

## **Beyond the individual: socio-ecological factors impacting activity after Gestational Diabetes Mellitus**

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# Beyond the individual: socio-ecological factors impacting activity after Gestational Diabetes Mellitus

## Barriers and facilitators to physical activity after Gestational Diabetes

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All authors were involved in the discussion of, and formulation of the research questions addressed. EI performed the one-to-one interviews and data collection. Analysis plans and results were discussed and decided by all authors. HH and EI did the initial coding, with themes generated iteratively in team meetings with CH. EI prepared the original draft manuscript. All authors read, edited, and approved the final manuscript. HH, CH and AP are the lead author's (EI) supervisors and aided the whole process.

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## Conflicts of interest

The authors declare no conflicts of interest.

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## 27 **Novelty statement**

28 *What is already known?*

29 Physical activity independently reduces risk of Type 2 Diabetes after Gestational Diabetes, but  
30 engagement is low. Qualitative research to date focuses on exploring individual level factors  
31 influencing physical activity.

32 *What this study has found?*

33 We have identified factors beyond individual control that influence physical activity after Gestational  
34 Diabetes. These include social and organisational factors, like support from partners or contacts with  
35 healthcare professionals, and a lack of childcare.

36 *What are the implications of the study?*

37 Multi-level interventions are needed to effectively target barriers to physical activity at multiple  
38 levels of the system. Organisations and systems level actors need to take steps to support individuals  
39 to engage with physical activity after Gestational Diabetes.

40

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45

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## Abstract

**Aim:** Risk of Type 2 Diabetes is 10-times higher after a pregnancy with Gestational Diabetes. Physical activity can independently reduce this risk, yet engagement with physical activity remains low after Gestational Diabetes. Therefore, the present study aimed to explore the barriers and facilitators to the uptake of physical activity after Gestational Diabetes in the UK, using a socio-ecological approach.

**Methods:** The paper was written following the Standards for Reporting Qualitative Research. Patient and Public Involvement contributed to the study conceptualisation and design. Participants were recruited through an audit of Gestational Diabetes cases at a local Teaching Hospital in 2020. Twelve participants took part in semi-structured one-to-one interviews. Reflexive thematic analysis was used to generate themes in iterative rounds of refinement. Final themes were then organised using the socio-ecological model.

**Results:** Participants were all over 31 years old, predominantly self-identified as White British and were all in employment but were evenly spread across UK-based deprivation deciles. Ten themes were generated and organised according to the four levels of the socio-ecological model; intrapersonal (beliefs about activity, recovering from birth), social (health care professionals, family and partner, role as a mother), organisational (access and cost, environment, childcare and work) and community (connecting women with recent Gestational Diabetes).

**Conclusions:** Many of the amenable barriers and facilitators to physical activity were beyond the intrapersonal level, based at higher levels of the socio-ecological model (social, organisational, community). Multi-level interventions are needed to effectively address all barriers.

## **Key words**

“Gestational Diabetes Mellitus”, “Type 2 Diabetes Mellitus”, “Physical Activity”, “Exercise”, “Socio-Ecological Model”, Prevention, “Maternal Health”

## **Introduction**

Gestational Diabetes is a type of glucose intolerance that first appears in pregnancy<sup>1</sup>. In the UK, prevalence of gestational diabetes was estimated at 20.6% in 2021, but rates are steadily increasing<sup>2</sup>. Several chronic conditions are associated with a Gestational Diabetes diagnosis<sup>3</sup>. For example, risk of Type 2 Diabetes is ten-times higher in women with previous Gestational Diabetes. Costs related to Type 2 Diabetes diagnosis and treatment are rising and are currently estimated to cost the UK National Health Service (NHS) £14 billion annually<sup>4</sup>. Patients with Type 2 Diabetes have also reported that managing the condition is burdensome and can have substantial impacts on mental health<sup>5,6</sup>. Reducing this risk is thus a clinical priority<sup>7,8</sup>.

A combination of lifestyle behaviours including diet, physical activity (PA) and weight management, has been shown to reduce risk of progression to Type 2 Diabetes by 50%<sup>9–11</sup>. However, PA can independently reduce this risk, with data from the Nurses’ Health Study II cohort suggesting a risk reduction of 9% for every 100 minutes of moderate PA per week undertaken, even after adjusting for BMI<sup>12</sup>. Yet, PA tends to decrease from pre-pregnancy to postpartum<sup>13</sup>. Factors associated with declining PA include lack of childcare, working longer hours and postpartum weight retention<sup>14</sup>.

93 Additionally, uptake of PA is not effectively encouraged after Gestational Diabetes<sup>15</sup>. This could be  
94 because diabetes prevention initiatives are targeted at the general population, who may not  
95 experience the unique barriers present for women with young families<sup>16,17</sup>. Factors impacting PA  
96 engagement after Gestational Diabetes require further investigation.

97 Recently, a review exploring barriers and facilitators to PA in women after Gestational Diabetes has  
98 been published<sup>18</sup>. However, only two of the included studies focused solely on PA<sup>19,20</sup>. Jakobsen *et*  
99 *al.*, recently undertook a phenomenological approach to understanding the perceptions and  
100 motivation for PA in women after Gestational Diabetes<sup>21</sup>. These studies focus on individual  
101 motivation and experiences, and do not explore barriers and facilitators to PA outside of the  
102 individual's perspective.

103 Increasingly, it is understood that human behaviour occurs within a complex system of influences.  
104 Focusing solely on individual-level factors such as motivation risks designing interventions that may  
105 have limited impact because wider factors continue to act as a barrier to the behaviour, or could  
106 lead to a neglect of recommendations or efforts to address those wider influences<sup>22</sup>. The Socio-  
107 Ecological Model (SEM) depicts interrelationships between the social, physical and policy  
108 environments surrounding individuals<sup>23</sup>. It is a useful model for understanding wider influences on  
109 individual (health) behaviours<sup>24</sup> and can highlight parts of a system to target, through the lens of  
110 interpersonal, social, organisational and community levels. The present study aimed to explore  
111 barriers and facilitators to the uptake of PA after Gestational Diabetes, using the SEM to better  
112 understand the range of influences and contexts on PA.

## 113 **Methods**

114 The present paper was written in accordance with the Standards for Reporting Qualitative Research  
115 (SRQR)<sup>25</sup>.

### 116 *Study context*

The study took place in a city in North-East England. The city is one of the 20% most deprived areas in England<sup>26</sup>, with an ethnicity split broadly similar to that of England and Wales (as of the 2021<sup>27</sup> census): 79.1% White, 9.6% Asian, Asian British or Asian Welsh, 4.6% Black, Black British, Black Welsh, Caribbean or African and 3.5% Mixed or Multiple ethnic groups.

#### *Patient and public involvement (PPI)*

Members of a PPI group were recruited from across the UK via social media adverts, word of mouth and a Gestational Diabetes support group run by Diabetes UK. The PPI members had varying experiences of Gestational Diabetes and life after Gestational Diabetes; some were active, some were not, and some were diagnosed with Type 2 Diabetes.

In the development stages, the PPI group aided the conceptualisation of the present study. In further meetings, the PPI group helped develop key questions to address in the interviews and were asked to give feedback on the draft interview schedule, which was amended accordingly. The semi-structured interview guide was piloted first with another researcher, and then with a member of the PPI group. Following pilot interviews the guide was refined and shortened, to improve flow and clarity of questions and length. PPI members were also asked to give feedback on the study poster and information sheet, with subsequent changes made based on feedback received, related to use of plain English language.

#### *Sampling and recruitment*

NHS ethical approval was obtained (IRAS Project ID: 312509). A Research Coordinator at the local NHS Teaching Hospitals Trust identified eligible women from an audit on Gestational Diabetes cases from 2020, and sent packs with study information and consent to 350 women (Table 1). Participants were offered a £10 thank you voucher for their time if they took part in the study.

Other qualitative papers in this topic area have varied greatly in terms of sample size<sup>18</sup>. Consistent with Braun and Clarke's approach to reflexive thematic analysis, the concept of theoretical

saturation was not applied in this study<sup>28</sup>. Instead, sampling ceased when no further responses were obtained after a 4-month period<sup>29</sup>.

#### *Data collection*

One-to-one semi-structured interviews were conducted by the lead author (EI) with women who had a history of Gestational Diabetes within the past 5 years (**Error! Reference source not found.**). Participants were not excluded based on a current Type 2 Diabetes diagnosis, if the diagnosis happened after the most recent Gestational Diabetes pregnancy. Upon obtaining informed consent interviews were conducted over the phone (n=6), online (via Zoom Video Communications Inc., USA) (n=5), or face-to-face (n=1), as per participant's preferences. Interviews were recorded using a digital audio recorder and transcribed by a transcription company and, on average, lasted 45 minutes (range: 27 – 54 minutes).

#### *Data analysis*

A reflexive thematic analysis<sup>30</sup> was undertaken using NVivo 12 (Lumivero, Denver, USA). Data recorded from interviews was taken to reflect the articulated meanings and experiences of participants<sup>31</sup>. The coding approach was initially inductive, and once final themes were generated, these were deductively organised, using the SEM as a framework. Levels of the SEM are not strictly distinct, rather they represent interrelationships. However, inductively generated themes were subsequently aligned to whichever level of the model they might most usefully be targeted. For example, 'childcare' was aligned with the organisational level as this is where childcare could be addressed i.e., organisations could provide childcare.

A reflexive thematic analysis was undertaken following the six phases outlined by Braun and Clarke; familiarisation, initial coding, theme generation, reflection and reviewing themes, defining and writing up the themes<sup>30, 32</sup>. A female PhD student with a background in sport science and nutrition (EI) did the initial open coding. Two female researchers experienced in qualitative research with



qualifications and applied experience in health psychology and public health (CH and HH) also independently read and coded a random sample of transcripts to discuss in the initial theme refinement. EI, HH and CH discussed and reviewed codes and themes iteratively in four rounds, to aid development and refinement of themes, and to support researcher reflexivity<sup>33,34</sup>. These discussions included reflections about use of the SEM, to ensure initial inductive themes generated were data-driven, with the SEM only being used to latterly organise these themes rather than dictate them.

## Results

### *Participant characteristics*

Twelve participants took part in the study. A summary of their demographic information is presented in **Error! Reference source not found.**. Compared to the potential participants invitation packs were sent to (Table 1), a high proportion of White British women, a lower proportion of Asian women and women living in more deprived areas (IMD 1-3) were recruited. Allowing choice regarding interview mode (i.e., telephone, zoom or face-to-face) aided participants' ability to take part in the interview but had no obvious impact on participants' engagement with interview questions, depth of responses or interview length.

### *Themes*

Ten themes were generated and organised using the levels of the SEM (Figure 1); intrapersonal (n=2), social (n=3), organisational (n=4) and community (n=1). Factors that limited or impeded PA (barriers) or supported PA (facilitators) appeared within each of these themes. **Error! Reference source not found.** displays how these themes and the factors within them were organised.

### Intrapersonal level factors

## 188 **Beliefs about PA**

189 This theme summarises why participants thought they should be active. Some participants had an  
190 awareness of PA for managing Type 2 Diabetes risk or mental health as a result of their Gestational  
191 Diabetes diagnosis: *"I thought, you know what, I'm going to have to do this (PA). I don't really want*  
192 *diabetes. Diabetes is rubbish, and that is enough reason"* [P6]. However, many participants believed  
193 PA was helpful for mitigating Type 2 Diabetes risk through weight-management alone, rather than  
194 the independent benefits of PA. A focus on weight or aesthetics encouraged PA for some  
195 participants *"So I don't get fat... just to keep my weight down"* [P2]. For others a weight or aesthetic  
196 focus was negative for longer-term PA maintenance: *"I stopped seeing any physical results and*  
197 *stopped losing weight, I just stopped everything altogether."* [P4]. While some participants were not  
198 satisfied with current PA levels, these tended to be when discussing purposeful leisure time exercise  
199 and this dissatisfaction did not necessarily result in increased PA engagement.

## 200 **Recovering from birth**

201 The impact of birth on mental or physical health differentially affected the amount of time women  
202 needed to feel "ready" to engage with PA postnatally. Participants described physical after-effects  
203 from giving birth: *"I found it took a lot of building back up to even just be able to walk that amount...*  
204 *I've never ever experienced anything like that. I've never ever thought I can barely walk ten minutes."*  
205 [P3]. Some took a graded approach to PA, building up from gentle movement to more purposeful  
206 exercise within the early postpartum period: *"I'd still got hip and pelvis problems. I set off walking a*  
207 *little bit in the first six months, and then I thought right, I'll try Couch25k, then I did Couch210k"* [P6].  
208 Others described a longer recovery, or cited the emotional impact and adjustment to motherhood in  
209 terms of new priorities and responsibilities which created a more long-lasting barrier.

## 210 **Social level factors**

### 211 **Advice from Health Care Professionals**

212 Participants felt unsupported by Health Care Professionals (HCPs) postnatally: *"There was zero*  
213 *support, zero, zero, zero"* [P3]. Participants also felt HCPs focused more on diet and weight than PA  
214 for managing risk of Type 2 Diabetes. Other participants felt HCPs were positive and helpful: *"my*  
215 *doctor told me... it's quite helpful if you do walk every day. It decreases your risk level"* [P11]. Overall,  
216 most participants wanted more support postnatally, and to be directed to PA specific resources.

#### 217 **Role of partner or family**

218 Participants felt they needed supportive partners and/or close family both to encourage PA, and to  
219 enable time for them to undertake PA by providing help with household responsibilities (including  
220 childcare): *"he's always like, if you want to do something go off and do it, and he's happy to stay at*  
221 *home. He is always encouraging me."* [P9]. However, some participants were single mothers, or had  
222 partners that worked at a distance from home and felt PA was unattainable for this reason. Most  
223 participants did not want to rely on help from other family members for the sake of PA, preferring to  
224 reserve childcare support for emergencies or for other priorities.

#### 225 **Role as mother**

226 Participants identified themselves primarily as mothers, where their children's needs came first. This  
227 was often a barrier to PA: *"You are a mum and that comes first... you are last on the list of priorities"*  
228 [P7]. Participants subsequently felt guilty engaging with PA and preferred to spend time with their  
229 children in their free time. However, some participants wanted to role model PA as a positive  
230 behaviour for their children: *"I really want exercise to be important to her."* [P1]. Wanting to ensure  
231 children were happy and fulfilled also encouraged some participants to be more active: *"I've always*  
232 *been a bit lazy... to go and be active. It's more, I need to get my kids out, shall we go for a walk...*  
233 *We'll do an activity to keep the kids busy... rather than thinking I need to do some exercise."* [P4].

#### 234 **Organisational level factors**

##### 235 **Access to PA (cost)**

236 Increasing costs of daily life prompted active transport for some participants. However, for most  
237 participants, it reduced access to PA as money was prioritised for their children's benefits over e.g.,  
238 gym access *"I haven't got £40 a month... It's not a priority... You don't save money by not taking your*  
239 *kids to the play areas. So, you can't go to the gym because your kids come first"* [P7]. The distance to  
240 e.g., gyms also impacted uptake of PA in those settings, given time constraints felt as mothers.

#### 241 **Childcare**

242 The lack of childcare was one of the most significant barriers highlighted by participants: *"Yeah, it's*  
243 *just childcare reasons that gets in the way, I would be doing a lot more if it weren't for childcare*  
244 *reasons"* [P2]. The presence of childcare potentially enabled participants to be active. However,  
245 participants emphasised a lack of options for flexible, short duration and affordable childcare, which  
246 might be most helpful for enabling PA engagement: *"She goes to nursery while I'm at work, but it*  
247 *costs a fortune. It costs £60 or £70 a day... I could pay to put her in somewhere for an hour, but most*  
248 *places don't do that. Most places don't have that option."* [P6].

#### 249 **Environment**

250 The walkability of the environment aided active transport e.g., walking children to and from  
251 activities. Some participants preferred the flexibility of running and home-based PA e.g., following  
252 YouTube videos to overcome cost and time issues: *"I like doing it at home because it fits in"* [P12].  
253 The safety of the environment and the weather hindered PA when it was not felt safe, or the  
254 weather was unpleasant to e.g., run in.

#### 255 **Work**

256 Being in full-time work significantly reduced opportunity for PA due to time constraints, although  
257 some participants recognised that work-based PA initiatives existed. However, participants  
258 highlighted they could not make use of these, if other barriers were present e.g., lack of childcare,  
259 and needing to condense work hours. Weekends were therefore considered good opportunities for

being active as a family: *“then the weekends are a bit more family time. That’s when usually we have more time to go out for a proper walk”* [P7].

## **Community level factors**

### **Connecting women with recent Gestational Diabetes**

Participants wanted to be connected to other women with previous Gestational Diabetes but often felt they could not do this on their own: *“It’s just logistically getting together with other people that I haven’t met yet... I don’t know where to find these people that you can do activities with”* [P7]. Some participants preferred PA in group settings for increased motivation, accountability, and enjoyment of PA: *“I wouldn’t have just gone and run with my buggy I’d have wanted to have done it with a group of people”* [P12]. However, other participants would be deterred from group-based PA, depending on who was in the group: *“But then I suppose that can hinder you, because I’ve got friends who are so fit I’d hate to go to a class with them, because there’s no way that I’d keep up”* [P12]. Participants also highlighted that mum and baby groups only catered to very young babies; not all participants were ready to engage with PA at that point and would have preferred similar opportunities when their children were older.

## **Discussion**

The aim of this study was to explore barriers and facilitators to PA after Gestational Diabetes and understand these wider influences and contexts on PA using the SEM. The results highlighted how the barriers and facilitators to PA span across multiple levels of the SEM. “Recovering from birth”, “advice from HCPs” and “connecting women with previous Gestational Diabetes” were the main themes linked directly with the Gestational Diabetes experience. The results are discussed further below.

### *Intrapersonal*

Many participants described pursuing PA for weight management or body image reasons. These motives are commonly linked to experiences from school or societal pressures to conform to aesthetic female stereotypes<sup>35,36</sup>. For many participants in the current study these ideals existed pre-pregnancy rather than being specific to motherhood, although weight gain and weight management associated with pregnancy was highlighted throughout the Gestational Diabetes experience. Weight-loss intentions behind PA could explain increased motivation for PA in women<sup>37</sup> and Type 2 Diabetes risk has been shown to decrease with weight-loss<sup>38</sup>. However, for some of our participants, fluctuations in weight and an aesthetically-driven PA focus negatively impacted PA engagement. Research has suggested that PA interventions may be more successful without incorporating weight-based targets<sup>38</sup>. PA also independently reduces risk of Type 2 Diabetes along with other psychosocial benefits<sup>40-43</sup>. Emphasising the benefits of PA beyond weight-loss or weight management might therefore be useful for promoting sustained PA engagement.

Health interventions after Gestational Diabetes should be initiated as soon as possible after birth for effectiveness, due to higher risk of Type 2 Diabetes in the first six years after delivery<sup>44-47</sup>. Maingal *et al.*, proposed starting an initiative at 3-months postnatally, based on results from reviewing outcomes of trial data<sup>47</sup>. However, the acceptability of the best timing for diabetes prevention initiatives remains unclear<sup>17,48-51</sup>. Our results suggest 'Recovering from birth' could be impacted by the birth experience, where it takes time to build stamina required for any movement, especially purposeful or more intense exercise. Risk of foetal macrosomia (larger than average) and subsequent traumatic birth can be increased with a Gestational Diabetes diagnosis<sup>52,53</sup>. Risk of postpartum depression is also increased by 59% with a Gestational Diabetes diagnosis<sup>54</sup>. Therefore, if recovering mentally and physically after birth takes longer after Gestational Diabetes, targeting PA this early may not be effective for all women. Participants in the present study highlighted the importance of opportunities to engage with PA when children are older e.g., over 2-years-old, and not only at the initial postpartum period, and desired programmes beyond the current 'exercise with baby' opportunities. It is important for women to receive adequate support postnatally, to recover

from the mental and physical impact of more difficult or traumatic births, before targeting PA behaviours. Support could also be underpinned by behaviour change theories and techniques, to consider differing motivations and readiness to engage with PA. PA opportunities should also exist for women with previous gestational diabetes over an extended period of time to enable them to engage when such support has enabled them to feel sufficiently 'ready' for PA.

#### *Social*

One of the key barriers identified in this study was the lack of support to engage with PA postnatally, which was compounded depending on the quality of pregnancy advice and interactions with HCPs. Feeling unsupported can happen to any postnatal woman and is not specific to women with previous Gestational Diabetes<sup>55</sup>. However, as with our participants, women with previous Gestational Diabetes in other studies have described wanting more support to engage with varying lifestyle behaviours postnatally<sup>56</sup>. More postnatal support could be needed due to stricter and less transferable behaviours initiated in pregnancy (e.g., walking after meals for acute blood glucose control<sup>57</sup>). Participants also highlighted a heavier dietary or weight-management focus to reduce Type 2 Diabetes risk, suggesting a need for more PA-specific postnatal advice and support from these professionals.

As in previous research, this study identified that 'role as a mother' could facilitate PA when participants wanted to role model PA as positive, but it was also largely a barrier when children's needs were prioritised ahead of individual time for PA<sup>17,18</sup>. Support in the form of coaching or counselling could be helpful for overcoming any guilt experienced for mothers when trying to prioritise themselves<sup>58</sup>. Health coaching has also previously been shown to aid behaviour change for the management of, for example, diabetes<sup>59</sup>. Lifestyle coaches have previously been shown as beneficial for tailoring PA and supporting women to be active after Gestational Diabetes. However, this varied between individuals, with some women feeling suggestions and accommodations were not helpful or relevant for their circumstances<sup>60</sup>. Effective coaching and counselling support should

therefore be tailored to individual circumstances, and consider diversity and inclusivity. Family-based PA interventions could also potentially overcome the 'role as a mother' barrier for some women, embedding PA part of that social role rather than separate to it, and reducing the need for them to 'choose' between time alone or with family<sup>18,47</sup>. Further research is needed to determine the appropriate timing and acceptability of different types of family-based PA interventions, and understood for whom these might work.

#### *Organisational/Community*

Workplace initiatives may be helpful for working mothers after Gestational Diabetes, who spend a considerable amount of time at work<sup>62</sup>. However, many participants in this study were unable to make use of workplace initiatives due to childcare responsibilities (e.g., condensing working hours), which was also highlighted during the COVID-19 pandemic<sup>63</sup>. Therefore, workplace initiatives need to be improved to incorporate additional measures such as appropriate childcare provision or protected time during condensed working hours to participate.

For participants in this study, childcare outside of working hours was informal, such as partner support or nearby family. Some participants were single mums and for others partner support was not feasible. Therefore, while including partners in PA initiatives could be important<sup>17,55</sup>, it may still not be helpful for many women after Gestational Diabetes and childcare support provided by other organisations could address this barrier. Co-locating childcare opportunities within PA spaces could be helpful, although participants in the present study highlighted that such spaces would need to be perceived as beneficial for their children. Co-designing co-located spaces with mothers could optimise uptake and use of such spaces.

Access to PA, whether due to location or cost was a notable barrier in the present study. These barriers are common to PA for the general population, however, specific to women with young families, they were compounded by the desire to prioritise spending on childrens' enrichment activities over adult-specific PA. The WHO's global action plan encourages use of community-based



initiatives in public spaces to increase affordability and access of PA<sup>64</sup>. Such initiatives could align well with the facilitators in the present study, including walkability of the environment, practical and flexible access to PA. Community-based groups also represent opportunities to connect women with previous Gestational Diabetes, encouraging a sense of community and relatability which could be built on to encourage PA<sup>65</sup>. Group-based PA could be helpful for those women who express a preference for that format (not all do), and PA can be equitably promoted through community-based approaches<sup>66</sup>. Further research is required to understand what community-based approaches exist that women with previous Gestational Diabetes could be eligible for, and how to direct and encourage women to access these resources.

#### *Strengths & limitations*

Using the SEM to organise barriers and facilitators to PA after Gestational Diabetes according to frame, intrapersonal social, organisational and community system levels provides a useful lens for considering how to tackle these factors when aiming to increase engagement with PA after Gestational Diabetes.

Participants were well-spread in terms of their socio-economic backgrounds, however, were all highly educated. This could have been influenced by the recruitment approach. However, participants were not all highly active, which can be a common bias in research exploring PA perceptions. Despite being highly educated and from less deprived areas than women invited to interview, costs were still a barrier to participants, highlighting that resources may still not be available for this group of women. Participants also predominantly self-identified as White British, therefore findings may not be generalisable to all ethnic groups. This is important to consider given women with South Asian heritage are twice as likely to develop Gestational Diabetes and have subsequent higher risk of progression to Type 2 Diabetes<sup>67,68</sup>. Future research should aim to explore the barriers and facilitators of PA for women from different ethnic backgrounds. This could involve

removing the eligibility criteria of being able to communicate in English, and work with interpreters to increase participation.

Participants in the present study experienced some of their pregnancy and early postpartum period during the COVID-19 pandemic, and thus some of their experiences may have been influenced to e.g., periods of lockdown which may be different for pregnant women ‘post-pandemic’<sup>69</sup>. As access to and service provision change going forward i.e., remote appointments, hybrid working become increasingly these evolving contextual factors need to be considered for their impact on PA access.

## Conclusions

Use of the SEM highlighted that most amenable barriers and facilitators to PA were beyond the intrapersonal level, based at higher levels of the SEM (social, organisational, community). A range of, interventions, or multi-level are needed to effectively address these barriers. Improving postnatal support and HCP contact are social and organisational level targets. Access to flexible, cost-effective PA and childcare opportunities are important for PA engagement, and should therefore be addressed and targeted accordingly e.g., through co-locating childcare with PA opportunities and within workplace initiatives. Directing women to community-based PA resources could also provide support needed to engage with PA, and overcome cost and access barriers to PA.

## References

1. WHO. Diagnostic criteria and classification of hyperglycaemia first detected in pregnancy: a World Health Organization Guideline. *Diabetes Res Clin Pract.* 2014;(103):341–63. doi:<https://doi.org/10.1016/j.diabres.2013.10.012>
2. IDF. United Kingdom diabetes report 2000 — 2045. 10th edition IDF Diabetes Atlas. Published 2021. Accessed March 9, 2023. <https://diabetesatlas.org/data/en/country/209/gb.html>
3. Metzger BE. International Association of Diabetes and Pregnancy Study Groups recommendations on the diagnosis and classification of hyperglycemia in pregnancy. *Diabetes Care.* 2010;33(3):676-682. doi:10.2337/dc09-1848

4. DIABETES UK. Cost of Diabetes. Cost of Diabetes Guides and Information. Published January 25, 2023. Accessed September 13, 2023. <https://www.diabetes.co.uk/cost-of-diabetes.html>
5. Kalra S, Jena BN, Yeravdekar R. Emotional and Psychological Needs of People with Diabetes. *Indian J Endocrinol Metab.* 2018;22(5):696. doi:10.4103/IJEM.IJEM\_579\_17
6. Ducat L, Philipson LH, Anderson BJ. The Mental Health Comorbidities of Diabetes. *JAMA.* 2014;312(7):691. doi:10.1001/JAMA.2014.8040
7. Vounzoulaki E, Khunti K, Abner SC, Tan BK, Davies MJ, Gillies CL. Progression to type 2 diabetes in women with a known history of gestational diabetes: Systematic review and meta-analysis. *The BMJ.* 2020;369. doi:10.1136/bmj.m1361
8. Ayman G, Strachan JA, McLennan N, et al. The top ten research priorities in diabetes and pregnancy according to women, support networks and healthcare professionals. *Diabetic Medicine.* 2021;00:14588. doi:10.1111/dme.14588
9. Knowler W, Barrett-Connor E, Fowler S, et al. Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin. *New England Journal of Medicine.* 2002;346(6):393-403. doi:10.1056/NEJMoa012512
10. Tuomilehto J, Lindström J, Eriksson JG, et al. Prevention of Type 2 Diabetes Mellitus by Changes in Lifestyle among Subjects with Impaired Glucose Tolerance. *New England Journal of Medicine.* 2001;344(18):1343-1350. doi:10.1056/nejm200105033441801
11. Pan XR, Li GW, Hu YH, et al. Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance: The Da Qing IGT and diabetes study. *Diabetes Care.* 1997;20(4):537-544. doi:10.2337/diacare.20.4.537
12. Bao W, Tobias DK, Bowers K, et al. Physical activity and sedentary behaviors associated with risk of progression from gestational diabetes mellitus to type 2 diabetes mellitus: a prospective cohort study. *JAMA Intern Med.* 2014;174(7):1047-1055. doi:10.1001/jamainternmed.2014.1795
13. Engberg E. Physical Activity, Pregnancy and Mental Well-Being : Focusing on Women at Risk for Gestational Diabetes. University of Helsinki; 2018.
14. Pereira MA, Rifas-Shiman SL, Kleinman KP, Rich-Edwards JW, Peterson KE, Gillman MW. Predictors of Change in Physical Activity During and After Pregnancy: Project Viva. *Am J Prev Med.* 2007;32(4):312. doi:10.1016/J.AMEPRE.2006.12.017
15. Jones EJ, Fraley HE, Mazzawi J. Appreciating Recent Motherhood and Culture: A Systematic Review of Multimodal Postpartum Lifestyle Interventions to Reduce Diabetes Risk in Women with Prior Gestational Diabetes. *Matern Child Health J.* 2017;21(1):45-57. doi:10.1007/s10995-016-2092-z
16. Siew L, Mingling C, Makama M, O'Reilly S. Preventing Type 2 Diabetes in Women with Previous Gestational Diabetes: Reviewing the Implementation Gaps for Health Behavior Change Programs. *Semin Reprod Med.* Published online 2021:1-7. doi:10.1055/s-0040-1722315
17. Dennison RA, Ward RJ, Griffin SJ, Usher-Smith JA. Women's views on lifestyle changes to reduce the risk of developing Type 2 diabetes after gestational diabetes: a systematic review, qualitative synthesis and recommendations for practice. *Diabetic Medicine.* 2019;36(6):702-717. doi:10.1111/dme.13926
18. Ioannou E, Humphreys H, Homer C, Purvis A. Systematic review and thematic synthesis of the barriers and facilitators to physical activity for women after gestational diabetes: a socio-ecological approach. *British Journal of Diabetes.* 2023;23(1):2-13. doi:10.15277/bjd.2023.413

19. Doran F. Gestational Diabetes Mellitus: Perspectives on Lifestyle Changes during Pregnancy and Post- partum, Physical Activity and the Prevention of Future Type 2 Diabetes. *Aust J Prim Health*. 2008;13(3):85-92.
20. Graco M, Garrard J, Jasper AE. Participation in physical activity: perceptions of women with a previous history of gestational diabetes mellitus. *Health Promot J Austr*. 2009;20(1):20-25. doi:10.1071/HE09020
21. Breinholm J, Jakobsen S, Brodersen JS, Sheikh ZA, Nielsen KK. Perception of and Motivation for Physical Activity among Women with a History of Gestational Diabetes. *Women 2021*, Vol 1, Pages 109-119. 2021;1(2):109-119. doi:10.3390/WOMEN1020010
22. Chater N, Loewenstein G. The i-frame and the s-frame: How focusing on individual-level solutions has led behavioral public policy astray. *Behav Brain Sci*. 2022 Sep 5;46:e147. doi: 10.1017/S0140525X22002023. PMID: 36059098.
23. Mcleroy KR, Bibeau D, Steckler A, Glanz K. An Ecological Perspective on Health Promotion Programs. *Health Education & Behavior*. 1988;15(4):351-377. doi:10.1177/109019818801500401
24. Stokols D. Translating social ecological theory into guidelines for community health promotion. *Am J Health Promot*. 1996;10(4):282-298. doi:10.4278/0890-1171-10.4.282
25. O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: A synthesis of recommendations. *Academic Medicine*. 2014;89(9):1245-1251. doi:10.1097/ACM.0000000000000388
26. PHE. Local Authority Health Profile 2018.; 2018. Chrome extension://efaidnbmnnnibpcajpcglclefindmkaj/https://democracy.sheffield.gov.uk/documents/s32505/Local Authority Health Profile 2018.pdf
27. ONS. How life has changed in Sheffield: Census 2021. Census. Published 2021. Accessed July 21, 2023. <https://www.ons.gov.uk/visualisations/censusareachanges/E08000019/>
28. Braun V, Clarke V. To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. *Qual Res Sport Exerc Health*. 2021;13(2):201-216. doi:10.1080/2159676X.2019.1704846
29. Saunders B, Sim J, Kingstone T, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant*. 2018;52(4):1893-1907. doi:10.1007/S11135-017-0574-8
30. Braun V, Clarke V, Weate P. Using Thematic Analysis in Sport and Exercise Research. In: Smith B (Brett M), Sparkes AC, eds. *Routledge Handbook of Qualitative Research in Sport and Exercise*. Routledge international handbooks. Routledge; 2019:191-206.