Full length article

Maternal obesity trends in a large Irish university hospital

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ABSTRACT

Objective(s): This study aimed to examine recent trends in maternal obesity.
Study design: This retrospective observational study used routinely computerised clinical and sociodemographic data of women who presented for antenatal care in a large maternity hospital in Ireland during the eight years 2010-17. Women with complete body mass index (BMI) data who delivered a baby weighing ≥500 g were included in the study. BMI was based on the measurement of weight and height and was categorised into the World Health Organizations (WHO) classifications.
Results: The number of women delivered was 67,949 and 99.1% had complete data. The overall obesity rate increased from 16.0% (95% CI 15.3–16.8%) in 2010 to 18.9% (95% CI 18.0–19.7%) in 2017 (+18.1%, p < 0.001). This increase occurred in the mild, moderate and severe obesity subcategories (all p < 0.01). Overall, obesity was associated with multiparity, maternal age, maternal birth in Ireland or the United Kingdom (UK), depression, unemployment and unplanned pregnancy. The increase in obesity was more pronounced in nulliparas than in multiparas, particularly nulliparas <30 years. The increased obesity levels were accompanied by major sociodemographic changes in the hospital population from 2010 to 2017 with an increase in the average maternal age from 30.5 years to 32.2 years (p < 0.001) and a decrease in the proportion of nulliparas aged <30 years (from 40.6% to 28.8%, p < 0.001).
Conclusion(s): It is likely that the escalating maternal obesity levels will lead to further increases in obstetric complications and interventions. The escalation was accompanied by major sociodemographic changes which have implications for healthcare planning and public health interventions.

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Introduction

Based on a Body Mass Index (BMI) >30.0 kg/m^2, maternal obesity has emerged as one of the greatest challenges in contemporary maternity care, especially in high-income settings [1,2]. It is associated with an increase in pregnancy complications, such as Gestational Diabetes Mellitus (GDM) and preeclampsia, and an increase in interventions, such as Caesarean Section (CS) [2,3]. Severe obesity (BMI ≥ 40.0 kg/m^2), in particular, is associated not only with increased clinical risks but also technical challenges, for example, with diagnostic ultrasound, anaesthesia, surgical access, blood pressure measurements and appropriate equipment [4,5]. Maternal obesity may also potentially pose lifelong cardiovascular and metabolic problems for the woman and her offspring. Meeting all these challenges increases financial demands on the health services.

There is considerable evidence that adult obesity levels are continuing to escalate globally [6,7]. There is a dearth of high quality data on obesity trends in pregnant women, including obesity subcategory trends, and evidence is often inferred from obesity trends in women of reproductive age [8,9]. The lack of quality data is also because BMI, if recorded, is usually based on self-reported weight and height which has underestimates BMI and miscategorises women using the WHO BMI classification [10,11]. Furthermore, others are based on prepregnancy weight which is poorly standardised and open to recall bias [12].

The purpose of this study, therefore, was to report maternal obesity trends using prospectively measured height and weight at the first antenatal appointment from 2010 to 2017.

Methods

Data were prospectively collected and routinely computerised by trained midwives using a standardised questionnaire as part of the medical records at the first antenatal visit. The hospital is one of the largest maternity hospitals in Europe. It receives women from

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all socioeconomic groups, from urban and rural areas, with and without private health insurance [13].

Women were included in the study if they delivered an infant weighing ≥ 500 g over the eight year period 2010–2017 and had complete data for BMI. The routinely collected data included employment status, parity, medical complications, psychiatric history, and lifestyle data including drug use, alcohol consumption and cigarette smoking. Height and weight were measured by the midwife [10].

BMI was calculated and categorised using the World Health Organizations (WHO) classifications. [14]. Maternal employment status was categorised according to the Irish Census [15]. Nationality was categorised by country of birth into Ireland, United Kingdom, EU 14 (countries that joined the European Union (EU) before the year 2004) and EU 13 (the Accession countries that joined the EU following enlargement in 2004), and Other (countries outside the European Union).

'Binge drinking' was defined as consuming >5 units of alcohol in one sitting. 'Illicit drugs' were defined as the nonmedical or misuse of a variety of drugs, including prescription drugs, and those prohibited by international law. Depression and anxiety were self-reported, whereas antidepressant/anxiolytics were recorded as currently prescribed medications. The study received ethical approval from the Hospital Research Ethics Committee (4-2013).

Pseudonymised data were analysed using the statistical software package SPSS version 24.0 and the online statistical program Vassarstats [16]. The normality of data was investigated using visual inspection of histograms, examining the skewness and kurtosis of the data and the Kolmogorov-Smirnov test. Descriptive analysis and one way analysis of variance (ANOVA) were used to describe the study population stratified by year. Tukey's post-hoc test was used to examine the mean differences in maternal characteristics between years. Proportional differences of maternal characteristics between years were evaluated by the test for difference between two independent proportions. Analysis of covariance (ANCOVA) was used to assess the differences in mean BMI between years adjusted for maternal age.

Pearson's correlations and simple and stepwise linear regression analysis were used to investigate the relationship between BMI and the known associated factors of age and parity. Adjusted binary logistic regression analyses were then conducted to assess the magnitude and significance of predictor variables on maternal obesity in the years 2010 and 2017. Analyses were adjusted for maternal age, parity and nationality, known confounders of obesity. The results of the models were presented as adjusted odds ratios (aOR), 95% CI, and associated p-values.

Results

A total of 67,949 women delivered a baby weighing ≥ 500 g in the eight years between 2010 and 2017. Of these, 99.1% had BMI data available for analysis. Overall, 1.9% of women were categorised as underweight, 52.0% were normal weight, 29.1% were overweight, and 17.0% were obese. The characteristics of the study population analysed by year are shown in Table 1.

In 2010, the mean BMI of all women was 25.5 ± 5.0 kg/m^2 which increased gradually, but not linearly, to 25.9 ± 5.3 kg/m^2 in 2017 (mean difference 0.4 kg/m^2, p < 0.001). Following an adjustment for maternal age, the mean increase in BMI remained (0.3 kg/m^2, p = 0.003). The mean age of the study cohort also increased between the years 2010 and 2017 (mean difference 1.7 years, 95% CI 1.5–1.8, p < 0.001).

Nulliparas had a greater increase in mean age compared to multiparas between 2010 and 2017 (2.3 years, 95% CI 2.0–2.5 vs. 1.1 years 95% CI 0.9–1.3, p < 0.001). Furthermore, the proportion of nulliparas presenting <30 years fell from 40.6% in 2010 to 28.8% in 2017 (-29.1%, p < 0.001). In 2017, professional/managerial women had the highest mean age, and unemployed women the lowest, compared to all other employment categories (34.8 ± 3.9 years, p < 0.001 and 26.4 ± 6.3 years, p < 0.001) (data not shown).

The rate of planned pregnancy increased from 2010 to 2017 (68.4% vs. 73.5%, p < 0.001). In 2017, professional/managerial women had the highest rate of planned pregnancies whilst unemployed women had the lowest rate (88.1% vs. 42.7%, p < 0.001) (data not shown).

The yearly trends in maternal BMI categories are shown in Table 2. The overall rate of maternal obesity increased by 18.1% from 16.0% (95% CI 15.3–16.8%) in 2010 to 18.9% (95% CI 18.0–19.7%) in 2017 (p < 0.001). The increase within the overall obesity category was evident in all three subcategories of obesity (mild 10.8% to 12.0%, p < 0.001; moderate 3.7%– to 4.8%, p < 0.001; and severe 1.5%– to 2.1%, p < 0.001).

Table 3 shows maternal obesity levels analysed by parity, age, country of birth and employment status. The proportion of obese nulliparas increased by 40.4% between 2010 and 2017 (p < 0.001) whereas the proportion of obese multiparas increased by 7.2% (p < 0.05). Nulliparas aged 20–24 years had the largest increase in mean BMI (24.0 ± 4.4 kg/m^2 vs. 25.4 ± 5.4 kg/m^2, p < 0.001) and the highest percentage change in obesity between 2010 and 2017 at 77.3% (9.7% vs. 17.2%, p < 0.001), followed by nulliparas aged 25-29 years (mean BMI change 24.6 ± 4.8 kg/m^2 vs. 25.6 ± 5.6 kg/m^2, p < 0.001; obesity rate 11.3% vs. 17.8%, p < 0.001). No difference was found in nulliparas >30 years in terms of mean BMI or obesity rate (all p > 0.05).

Despite no increase in the proportion of women from EU 13 attending the hospital (11.9% vs. 11.8%, p = 0.362) between 2010 and

Table 1
Characteristics of the study population analysed by year.

	2010 n =8814	2011 n =8599	2012 n =8525	2013 n =8102	2014 n =8429	2015 n =8354	2016 n =8394	2017 n =8131	Change 2010-2017 n = -683	Total n = 67,348
Age (years) (mean, SD)	30.5 (5.7)	30.8 (5.6)	30.9 (5.6)	31.2 (5.5)	31.6 (5.5)	31.9 (5.4)	32.0 (5.5)	32.2 (5.5)	+1.7	31.4 (5.6)
BMI (kg/m^2) (mean, SD)	25.5 (5.0)	25.7 (5.1)	25.6 (5.1)	25.6 (5.1)	25.5 (5.2)	25.8 (5.1)	25.8 (5.1)	25.9 (5.3)	+0.4	25.6 (5.1)
Irish-born (%)	69.7	70.5	69.6	70.4	71.5	70.5	70.4	70.6	+0.9	70.4
Nulliparas (%)	42.6	40.6	40.3	38.9	39.2	38.7	40.2	41.0	−1.6	40.2
Unemployed (%)	9.5	10.3	11.6	11.6	10.9	10.2	9.6	9.0	−0.5	10.3
Planned pregnancy (%)	68.4	68.5	69.6	69.7	70.2	72.2	72.3	73.5	+5.1	70.5
Current smoker (%)	15.1	14.7	14.4	12.6	11.9	10.3	10.5	9.7	−5.4	12.4
Current alcohol (%)	2.2	3.3	1.7	1.5	1.4	1.1	1.0	0.8	−1.4	1.6
Current binges[*] (%)	0.6	0.7	0.3	0.3	0.2	0.2	0.2	0.1	−0.5	0.3
Current depression (%)	1.5	1.5	1.6	1.5	1.5	1.5	1.6	1.9	+0.4	1.6
Antidepressants and anxiolytics (%)	1.8	1.9	2.0	1.9	2.2	1.9	2.4	2.6	+0.8	2.1

[*] Binges; consuming >5 units of alcohol in one sitting.

Table 2

Trends in the proportion of women in each Body Mass Index category annually.

	n	2010 (%)	2011 (%)	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	2017 (%)	Change 2010-2017 (%)	p-value
Underweight	1266	2.1	1.5	1.7	1.9	2.2	2.0	1.9	1.7	−0.4	0.035
Normal weight	35025	52.4	50.8	53.3	51.5	53.5	53.9	50.7	49.9	−2.5	<0.001
Overweight	19624	29.4	29.9	28.5	29.6	27.5	28.9	29.9	29.5	+0.1	0.448
Total obesity	11434	16.0	17.8	16.5	17.0	16.8	15.3	17.5	18.9	+2.9	<0.001
Obese class I	7540	10.8	12.2	11.0	11.3	10.5	10.2	11.6	12.0	+1.2	0.009
Obese class II	2741	3.7	3.9	3.7	4.0	4.5	3.7	4.2	4.8	+1.1	<0.001
Obese class III	1153	1.5	1.7	1.8	1.7	1.8	1.4	1.7	2.1	+0.6	0.004

p-values indicate differences between columns 2010 and 2017.

Table 3

Maternal obesity rates analysed by parity, age and country of birth.

	Maternal obesity	2010	2011	2012	2013	2014	2015	2016	2017	Change 2010-2017
	n	n =8814 (%)	n =8599 (%)	n =8525 (%)	n =8102 (%)	n =8429 (%)	n =8354 (%)	n =8394 (%)	n =8131 (%)	n = -683 (%)
Parity										
Nulliparas	3699	11.4	14.1	13.6	13.1	14.2	12.5	14.7	16.0	+4.6
Multiparas	7735	19.5	20.3	18.5	19.4	18.5	17.1	19.5	20.9	+1.4
Age										
<20	146	7.1	11.2	6.0	11.3	7.2	8.8	14.0	7.9	+0.8
20-24	1071	13.2	16.0	16.7	15.1	16.4	13.4	16.6	19.1	+5.9
25-29	2563	15.0	16.8	17.4	18.0	18.0	15.6	19.8	21.9	+6.9
30-34	3837	16.3	17.7	15.4	16.2	15.1	15.4	16.4	17.7	+1.4
35-39	2994	19.5	19.4	17.2	17.2	17.9	15.2	16.4	18.6	−0.9
>40	823	18.9	24.2	21.8	21.6	22.3	18.7	25.1	20.1	+1.2
Country of birth										
Ireland	8356	16.9	18.6	17.0	17.4	17.4	16.0	18.7	19.4	+2.5
United Kingdom	321	12.2	22.8	16.4	18.3	22.7	16.0	20.5	18.2	+6.0
EU 13	808	7.4	8.3	9.9	9.4	9.1	9.7	10.7	12.6	+5.2
EU 14	137	15.8	16.8	7.1	11.5	7.1	14.1	12.5	15.9	+0.1
Other	1764	19.6	21.1	20.8	22.4	21.4	17.1	18.5	22.2	+2.6
Employment status										
Professional/managerial	1998	11.6	12.2	10.1	11.6	11.8	10.3	11.9	12.8	+1.2
Other non-manual/skilled manual	4322	15.4	18.0	16.8	16.5	16.1	15.9	18.2	19.5	+4.1
Semi-skilled/unskilled manual	823	17.4	17.3	16.8	17.8	16.4	16.5	20.3	23.6	+5.8
Unemployed	1323	15.9	20.1	20.7	18.7	18.9	17.3	19.7	21.9	+6.0
Homemaker	2874	21.1	22.4	20.8	23.1	24.5	19.9	23.4	25.7	+4.6

2017, the proportion who were obese increased by 70.3% (7.4% vs. 12.6%, p < 0.001). The proportion of unemployed women who were obese increased by 37.7% between 2010 and 2017 (p = 0.001).

Table 4 shows the magnitude and significance of predictor variables on the prevalence of maternal obesity in 2010 and 2017. Predictors of maternal obesity in 2010 and 2017 were similar in terms of maternal age, country of birth, parity, employment status and pregnancy intention. In 2017, women who were prescribed antidepressants/anxiolytics were more likely to be obese than women not prescribed these medications but this relationship did not reach statistical significance in 2010.

Discussion

Main findings

In this large epidemiological study, we found that the overall prevalence of maternal obesity in 2017 was 18.9%, an increase of 18.1% from 2010. The increase in obesity was evident in all three subcategories of mild, moderate and severe obesity. Overall, maternal obesity was associated with maternal age, multiparity, maternal birth in Ireland or the UK, unplanned pregnancy, unemployment, and depression. Our findings have clinical implications and are likely to lead to an increase in obstetric complications and interventions. The escalation in maternal obesity also has implications for future healthcare services planning and resourcing.

A strength of this study is that the calculation of BMI throughout the study was based on the measurement of maternal weight and height by a trained midwife at the first antenatal hospital visit [10]. Studies on BMI category trends over time in pregnant women are surprisingly few and are often based on self-reporting of weight. In one study where BMI calculation was based on self-reporting, 59% of pregnant women were found to have underreported their weight [10]. This led to the wrong categorisation of BMI in 22% of cases and a under diagnosis of obesity in 5% of women.

A limitation of the study is findings are confined to one maternity hospital, however; the hospital is one of the largest in Europe. About one in eight women in the country delivers in the hospital annually and the study population and clinical outcomes are similar to national data [17].

The explanation for the increased levels of maternal obesity is challenging. The escalation is too fast for genetic explanation. It is more likely due to changes in our social environment, with diets shifting towards increased intake of unhealthy convenience low-cost foods and trends towards decreased physical activity due to increasingly sedentary work and recreation activities, changing modes of transport, commuting, and increasing urbanisation [18].

Previous Irish research demonstrated that maternal obesity nine months postpartum was associated with increasing parity [19]. However, when analysed by socioeconomic group, this relationship only persisted in women from lower income households. As maternal obesity is associated with risk factors that are

Table 4
Maternal characteristics, socioeconomic and lifestyle factors associated with maternal obesity in 2010 and 2017.

	2010 n = 8814			2017 n = 8131		
	% obesity	aOR (95% CI)	p-value	% obesity	aOR (95% CI)	p-value
Age						
< 20 years	7.1	0.5 (0.3-0.9)	0.018	7.9	0.4 (0.2-0.8)	0.005
20-24 years	13.2	Reference	Reference	19.1	Reference	Reference
25-29 years	15.0	1.1 (0.9-1.4)	0.239	21.9	1.2 (0.9-1.5)	0.208
30-34 years	16.3	1.0 (0.9-1.3)	0.502	17.7	0.9 (0.7-1.1)	0.183
35-39 years	19.5	1.2 (0.9-1.5)	0.066	18.6	0.9 (0.7-1.1)	0.192
> 40 years	18.9	1.2 (0.8-1.6)	0.368	20.1	0.9 (0.7-1.3)	0.681
Nationality						
Irish-born	16.9	Reference	Reference	19.4	Reference	Reference
UK	12.2	0.7 (0.5-1.0)	0.068	18.2	0.9 (0.6-1.3)	0.585
EU 14	15.8	1.0 (0.6-1.6)	0.974	15.9	0.8 (0.5-1.3)	0.403
EU 13	7.4	0.4 (0.3-0.6)	<0.001	12.6	0.6 (0.5-0.7)	<0.001
Other	19.6	1.2 (1.0-1.4)	0.072	22.2	1.1 (1.0-1.3)	0.136
Parity						
Nulliparas	11.4	Reference	Reference	16.0	Reference	Reference
Multiparas	19.5	1.6 (1.4-1.9)	<0.001	20.9	1.4 (0.2-1.6)	<0.001
Employment status						
Professional/managerial	11.6	0.6 (0.5-0.8)	<0.001	12.8	0.6 (0.5-0.7)	<0.001
Other non-manual/skilled manual	15.4	Reference	Reference	19.5	Reference	Reference
Semi-skilled/unskilled manual	17.4	1.4 (1.1-1.8)	0.003	23.6	1.5 (1.2-1.8)	0.001
Unemployed	15.9	1.3 (1.0-1.6)	0.023	21.9	1.3 (1.1-1.7)	0.007
Homemaker	21.1	1.4 (1.2-1.6)	<0.001	25.7	1.3 (1.1-1.6)	0.001
Pregnancy intention						
Planned	14.9	Reference	Reference	17.7	Reference	Reference
Unplanned	18.5	1.4 (1.3-1.6)	<0.001	22.0	1.3 (1.1-1.5)	<0.001
Prescribed antidepressants/anxiolytics						
No	16.0	Reference	Reference	18.5	Reference	Reference
Yes	21.8	1.3 (0.9-1.9)	0.188	31.3	1.9 (1.4-2.6)	<0.001
Depression						
No	15.5	Reference	Reference	18.2	Reference	Reference
Previous	20.5	1.3 (1.1-1.6)	0.010	22.3	1.3 (1.0-1.5)	0.017
Current	26.6	1.8 (1.2-2.7)	0.004	33.1	2.2 (1.5-3.1)	<0.001

not modifiable before pregnancy, such as age and parity, the sociodemographic shifts that we have identified are important for developing interventions to reduce the rates in the future.

Our observations are consistent with a report on recent trends in female labour force participation in Ireland [20]. So far in this century, Ireland has experienced an economic roller coaster with an initial boom, followed by an acute recession in 2008, and a remarkable subsequent recovery where it has become one the fastest growing economies in Europe [21].

During the recession, women and men differed in terms of emigration, unemployment, and continuing education [20]. Women were less likely than men to emigrate (over the 2009–2015 period, net emigration account for almost 12% of men aged 15–34 years, where the figure for women was 5%). The participation by women aged 20–29 years in third level education increased. Women's unemployment rate was lower than men's. Labour force participation for women with a third level education remained high in their 20 s and 30 s [20].

Our findings are also consistent with the limited international evidence published. In a study based on publicly accessible data from 184 countries, there was an increase in maternal obesity in high and middle income countries between 2005 and 2014 [22]. It was estimated that one third of pregnant women in the USA was obese. The increased rate of obesity in economically developed countries was linked with increases in food energy supply, increasing urbanisation, and sedentary occupations [23,24].

In a UK study of maternal obesity rates, the incidence increased from 7.6% in 1989 to 17.6% in 2007 (p < 0.001) [25]. In the United States, the rate of total obesity calculated for 48 states was 25.6% in 2015 [24]. An 8% increase in maternal obesity from 2011 to 2015 coincided with a decline in prepregnancy normal weight from

47.3% to 45.1%. The data analysed in the study included self-reported maternal height and prepregnancy weight, thus, is likely an underestimation.

Our findings have implications for public health policies. Despite a large number of studies to date, interventions before, during and after pregnancy have had little impact on improving pregnancy outcomes for obese women or reducing the prevalence of maternal obesity [26,27]. While attempts may be made by healthcare professionals to improve dietary and physical activity behaviours for women individually and to introduce national initiatives such as the Obesity Policy and Action Plan 2016–2025, risk factors such as maternal age, parity, and ethnicity require change at a population level [28].

Our findings have financial implications for maternity services. Escalating obesity rates will increase, for example, the need for laboratory testing, fetal surveillance investigations, dietary advice, medications, specialised clinics, operative deliveries, and pregnancy complications in the future. In a large study of 13,442 pregnancies from 2000 to 2004 in the North West of the United States with a managed health care plan, obese women were more likely than normal-weight women to require more prenatal tests, medications and both personal and telephone consultations [29]. Obese women were also found to have longer average length of bed stay, principally due to higher probability of CS delivery.

In a retrospective analysis from the 2000-4 Growing Up in Wales study the total maternity service usage cost for obese women was estimated at £4719 compared to £3346 for normal-weight women [30]. Neonatal costs were excluded. In a recent retrospective study from Nova Scotia, the children of obese mothers were 1.7 times more likely to be high users of healthcare in the first 18 years of life compared with the children of normal-

weight mothers [31]. The economic costs of maternal obesity for the health services and for the women personally are unknown in an Irish setting, but it is likely that the trends we observed in this study have and will continue to incur substantial increases in healthcare expenditure.

In conclusion, increased maternal obesity levels have clinical implications for women in the short and long term. There are also resource implications for primary and tertiary care. The socio-demographic changes and factors associated with maternal obesity identified in this study may help focus public health policies and interventions.

Disclosure of interests

All authors declare they have no competing interests.

Contribution to authorship

CMER contributed to the conception and design of the study, performed the analysis of the data, interpreted data, wrote, revised and finalised this original article. MJT contributed to the conception of the study, interpretation of data as well as made significant contributions to the writing, revising and final approval of this manuscript. LMcM, EOM, BE and SRS contributed to the interpreting of data as well as the writing, revising and final approval of this manuscript. MJT contributed to the conception of the study, interpretation of data as well as contributing to the writing, revising and final approval of this manuscript.

Details of ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the hospital research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethical approval was received for this study by the Hospital Research Ethics Committee on the 28/10/2018, study number 4-2013.

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