



“Smoking during pregnancy – Perinatal outcomes, financial implications, and tobacco treatment services”

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ABSTRACT

Objective: Smoking in pregnancy is the leading modifiable risk factor for poor pregnancy outcomes. A sample population from United Lincolnshire Hospital NHS Trust (ULHT), with the highest prevalence of smoking at the time of delivery (SATOD) in England from April 2020 to March 2021 was studied. The project mapped the journey of women who smoked during pregnancy until birth and compared with a non-smoking cohort. In addition, it explored the options for possible changes to the current tobacco treatment service and importance of catering to the population demographics.

Methods: Data was analysed using Chi-squared or Mann Whitney and student T-test for categorical and continuous variables respectively. A p-value of < 0.05 was considered statistically significant.

Results: All women who smoked during pregnancy were referred to the stop smoking service. However, only 34.9 % accessed the service. Smoking mothers were younger ($P = 0.001$), had more complex obstetric history ($P = 0.044$), required increased fetal surveillance ($P < 0.001$), delivered at an earlier gestation ($P = 0.033$), and had babies with lower birth-weight ($P < 0.001$) compared to non-smokers. In addition, women who smoked demonstrated a downward trend in breast feeding their babies at birth and on discharge ($P < 0.001$ and $P < 0.001$ respectively).

Conclusions: Findings from the study informed a successful business case for improvements to the current tobacco treatment service and the development of in-house maternity model for pregnant smokers at ULHT.

Implications for Policy and Practice.

- Study findings influenced change in the community through a tailored programme which is fully compliant with the National Institute for Health and Care Excellence (NICE) guidance.
- Implementation of effective smoking cessation services is cost saving and crucial in improving maternal and perinatal outcomes.
- Supporting those who are pregnant and smoking will not only provide improvements in their health but also reduce health inequalities and address the growing demand for the NHS by reducing the number of smoking related admissions and readmissions.

1. Introduction

Many studies have shown that maternal smoking during pregnancy due to tobacco dependency affects the growth and organ development of the fetus. The negative effects of maternal smoking continues into later life, where a correlation can be found between in-utero exposure of cigarette smoke and higher incidences of attention deficit hyperactivity disorder, worse academic achievement and poorer physiological brain development in preadolescence (McDonnell and Regan, 2019; Lindblad and Hjern, 2010; Ekblad, 2022).

Across England, 9.6 % of women were smokers at the time of delivery (SATOD) in 2020–2021 with minimal change (9.1 %) in 2021–2022 (Statistics on Women's Smoking Status at Time of Delivery: England, 2023). This is above national ambitious target of 5 % or less by 2025

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(Delivering a Smokefree, 2030) and smoke free pregnancy by 2030 (Advancing our health: prevention in the, 2020s). These women are subject to an increased rate of complications such as miscarriage, preterm birth (PTB), fetal growth restriction (FGR), placental abruption, stillbirth, and sudden infant death syndrome (McDonnell and Regan, 2019). The total annual cost incurred by the National Health Service (NHS) for treating complications that result from smoking during pregnancy is estimated to be between £8.1 million and £64 million per year. Moreover, the costs of treating the affected infants (aged 0–12 months) are estimated to amount to between £12 million and £23.5 million per year (Ekblad, 2022).

Low-cost tobacco dependency treatments interventions during pregnancy generate monetary savings, aside from the health benefits for woman and infant (Ekblad, 2022). Psychosocial interventions such as counselling, feedback interventions e.g. personal carbon monoxide (CO) reading, and provision of incentives are effective at aiding smoke free pregnancies. Furthermore, they decrease the incidence of low birth-weight and neonatal intensive care unit admission (Solomon and Quinn, 2004). In the financial year April 2020 – March 2021, Lincolnshire Local maternity and Neonatal services (LMNS) was reported to have the highest prevalence of smoking at the time of delivery (SATOD) in England at 15.8 % with a marginal fall to 15.0 % in 2021–2022 (Statistics on Women's Smoking Status at Time of Delivery: England, 2023).

This study was undertaken to gain an in-depth understanding of the high rates of smoking in pregnant women at United Lincolnshire Hospitals NHS Trust (ULHT), investigate the impact of smoking in pregnancy, during labour, postpartum and the cost incurred in providing care to pregnant women who smoked during pregnancy at ULHT. It further explored possible options to improve measures and support pregnant women in quitting smoking through treating tobacco dependency.

2. Methods

A sample population of 102 women who smoked at delivery between 1st October 2020 and 31st March 2021 were randomly selected from the maternity electronic records and compared with 98 non-smoking women who delivered in the same timeframe at ULHT. ULHT is situated in the county of Lincolnshire and is one of the biggest acute hospital trusts in England with a birth rate of approximately 5,500 per annum, serving a predominantly rural population. The term 'non-smoking' was defined as woman who did not smoke from conception until birth.

Inclusion criteria were singleton pregnancy, no alcohol or substance misuse, maternal age between 18–40 years, no medical condition and a normal body mass index (BMI) (18–25). Data was extracted from the electronic maternity pathway.

Maternal demographics including age, body mass index, parity, ethnicity and smoking details were recorded. Antenatal data included previous obstetric history (stillbirth, small-for-gestational-age (SGA), PTB, miscarriages etc.) as well as details of the current pregnancy, including gestation at booking, fetal growth scans, antenatal contacts including clinic appointments, admissions in day assessment unit with reduced fetal movements (RFM), overnight hospital stay and antenatal complications (FGR, threatened preterm labour etc.).

In addition, information on intrapartum events, details around delivery, birth weight and breast feeding were collected.

Statistical analysis was performed using SPSS Version 26. Differences between categorical groups were analysed using the Chi-Squared test or Mann Whitney *U* test for normal and non-normal distributions of data respectively. Continuous variables were analysed using the student *t*-test or Mann Whitney *U* test, depending on the normality of the data. A *P*-value of < 0.05 was considered statistically significant.

This study was conducted as an evaluation project to inform service improvement so formal ethical approval was not required. However, the study met the institution guideline for protection of human subjects concerning safety and privacy.

3. Results

Table 1 demonstrates the demographics, antenatal, intrapartum and postnatal variables between the smoking and non-smoking women.

Between 1st October 2020 and 31st March 2021, there were 2225 births at ULHT. Of 2225, 412 were smokers (prevalence of 18.5 %). However, using the inclusion criteria, 102 women were included in the study.

When we studied the journey of 102 women who smoked at delivery, we observed that all women continued to smoke (mean of seven cigarettes per day) from booking until delivery. In addition, we found that all women were referred to the stop smoking services at their booking appointment; however, only 34.9 % reported accessing this service.

Key findings include a statistically significant difference in the age of the two cohorts: the smoking women were younger, with a mean age of 26.8 (SD:4.3) in contrast to the mean age of 28.8 (SD:4.2, $P < 0.001$) in the non-smoking cohort. Although there was no significant difference in the parity; descriptive analysis showed that a greater number of women in the smoking cohort were multiparous.

Women who smoked demonstrated complex obstetric history, booked late in pregnancy, exhibited more complications during pregnancy and required intense fetal surveillance compared to non-smokers

Table 1

A comparative analysis of the demographics, antenatal, intrapartum and postnatal variables between pregnant women who smoked ($n = 102$) vs non-smokers ($n = 98$) during the study period.

| Variables | % (or mean [SD]) among smokers | % (or mean [SD]) among non-smokers | P-value |
|---|--------------------------------|------------------------------------|---------|
| Age (years) | 26.8 (4.3) | 28.8 (4.2) | 0.001 |
| BMI | 21.6 (2.3) | 21.6 (1.8) | 0.6 |
| Parity (% primiparous) | 26.5 | 37.4 | 0.13 |
| Ethnicity | 60.8 (White British) | 50.5 (White British) | 0.18 |
| Gestation at booking (weeks) | 11.4 (4.7) | 9.6 (3.7) | 0.002 |
| Antenatal | | | |
| Previous significant Obstetric history | 45.1 | 30.3 | 0.044 |
| Number of antenatal contacts | 22.5 (10.4) | 23.5 (12.9) | 0.87 |
| Number of fetal biometry scans | 3.15 (1.09) | 1.64 (1.56) | <0.001 |
| Number of episodes of reduced fetal movements | 0.64 (1.36) | 0.91 (1.26) | 0.024 |
| Antenatal complications. ^a | 41.2 | 27.3 | 0.038 |
| Perinatal | | | |
| Induction of labour (IOL) | 39.2 | 39.4 | 0.98 |
| Operative delivery | 12.7 | 14.1 | 0.19 |
| Complications in labour ^b | 36.3 | 41.4 | 0.35 |
| Gestation at birth (weeks) | 39.5 (1.3) | 39.9 (1.5) | 0.033 |
| Birth weight (kg) | 3.18 (0.45) | 3.41 (0.48) | 0.001 |
| Postpartum | | | |
| Admission to NNU/ Transitional Care | 12.7 | 14.1 | 0.77 |
| Postnatal complications ^c | 28.4 | 26.3 | 0.85 |
| Breastfeeding at birth | 51 | 79.8 | <0.001 |
| Breastfeeding at discharge | 35.3 | 74.5 | <0.001 |

a Low PAPPa MoM, Fetal anomaly; SGA; Preterm birth <37/52; Antepartum haemorrhage; Oligohydramnios; Polyhydramnios.

b Fetal distress; Prolonged rupture of membranes; Augmentation; Operative delivery.

c Post-partum haemorrhage, Woman or neonatal required antibiotics; Low APGAR score (<7 at 5 min); Oxygen requirement for neonate.

Study performed 2021–2022, Lincolnshire, UK. Study population 102 smoking women and 98 non-smoking women.

($P = 0.044$, $P = 0.002$, $P = 0.038$ and $P < 0.001$ respectively).

Interestingly, the smoking cohort reported a lower number of admissions with RFM compared to non-smokers (mean of 0.64 vs 0.91; $P = 0.024$).

During peripartum, there was no significant difference in the rates of induction of labour (IOL) or operative delivery (instrumental or caesarean section) between the two cohorts. However, smoking women delivered at an earlier gestation and the mean birth weight of their babies was significantly lower than the non-smokers ($P = 0.033$ and $P < 0.001$ respectively).

Postnatally, babies of smoking women did not require additional care on the neonatal unit. However, smoking women were less likely to breastfeed their babies, both at birth (51 % vs 79.8 %; $P < 0.001$) and on discharge (35.3 % vs 74.5 %; $P < 0.001$).

4. Discussion

4.1. Poorer outcomes due to smoking in pregnancy

We observed significantly increased obstetric problems in women who smoked during pregnancy. Our findings are in agreement with the existing literature and evidence that placental complications due to the harmful compounds in cigarette smoke could result in devastating maternal and perinatal outcomes (Delpisheh et al., 2006; Haas et al., 2005; Grillo and Freitas, 2011).

It is well-recognised that babies born to women who smoked throughout pregnancy are more likely to be SGA (Kobayashi et al., 2019; Horta et al., 1997; Meyer et al., 2009). It is hypothesised that this is due to a combination of CO exposure (leading to a decreased fetal haemoglobin oxygen-carrying capacity) and nicotine (which induces maternal catecholamine release). These result in repetitive episodes of reduced maternal perfusion of the placenta (Andriani and Kuo, 2014) and can manifest with RFM with poor perinatal outcome (FGR and stillbirth).

Our data illustrate that more non-smokers sought advice for RFM than women who smoked. Available evidence on association of smoking and RFM is not consistent with some studies reporting increase incidence of RFM in smokers compared to non-smokers and vice versa (McCarthy et al., 2016; Kapaya et al., 2020; Tveit et al., 2010). Women in their first pregnancy are anxious and frequently attend maternity units with RFM compared to multiparous women (Kapaya et al., 2020; Turner et al., 2021). We observed a high proportion multiparous women in the smoking cohort (73.5 %) compared to non-smokers (62.6 %) in the study sample. This may explain increase admissions with RFM in the non-smokers included in our study.

The two main indications for IOL in our study were antenatal complications (SGA) and RFM. Although we observed higher rates of SGA in our smoking cohort; non-smokers attended maternity unit with frequent episodes of RFM. This may explain why we did not observe a statistically significant difference in the IOL between the two cohorts.

A significantly poor uptake of breastfeeding in the smoking cohort is in keeping with the existing literature (Liu et al., 2006; Can Özalp and Yalçın, 2021; Lok et al., 2018; Chimoriya et al., 2020). This finding is worrying and has long term effects such as diabetes, obesity, hypertension and cardiovascular disease (Dieterich et al., 2013; Binns et al., 2016; Schnurr et al., 2022).

It is not only the women for whom smoking has a negative effect: the increased surveillance and complication rates in smoking women create a higher financial burden for the NHS. For example, the number of scans for fetal surveillance required for the pregnant women who smoked (mean 3.14) incurred a cost of £169.94 per woman. This is almost double the cost for women who did not smoke and required a mean of 1.65 scans, amounting to an average cost of £89.27 per woman. This is without taking into consideration the time cost to maternity services, which is potentially more significant in view of staffing pressures. Furthermore, there are time and financial costs to the women through the effects of appointments on working hours and the cost of public

transport.

4.2. Smoking cessation services

High SATOD rate across Lincolnshire, associated with adverse clinical outcomes and financial costs across the whole pathway, highlighted the need to redesign the current tobacco treatment service.

National Institute for Health and Care Excellence (NICE) recommends that all smokers (regardless of frequency) and those that have stopped smoking in the last two weeks be referred to NHS stop Smoking services (Institute, 2021; Institute, 2021). The poor uptake of accessing the stop smoking service (34.9 %) is worrying and raised a question on the efficacy of the existing interface of maternity and smoking cessation services at point of referral.

The smoking cessation service offered to pregnant women at ULHT at the time of study assumed a homogenous smoking in pregnancy population and was not tailored to population demographics, which may have contributed to the lack of engagement and efficacy.

To address the national crises and achieve the England SATOD ambition, it was crucial to implement tobacco treatment services in line with the NHS Long Term Plan (LTP) recommended delivery model as a matter of priority. This is a more intensive program of support and monitoring than is currently offered across Lincolnshire. It involves a carbon monoxide (CO) exposure assessment at booking and at every subsequent antenatal appointment, very brief advice with an opt-out referral to dedicated tobacco treatment that includes weekly face-to-face behavioural support and licenced pharmacotherapy – specifically combination Nicotine Replacement Therapy (NRT) (The NHS Long Term Plan, 2019).

The study highlighted an urgent need to deliver a different service for tobacco dependency treatment for pregnant smokers, in accordance with NICE guidelines that are supported by new funding released in line with NHS LTP ambitions (The NHS Long Term Plan, 2019). Achieving this required all Lincolnshire Sustainability and transformation partnership (STP), the local authority public health team and stop smoking service partners' work in collaboration with pregnant smokers.

Furthermore, novel schemes to encourage smoking cessation are being considered alongside changes to existing services. For example, the compelling evidence base published in April 23 by the Department of Health and Social Care (Department of Health and Social Care, 2023) suggests offering financial incentives in the form of vouchers alongside behavioural support may be effective in increasing the rate of stopping smoking in pregnant women.

4.3. Consideration of local demographic in smoking cessation services

Although smoking during and after pregnancy is a national problem, some population groups in specific localities have higher prevalence than others. Given the variation in prevalence and the slow progress made on achieving the SATOD target, it raised a question as to whether the current recommended interventions have the same efficacy on different population groups (Ekblad, 2022) and whether greater specificity is required.

Pregnant smokers in localities across Lincolnshire have a slightly different smoking demographic and social profile to the averages used in national level statistics. Nationally, women between 20 and 34 years of age account for the highest proportion of smokers at time of booking; however, in Lincolnshire pregnant women under 24 are more likely to smoke than those over 25 years of age. As age can affect efficacy of nicotine replacement therapy (NRT) interventions (NICE, 2021) this could impact on smoking quit rates, and given our study demonstrates high prevalence of smoking in younger population, it is vital that we provide this information prior to conception when counselling smoking women of childbearing age (Delpisheh et al., 2006; Scholz et al., 2016; Andriani and Kuo, 2014).

The proportion of women who are smoking at the booking visit also

varies according to their nationality. Women with a British background have a smoking rate of 15 % compared to 35 %, 24 % and 22 % for Bulgarian, Latvian and Romanian respectively. Using approaches informed by behaviour to change methods for tailoring smoking interventions in response to the social norms of foreign communities may have a positive impact in achieving the SATOD ambition (Lassi et al., 2014).

5. Strengths and limitations

To our knowledge, this is the first study that has mapped the journey of women from booking until delivery as well as explored and explained demographic reasons for the increased burden of smoking in our local population and measures that can be adopted to address the problem.

An in-depth understanding of variables across the whole care pathway enabled this study to inform a successful business case for fundamental changes to the current tobacco treatment service. In January 2023, an in house maternity model was implemented in areas of Lincolnshire with highest prevalence of smoking with a potential roll out to cover all areas by March 2024.

The funding that Lincolnshire has received for LTP Tobacco provides an opportunity to invest in a programme that focuses efforts on treating tobacco dependency through a tailored programme which is fully compliant with NICE and offers evidence-based approaches to increase engagement and quit outcomes. This demonstrates that service-based research, when gathered in conversation and collaboration with stakeholders, considering local demographics and social dynamics helps interpret national policy for local implementation and delivers impact through changes in professional practice.

To ensure we captured the impact of smoking and minimised the confounding factors, we used strict inclusion criteria and excluded women with pre-existing medical conditions, raised BMI etc. This produced a small sample size and may have had an impact on the significance of result. Nonetheless, our findings corroborate the existing literature and the use of clinical coding eliminated recall bias.

Lack of information about socioeconomic markers of deprivation and occupation is a potential weakness of this study. This information is vital and has an impact on engagement with the smoking cessation services.

6. Conclusion

The study has given an insight into the need for effective, targeted, and proportionate tobacco treatment services to address the Lincolnshire SATOD rate and align it with Government targets, NICE guidance, and NHS Long Term ambitions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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