparisons. Second, depressive symptoms were measured using self-reported information and could not be validated against clinical diagnoses or medication records, potentially resulting in some misclassification of mental health status. In addition, the cross-sectional design of the EHIS limits the ability to draw causal inferences, and residual confounding cannot be ruled out. Third, although the number of hospital nights provides a valuable indicator of inpatient healthcare utilisation, it does not capture other relevant dimensions of healthcare use, such as outpatient visits, pharmaceutical consumption or indirect costs, all of which may also be influenced by obesity and chronic conditions. Finally, cross-country comparisons should be interpreted with caution, as differences in healthcare system organisation, admission practices and reporting standards may contribute to observed variations in hospitalisation patterns.

Despite these limitations, the findings have important policy-related, economic and clinical implications. The substantial hospital burden associated with obesity underscores the urgency of preventive interventions aimed at weight management and the promotion of active lifestyles. Even modest reductions in obesity prevalence could translate into significant healthcare savings across European health systems. Moreover, the protective roles of education and income highlight the importance of addressing social inequalities in health and improving access to preventive and primary care services. Regional differences further suggest that healthcare system organisation and cultural factors shape hospital demand, pointing to opportunities for cross-country learning and system-level reforms. Taken together, these results indicate that reducing hospital demand will require a comprehensive strategy integrating health promotion, chronic disease management, mental health support and socioeconomic equity into healthcare planning, with the potential to generate both health gains and substantial economic benefits.

Conclusions

This study provides clear evidence that both obesity and underweight are important predictors of hospitalisation in Europe. Importantly, our findings, specifically the substantial number of hospital nights associated with obesity, highlight and reinforce the concept that obesity is not an aesthetic issue but a serious disease that negatively impacts health to an extent that requires increased hospitalisation. Because of this, actions are needed at various levels, including raising awareness among the general population through prevention and educational campaigns as well as governmental decisions. For example, Italy has recently taken a historic step forwards in the fight against obesity and achieved a major milestone in public health by becoming the first country to legally recognise obesity as a chronic, progressive and relapsing disease; other EU countries must make similar decisions soon [47].

The findings show that while obesity remains a major driver of hospital demand and related costs, the health risks associated with underweight individuals also deserve greater policy attention. Age, chronic diseases and depressive symptoms were key determinants of hospital nights, highlighting the importance of addressing both physical and mental health in healthcare planning. Preventive measures that promote healthy weight and active lifestyles could generate significant savings, as even small reductions in obesity prevalence may lead to billions of euros in savings on hospital expenditures each year. The protective effects of education and income further emphasise the need to reduce social inequalities in health, while regional differences suggest that valuable lessons can be learned from various healthcare systems across Europe. Overall, reducing the hospitalisation burden related to weight and chronic conditions requires a comprehensive strategy that integrates health promotion, disease prevention and socioeconomic equity. Such coordinated actions are essential to improve population health and ensure the long-term sustainability of European healthcare systems.

Abbreviations

BMI	Body Mass Index
EHIS	European Health Interview Survey
EU	European Union
IRR	Incidence Rate Ratio
OECD	Organisation for Economic Co-operation and Development
US	United States
VIF	Variance Inflation Factor
WHO	World Health Organisation

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

Muhammad Adzran Che Mustapa contributed to data curation, software, validation, formal analysis, visualisation, the writing of the original draft and writing—review and editing. Noah Larvoe contributed to methodology, software, data curation, formal analysis, visualisation and writing—review and editing. Marwan El Ghoch contributed to conceptualisation and writing—review and editing. Zein Kallas contributed to conceptualisation, supervision, funding acquisition, and writing—review and editing. All authors read and approved the final manuscript.

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Data availability
The EHIS microdata are available to researchers who carry out statistical analyses for scientific purposes. The microdata do not contain any administrative information, such as names or addresses, that would allow direct identification. To ensure a high level of confidentiality, a number of anonymisation rules have been applied, including the omission of some variables and the grouping of response categories. Further details on access to the microdata can be found at [https://ec.europa.eu/eurostat/web/microdata/].

Declarations

Ethics approval and consent to participate
EHIS Wave 3 was carried out in strict compliance with the EU General Data Protection Regulation (GDPR). Participation in the survey was voluntary. Respondents were informed about the study's objectives, content and data protection measures and provided verbal informed consent. Country-specific sub-studies followed their respective national guidelines and procedures.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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